Use of Capital Forecasts for Estimating Forward-Looking Costs

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Abstract: This paper examines the ability of regulators to implement a methodology for pricing telecommunications interconnection and unbundled network elements ("UNEs") based on the configurations and costs of the local networks of the incumbent local exchange carriers ("ILECs"). As proposed by the ILECs and discussed by the Federal Communications Commission, this methodology would combine: (a) forecasts of adjustments to and expenditures on the ILECs' telecommunications plant over a medium-run period of between three and five years; with (b) the historical cost (or some re-costing to "current") of the ILECs' embedded plant that would not be subject to augmentation or replacement over this medium-run period. While the latter component representing embedded network costs appears not to be a proper part of the incremental cost of interconnection and UNEs that must undergird any system of economically efficient prices; the former component of forecast plant expenditures is potentially admissible for use in a medium-run costing/pricing scheme. But these forecasts are of value only if they provide reasonably accurate and stable estimates of actually resulting plant expenditures. The empirical data reported by the ILECs in their quarterly financial reports and used in this paper suggest that these capital expenditure forecasts are severely inaccurate – even over very short time horizons. Thus, on this basis alone, the adjusted embedded network methodology proposed by the ILECs seems not to be a wise replacement for the currently-used total element long-run incremental cost ("TELRIC") methodology.

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1. Overview

At bottom, the principal disputes between the incumbent and competitive local exchange carriers ("ILECs" and "CLECs") over the provision of interconnection and unbundled network elements ("UNEs") reduce to price. The CLECs believe that the Telecommunications Act of 1996 and sound competitive economic principles require these prices to be based on the long-run incremental cost of an efficient, forward-looking local network. In contrast, the ILECs contend that these same principles require such prices to be based on their embedded network configurations adjusted for incremental alterations and expenditures that they expect to make over an intermediate time period – generally three to five years.[1]

Regardless of whether sound economic theory favors current regulatory definitions of the proper cost basis for interconnection and UNE charges or the ILECs' proposed definitions, for any methodology to be admissible for regulatory ratemaking, it must be capable of being implemented reliably. The central purpose of this paper is to analyze the ability of regulators to implement reliably one particular aspect the ILECs' proposed pricing methodology – adjustment of the cost of the current network base to reflect anticipated changes in its capital assets. To perform any such adjustments reliably, it is essential that there be accurate forecasts of ILEC capital expenditures over the suggested three to five year time horizons.

This paper begins by reviewing the statutory basis for interconnection and unbundled element pricing, and its consistency with economic theory. I then present the alternative pricing proposal advanced by the ILECs and discuss briefly its consistency with economic theory. Although this proposal appears not to conform with accepted economic views that efficient prices must be based on incremental costs, I go on to examine whether the ILEC methodology can be implemented reliably. While such a pricing methodology would present many implementation challenges for determining the cost of ILEC capital that is to remain fixed, I examine closely only whether reliable forecasts of "actual" future ILEC capital expenditures are available to regulators.

Based on recent empirical data from ILEC financial reports, I find that the ILECs' best forecasts of these near-term capital expenditures are characterized by severe errors

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[1] The ILECs have dubbed the costs calculated from this adjusted embedded network basis to be their "actual forward-looking costs." *See* SBC Comments in WC Docket No. 03-173 (filed December 16, 2003) at 24-29; or Verizon Comments in WC Docket No. 03-173 (filed December 16, 2003) at 25-30. This current ILEC position on the proper basis for interconnection and UNE pricing appears to differ from the position argued by these ILECs to the U.S. Supreme Court in the *Verizon* case (535 US 467 (2002)). The former ILEC position was that such prices must be set to recover full embedded costs. The Supreme Court rejected this position as not supported by the language or intent of the Telecommunications Act. *See* section 2 of this paper for more details.

– even over forecast periods far briefer than the three to five year time horizons contemplated by their proposed pricing methodology. Because even one-year-ahead capital forecast errors average over 20%, this alone would cause the "forward-looking" component of interconnection and UNE prices developed under the ILECs' proposed adjusted embedded network/cost mechanism to deviate by an average of at least 60% from what would be supported by the incremental capital costs actually experienced by ILECs. Based on this finding of severe inaccuracy, the adjusted embedded cost pricing concept seems to be an unwise basis for regulatory pricing of interconnection and UNEs.

2. Background for pricing criteria

The Telecommunications Act of 1996 requires that prices for interconnection and unbundled network elements shall be set, "based on the cost (determined without reference to a rate-of-return or other rate-based proceeding) of providing the interconnection or network element." [47 USC § 252(d)(1)(A)(i)] In its Local Competition Order,[2] the Federal Communications Commission interpreted this statutory language to mean that such prices should be calculated, "pursuant to a forward-looking economic cost-based methodology" [47 CFR § 51.503(b)(1)] and that forward-looking economic costs shall be the, "total element long-run incremental cost of the element" [47 CFR § 51.505(a)(1)] plus "a reasonable allocation of forward-looking common costs" [47 CFR § 51.505(a)].[3] The FCC further defined the total long-run incremental cost ("TELRIC") of an element to be the "the forward-looking cost over the long run of the total quantity of the facilities and functions that are directly attributable to, or reasonably identifiable as incremental to, such element," [47 CFR § 51.505(b)] assuming the "use of the most efficient telecommunications technology currently available and the lowest cost network configuration" [47 CFR § 51.505(b)(1)].[4]

From 1996 through 2002, these pricing rules were the subject of repeated lawsuits by the ILECs. Over this period, the ILECs argued both to the Eighth Circuit Court of Appeals and to the U.S. Supreme Court, that the FCC's national rules were unlawful under the Telecommunications Act because they usurped pricing authority from the states and did not provide for the full recovery of the ILECs' historical embedded costs.

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[2] FCC, Implementation of the Local Competition Provisions in the Telecommunications Act of 1996, CC Docket No. 96-98, 11 FCC Rcd 15499 (1996) (Local Competition Order).

[3] While the FCC initially defined forward-looking economic costs to be composed of two separate components, "total element long run incremental costs" and "a reasonable allocation of forward-looking common costs," the acronym "TELRIC" used to describe this cost concept has come to incorporate both the forward-looking incremental and common costs together. Thus, in the balance of this paper, I shall refer to the FCC's overall cost concept as "TELRIC."

[4] I have omitted some of the detail contained in the FCC's pricing specifications that is extraneous to the issues at hand.

The first of these objections was affirmed by the Eighth Circuit in 1997.[5] The FCC appealed this decision to the Supreme Court, and in January 1999, the Supreme Court reversed the Eighth Circuit, ruling in Iowa Utilities Board that the FCC did have authority under the Act to promulgate national pricing rules.[6]

The ILECs then returned to the Eighth Circuit. This time, they argued that the particular TELRIC rules promulgated by the FCC were unlawful because they required prices to be based on the costs of a hypothetical efficient network – and therefore would not allow the recovery of the embedded costs of the ILECs' actual (presumably somewhat inefficient) networks. Although the Eighth Circuit disagreed that the Act required interconnection and UNE prices to recover the ILECs' embedded costs, it did find the FCC's TELRIC pricing rules to be unlawful because the forward-looking costs that they recovered were ones that were of a hypothetical network, and not the costs of the actual network element or interconnection that was being provided by the ILEC.[7] This decision was also appealed to the Supreme Court, and in Verizon v. FCC, the Supreme Court once again reversed the Eighth Circuit and rejected all of the ILECs' remaining allegations of illegality concerning the FCC's TELRIC pricing rules.[8] The Court found that the Telecommunications Act did not require the use of historical cost, and because the goal of Congress was to foster the competitive entry into local telephone markets, there was good reason for the FCC to adopt its TELRIC forward-looking economic cost concept.[9] Furthermore, the Court opined, the pricing rules adopted by the FCC appeared to be well within the scope of deference given to an expert agency consistent with Chevron.[10] And the Court went on to find that the FCC's TELRIC rate methodology also appeared to have been effective at realizing Congress' competitive intentions for the Telecommunications Act.[11]

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[5] Iowa Utilities Board v. FCC, 120 F.3d 753 (8th Circuit 1997).

[6] AT&T Corp. v. Iowa Utilities Board, 525 US 366 (1999).

[7] Iowa Utilities Board v. FCC, 219 F.3d 744 (8th Circuit 2000).

[8] Verizon Communications v. Federal Communications Commission, 535 US 467 (2002).

[9] 535 US at 488 ("Under the local-competition provisions of the Act, Congress called for ratemaking different from any historical practice, to achieve the entirely new objective of uprooting the monopolies that traditional rate-based methods had perpetuated"); 535 US at 489 ("Congress passed a ratesetting statute with the aim not just to balance interests between sellers and buyers, but to reorganize markets by rendering regulated utilities' monopolies vulnerable to interlopers"); and 535 US at 489 ("The Act thus appears to be an explicit disavowal of the familiar public-utility model of rate regulation … in favor of novel ratesetting designed to give aspiring competitors every possible incentive to enter local retail telephone markets, short of confiscating the incumbents' property").

[10] Chevron USA, Inc. v. Natural Resources Defense Council, Inc., 467 US 837 (1984).

[11] 535 US at 507, 508 ("the incumbents [argue] … that the FCC's choice of TELRIC … was unreasonable as a matter of law because other methods of determining cost would have done a

Despite the Supreme Court's approval of the FCC's currently standing TELRIC rules for the pricing of interconnection and UNEs, the FCC has issued a *Notice of Proposed Rulemaking* to reevaluate these rules with an eye towards making them more representative of the costs of existing networks rather than those of hypothetical networks.[12] Although this *Notice* contains numerous proposals seeking this end, the following analysis will focus on just one of these proposals: whether the costed network should hew to its previous specifications ("long-run incremental cost … should be measured based on use of the most efficient telecommunications technology currently available and the lowest cost network configuration, given the existing location of the incumbent's wire centers") [47 CFR § 51.505(b)(1)]; or whether new FCC pricing rules "should define the relevant network as one that incorporates upgrades planned by the incumbent LEC over some objective time horizon (*e.g.*, three or five years), as documented, for example, in an incumbent LEC's actual engineering plans."[13]

This proposal for the definition of relevant network costs does not appear to be well-founded from the point of view of efficient pricing and welfare economics. It is beyond question that for prices to be economically efficient, they must be based on the pertinent incremental costs.[14] Thus, if the policy desire is for entry, investment and

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better job of inducing competition. Having considered the proffered alternatives and the reasons the FCC gave for rejecting them, … we cannot say that the FCC acted unreasonably in picking TELRIC to promote the mandated competition") (citations to *Local Competition Order* and FCC rules omitted). 535 US at 516, 517 ("At the end of the day, theory aside, the claim that TELRIC is unreasonable as a matter of law because it simulates but does not produce facilities-based competition founders on fact. The entrants have presented figures showing that they have invested in new facilities to the tune of $55 billion since the passage of the Act (through 2000) … . The FCC's statistics indicate substantial resort to pure and partial facilities-based competition among the three entry strategies … . The incumbents do not contradict these figures, but merely speculate that the investment has not been as much as it could have been under other ratemaking approaches … . We, of course, have no idea whether a different forward-looking pricing scheme would have generated even greater competitive investment than the $55 billion that the entrants claim, but it suffices to say that a regulatory scheme that can boast such substantial competitive capital spending over a 4-year period is not easily described as an unreasonable way to promote competitive investment in facilities.") (Footnotes and citations omitted).

[12] FCC, Notice of Proposed Rulemaking, *Review of the Commission's Rules Regarding the Pricing of Unbundled Network Elements and the Resale of Service by* Incumbent Local Exchange Carriers, WC Docket No. 03-173 at ¶ 4 (released September 15, 2003) (*Notice*) ("We seek comment on an approach that bases UNE prices on a cost inquiry that is more firmly rooted in the real-world attributes of the existing network, rather than the speculative attributes of a purely hypothetical network.")

[13] *Notice* at ¶ 54.

[14] *See*, for example, Jean Tirole, *The Theory of* Industrial Organization, MIT Press, 1988 at 6-7 ("A key property of competitive equilibrium is that each good is sold at marginal cost. … When deciding whether to consume one more unit of the good, a consumer faces a price that is socially the 'right

purchase decisions to be optimal based only on immediate (*i.e.*, short-run) cost and benefit considerations, the efficient price should match the short-run incremental costs facing the supplier.[15] If the policy desire is for entry, investment and purchase decisions to be optimal based only on intermediate horizon (*i.e.*, medium-run) considerations, the efficient price should match the medium-run incremental costs facing the supplier. And if the policy desire is for entry, investment and purchase decisions to be optimal based on consideration of an indefinite horizon (*i.e.*, the long-run), the efficient price is the one that matches the long-run incremental costs facing the supplier.

Microeconomics is also very clear as to what constitute incremental costs faced over a particular time horizon. Such incremental costs include only those costs that may be incurred or avoided over the relevant period.[16] Thus, any costs that cannot be incurred or shed over the short-run must not be included in a calculation of short-run incremental cost, and, thus, reflected in a price that is intended to be efficient over the short-run. Similarly, medium- or long-run incremental costs include only those costs that may be incurred or avoided over the medium or long runs – and no additional non-incremental costs may be properly inserted into prices that are intended to guide producers or consumers to efficient consumption or supply decisions over medium or long runs, respectively.

In local telecommunications networks, huge portions of cost are immutable over the short-run (which is generally considered to be a period of less than one year). Outside plant cables and structures like poles, trenches and conduits have long lead times for installation, have negative salvage values, and have useful lives that generally range between twenty and fifty years. Thus, none of these network investments would be admitted to short-run incremental costs, save for the very small fraction of such plant assets (perhaps 5%) that may have been previously scheduled for augmentation or replacement over the upcoming year. Even central office equipment such as switches and multiplexers have useful lives of ten years or more, so less than 10% of these asset

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one' and internalizes the cost of producing this extra unit. This is part of the intuition behind the Pareto optimality of competitive equilibrium."); or more generally, *see* Walter Nicholson, *Microeconomic Theory*, 2nd Ed., Dryden Press, 1978, at Chapters 18-20 on general equilibrium and welfare.

[15] This assumes that there are no externalities associated with the provision of interconnection or UNEs. To the extent that positive externalities exist from interconnection and increased competitive entry (*e.g.*, greater telephone subscribership, reduced political influence of large government-regulated entities, *etc.*), it may be optimal to set interconnection and UNE prices below the relevant private incremental costs. *See*, Tirole, *op. cit.* at 7 and 404-406; or Nicholson, *op. cit.* at 568-571.

[16] *See*, Nicholson, *op. cit.* at Chapter 8; and at 262-263 ("If firms are strict profit-maximizers, they will make decisions in a 'marginal' way. The entrepreneur will perform the conceptual experiment of adjusting those variables *that can be controlled* until it is impossible to increase profits further.") (emphasis added)

investments would be incremental over the short-run. Hence, ILEC short-run incremental costs (and resulting interconnection and UNE prices) would consist, almost completely, of the ILEC's ongoing operating and maintenance expenses – with only a tiny additional contribution for capital plant costs.

As a result of the foregoing conditions, efficient short-run incremental costs tend to be relatively simple to calculate. One aggregates the ongoing operating and maintenance expenses of the firm (subject to proof that the firm is both capable and incented to operate efficiently), and adds to these expenses the small amounts of capital that have already been irreversibly contracted for installation over the next several months. The resulting sum is the firm's short-run incremental cost. Note that these components of short-run incremental cost should match reasonably closely to the corresponding cost categories recorded in the ILEC's books of account for the relevant period – assuming these books are categorized to provide the cost granularity specified above.[17]

In particular, short-run incremental costs should be fairly immune to inaccuracies arising from speculation as to how the relevant network assets should be configured and costed. This is because the network configuration is what it currently is, subject only to already obligated (and presumably in-process) adjustments. But more importantly, the cost of this network and its minor adjustments should also be known quite precisely. Operations and maintenance costs are typically quite stable from one year to the next, and the only capital costs of relevance are those for irreversibly contracted purchases over the next several months – which should be verifiable through review of the controlling purchase contracts, and auditable by reference to payment ledgers. In particular, no speculative valuation of non-incremented capital assets (which constitute 95% or so of all ILEC assets) is required because capital costs associated with such assets are simply not an admissible component of short-run incremental costs.

Opposite from the short-run is the long-run time horizon. Economists define the "long-run" as the time horizon over which all assets and required expenditures become variable. Because of the fixity and long life of substantial portions of local telecommunications plant, the long run is generally estimated to be a period of, roughly, thirty to fifty years. Because practically all of an ILEC's network will be replaced over

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[17] Unfortunately, this is rarely the case. The accounting books of ILECs employ cost and plant categories that agglomerate multiple services in addition to interconnection and UNE services. In addition, these costs are rarely reported at a level of geographic specificity that is more granular than a particular state. *See* discussions provided in Mark T. Bryant, "TELRIC Models Properly Account for Real World Costs" and Janusz A. Ordover, "Alternatives to TELRIC are Inferior as Bases for UNE Pricing," in *Pricing Based on Economic Cost*, essays submitted *ex parte* to the FCC in WC Docket No. 03-173 by Joan Marsh, AT&T (filed December 8, 2003); and available at: http://gullfoss2.fcc.gov/prod/ecfs/retrieve.cgi?native_or_pdf=pdf&id_document=6515292437 and http://gullfoss2.fcc.gov/prod/ecfs/retrieve.cgi?native_or_pdf=pdf&id_document=6515292438

this period of time, all of the costs of this network (including the capital carrying costs for all of its assets) are incremental over this horizon.[18] Because the long-run provides the firm with the opportunity to adjust all of its asset selections, there is no reason to expect current embedded network configurations to constrain the carrier's choice as to its long-run network. And lacking any constraint from the current configuration, it makes no sense to assume that the ILEC's choice of its long-run network will be anything other than the most efficient configuration that it can currently imagine.

Because the long-run cost concept assumes an ILEC has freedom to choose an optimally configured network without being limited by its historical network choices, there is no need to determine either what the ILEC may have expended historically to acquire its current network, or to determine how much the ILEC would need to expend today to reproduce its current network. Rather, the sole costing task is to determine how much the ILEC would need to expend over the long run to engineer, install and operate an optimal network.[19]

In between the short and long runs are intermediate planning periods. Costs that are incremental over such periods include both ongoing operations and maintenance expenses, as well purchase costs for those capital assets that will be acquired over the relevant medium-run period. Again, all non-incremental costs – such as those related to depreciation and return on pre-existing capital assets, constitute no part of any economic definition of medium-run incremental costs.

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[18] Current FCC TELRIC rules provide for two simplifying exceptions to pure long-run costing. These are given in the requirements of 47 CFR § 51.505(b)(1) that "long-run incremental cost … should be measured based on use of the most efficient telecommunications technology currently available and the lowest cost network configuration, given the existing location of the incumbent's wire centers." Thus, while pure long-run costs should incorporate the costs of technologies that may not exist today, but are anticipated to arise in the future, TELRIC incorporates only the current cost of the most efficient technology that is currently available. By so doing, TELRIC restricts substantially the amount of technological speculation required to develop its measure of long-run costs. In addition, TELRIC's assumption that wire centers should be assumed to remain fixed in their current locations recognizes both that the land these wire centers occupy is an asset of indefinite life that does not depreciate away and need to be replaced, and that wire center boundaries are key to defining the geographical extent of franchised ILEC service areas and rate structures. While this latter assumption (called "scorched node") reduces significantly the ability of TELRIC to represent the most efficient level of long-run costs and raises substantially computed interconnection and UNE prices, it simplifies the cost calculation process and reduces greatly the scope of admissible speculation concerning long-run local network configurations.

[19] Note that because the long run allows the ILEC unconstrained flexibility to select the most efficient network configuration, it is anti-economic to presume that over the long run the ILEC would choose to purchase, install and operate any network not meeting the highest available standard of efficiency.

This exclusion of non-incremental fixed assets from the definition of medium-run costs is not an optional characteristic. For the medium run concept to have any foundation for efficient pricing, it must be defined consistently with respect to what costs are controllable by the firm over the relevant period. If a firm is seeking to optimize its decision-making over a horizon of just several years, it looks only to what it expects to expend over these several years. Given that it may already have a particular network structure in place, it will choose the incremental adjustments to this network that minimize its forward-looking costs over this period assuming that it will continue to enjoy use of its sunk embedded network assets at no incremental cost.

Thus, while over the long run, it may be patently uneconomic to serve customers using an antiquated 192-line SLC-5 digital loop carrier ("DLC") system with analog interfaces into a local switch; because such a system may pre-exist in a customer's neighborhood, it is more efficient for the ILEC to continue to use this pre-existing antiquated technology over the medium run (even if it must incur higher operating and maintenance expense to use the older system than may be entailed with the new system) than to pay the incremental capital costs of replacing the old SLC-5 system with a modern GR-303 DLC. This is simply because the medium-run incremental cost of continued use of the old technology DLC is cheaper because it entails little or no new capital purchases – even though the old technology's long-run incremental cost may be far higher. But in any event, what it once cost the ILEC to purchase the SLC-5 system, or what it might cost today to replace it with a DLC system of equivalently low efficiency, is irrelevant.

3. Adjusted embedded network pricing proposals

Despite the unequivocal principle of microeconomics that non-incremental costs do not inform efficient prices, and despite the unequivocal principle of business analysis that unalterable costs incurred in the past should be disregarded in current strategic decision-making and pricing, it has been suggested that wholesale prices for interconnection and UNEs should be based on a medium-run cost concept that combines cost forecasts for network segments that will be incremented over the next several years with a revaluation of the embedded network components that will not be incremented over these next several years.[20]

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[20] *See* Notice at ¶¶ 53-61 and SBC Comments at 31 (stating that "SBC's [actual forward-looking cost] approach asks how much it would cost to replace network assets in the technological form they will collectively take at the midpoint of an additional three-year period of expected facilities upgrades documented in an ILEC's actual engineering plans."); or Verizon Comments at 35-39 (stating that "the ILEC's costs should be based on the available information concerning its existing network configuration … as well as the actual investments it expects to make going forward. … Ideally, the planning period should be as long as the rates that are being set are expect to be in effect. A reasonable time frame is approximately three years.")

This proposal faces challenges both from an economic perspective as well as a practical perspective. First, because this proposal is to develop prices on costs that are not incremental to the ILEC over the relevant time horizon, it has no basis in economics. Indeed, prices developed on such a non-incremental basis can be shown to be profoundly inefficient. An example is, perhaps, the most instructive.

In the mid-1980s, the Williams Companies owned a number of gas pipelines that had become unused. Williams decided to create a subsidiary (Williams Telecommunications Group, later WilTel) to string fiber cable through these pipelines and enter the long-haul telecommunications business.[21] But what set of costs informed Williams' pricing of its wholesale and retail fiber communications services? Was it just the cost of the fiber cable placement in the pre-existing pipelines – a cost akin to short-run incremental cost? Was it the cost of placing an optimized network of fiber cables largely buried directly in the ground – as Sprint was doing contemporaneously (*i.e.*, long-run efficient incremental cost or TELRIC)? Or was it the cost of reproducing Williams' thousands of miles of unused gas pipeline in their existing locations plus the cost of placing fiber cable through these pipelines (the ILECs' concept of "actual" forward-looking cost)?

Of course, Williams' chosen pricing lay somewhere between the first two of these cost calculations. Williams certainly would not have placed its fiber cables if it could not expect to recover the immediate incremental costs of this fiber placement.[22] And if Williams chose to price above the costs being incurred by Sprint (TELRIC), it could not have hoped to attract customers to its services – especially since it was a *de novo* entrant into telecommunications without a brand name or base of telecommunications customers. In contrast, the cost of reconstructing Williams' "actual" network technology (fiber cables placed in gas pipelines) in its pre-existing configuration would have exceeded vastly either the short- or long-run incremental costs associated with long-haul fiber optic transmission.[23] And pricing based on this measure of "adjusted embedded

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[21] *See* http://www.williams.com/about/history.asp ("Williams' ingenuity provided the foundation for modern-day telecom networks when it ran fiber-optic cable through decommissioned pipelines.")

[22] Williams reported $28 million in capital expenditures to build its first 1000 miles of fiber optic line in 1985 (Michael E. Porter, Monitor Company, Inc., *Competition in the Long Distance Telecommunications Market: An Industry Structure Analysis*, 1990, at 22 and Exhibit 17.) This translates into capital costs of $5.30 per foot – a sum adequate only to account for the purchase and placement of fiber cable in the mid-1980s, and not enough to account for the cost of the physical pipeline structure or its right-of-way.

[23] Modern pipeline construction costs are typically in the range of $500,000 to $1.5 million per mile, or $95 to $285 per foot, with lower-end values being more prevalent in earlier years. *See* Warren R. True, "Special Report on Pipeline Economics," *Oil & Gas Journal*, September 8, 2003, pp. 60-81. These pipeline costs, of course, vary widely depending on the size of the pipeline and

network costs" or "actual forward-looking costs" would have been folly. Because Williams' pipelines were already "sunk," the short-run (or even medium-run) incremental cost of their use was next to nothing.[24] And because the long-run incremental cost of burying fiber in an optimized network configuration is so much less than the cost of reconstructing a historically designed pipeline configuration and placing fiber cables in these pipelines, the latter cannot represent efficient cost levels that should guide economic pricing.

This example provides three important instructions concerning efficient business decisions and pricing. First, it was efficient for Williams to use these decommissioned gas pipelines for long-haul fiber optic cables because they were pre-existing, sunk assets, and could be employed as cable structure without generating any incremental cost. Second, because Williams could use these pipelines for no incremental cost beyond that of placing the cables, it was efficient and incrementally profitable for Williams to price its fiber telecommunications services at any level between its short-run incremental cost (fiber cable placement) and its long-run incremental cost (burying new cables on new, optimized routes). Third, if instead of pricing based on these calculations of its incremental costs, Williams had determined to price based on its cost of fiber cable placement in these pipelines plus the cost of reconstructing the gas pipelines used to hold these cables, it likely would have attracted no telecommunications customers.[25]

It is easy to understand the unfortunate consequences that would have resulted if Williams had determined to use this inefficient, uneconomic pricing strategy. First, potentially productive, already purchased, sunk resources (Williams' decommissioned pipelines) would have continued to lie fallow. Second, Williams would have foregone the profit that it earned from telecommunications service revenues that exceeded its incremental costs of placing fiber in these decommissioned pipelines. And finally, customers would have been deprived of the opportunity to purchase

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its location. Buried or underground fiber costs only approach these pipeline cost levels in the most urban of environments (*e.g.*, Manhattan), and would never come within even an order of magnitude of pipeline costs in the rural environments that characterize the vast majority of long-haul fiber routes. *See*, FCC, Tenth Report and Order, *Forward-Looking Mechanism for High Cost Support for Non-Rural LECs*, CC Docket Nos. 96-45 and 97-160 at Appendix A (released November 2, 1999).

[24] This is only to a first approximation. Williams would have faced incremental opportunity costs of using these pipelines if they had profitable alternative uses. But because using them for gas transmission was no longer profitable, the opportunity cost of using them for fiber was likely close to negligible.

[25] Note that it likely matters little whether Williams incorporates the "cost" of these pipelines either at its historic embedded level (old ILEC position), or at the current level necessary to reproduce the pipelines (new ILEC position). Both of these measures would compute a cost that is not an incremental cost to Williams, thus is not properly loaded into any efficient economic price.

telecommunications services that they valued in excess of society's (or Williams') incremental cost of supplying them. Such a state of affairs represents the very definition of economic inefficiency – and all would result from a determination to charge prices that exceed pertinent incremental costs. Thankfully, because the market for fiber telecommunications services in the mid-1980s was effectively competitive (i.e., multiple carriers, no significant or asymmetric barriers to entry, etc.), Williams did not seek to charge prices in excess of its incremental costs.[26] As a result, Williams successfully entered the long-haul telecommunications market and was a valued supplier of competitive services.[27]

Nonetheless, despite the patent inefficiency of pricing to recover contrived measures of non-incremental costs, such a method is at issue in the FCC's instant proceeding. The analysis presented subsequently in this paper will abstract from the unwisdom of "adjusted actual network" or "actual forward-looking" cost pricing schemes on economic efficiency grounds, and instead, simply investigate whether it is possible for such schemes to be implemented reliably.

4. Implementation of adjusted embedded network pricing

To implement a method of adjusted embedded network pricing, the regulator must be able to calculate both a current value for the ILEC's embedded assets that will not be incremented over the planning period and an estimated "forward-looking" value for plant that will be incremented over the planning period. Although the latter calculation is the focus of the following empirical analysis, I discuss briefly the implementation challenges imposed by the former.

It matters little whether a regulator seeking to implement a method of medium-run adjusted embedded network pricing chooses to value pre-existing plant that will remain embedded and un-incremented over this horizon either by copying the historically-paid cost of this plant, or by attempting to calculate the current cost of reproducing this plant. Neither method will yield a value suitable for incorporation into an efficient price, and neither method can claim to be a more suitable proxy for the true

[26] If Williams had been an unregulated carrier in a market position similar to that faced by the ILECs today (pre-existing, near monopoly base of customers, significant and asymmetric barriers to entry by new competitors), Williams likely would have sought to charge a price in excess of its incremental costs. Of course, economics teaches us that despite the profits such above-cost pricing can return to a firm with monopoly power, prices above incremental costs are inefficient and degrade the overall performance of the economy.

[27] Ten years later in 1995, Williams sold its original fiber optic business to LDDS – a precursor of WorldCom – for $2.5 billion. Williams' more recent forays into telecommunications in the turbulent years since the Telecommunications Act have been less successful. See reference in note 21, supra and http://www.williams.com/investors/wmb/annual/95annual/confist.html .

forward-looking economic cost of such plant. Rather, either method will deviate from true forward-looking economic cost or from each other depending on: (1) whether the plant in question has been subject to relative cost inflation (such as might characterize civil engineering costs) or relative cost deflation (such as might characterize electronics costs); (2) whether the ILEC had irresistible incentives to engineer and procure efficiently at the time when the plant was designed and installed; and (3) whether technological change has developed network equipment, practices and configurations that are more efficient than those formerly available.

Regardless of the inadvisability of incorporating non-incremental costs into a price that is intended to be efficient, if any ratemaking methodology is to be admissible for regulatory use it must be feasible to implement. Whether or not this is the case will depend importantly on whether the regulator chooses to value the embedded plant at its historical embedded cost, or whether the regulator is compelled not to use historical cost in favor of a method that might reflect more current valuations. The former method is certainly implementable, assuming the ILEC has maintained books of account and plant records that are granular to the level necessary for pricing. As noted earlier, this is not currently the case.

Although an interconnection and UNE tariff may report only several hundred different rate elements for each ILEC in a state, each of these prices is itself the compilation of a myriad of cost elements. For example, the rate for a UNE loop not only varies by loop type, conditioning and geographical zone within a state, but is itself comprised of many components: network interface device ("NID"), drop wire, terminal, distribution cable, serving area interface, DLC remote terminal, plug-in cards, feeder cable, DLC host terminal, *etc.* In turn, each of these components represents a collection of further sub-components. A drop wire is comprised of a physical cable, the structure (*e.g.*, trench, conduit or poles) that carries it from the NID at the customer premises out to the distribution cable terminal at the street, the splicing connectors and the embedded labor to connect and install these pieces of equipment; and so on. Currently, ILEC records are not categorized to the level of granularity necessary to build up the complete embedded cost of a particular UNE.[28] Nevertheless, if ILECs were ordered to overhaul and enhance their current accounting and other record-keeping systems to achieve this necessary standard of granularity, the historical costs of an ILEC's embedded plant associated with a particular UNE should be ascertainable.[29]

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[28] *See* note 17, *supra*.

[29] This presumes that the ILECs will also reform their accounting systems to improve the fidelity with which these systems track the plant quantities and costs that these systems are intended to measure. In a recent audit of the Regional Bell Operating Companies' ("RBOCs") property records detailing their attested holdings of hard-wired central office equipment, the FCC found that a large fraction of this equipment was "missing" from its stated wire center location. *See* FCC Releases Audit Reports on RBOCs' Property Records, Report No. CC 99-3, 1999 WL 95044

The challenge in determining the current cost of an embedded network is likely to be more daunting. Although the original cost of each piece of network equipment may be available from the ILEC's accounting books (subject to the caveats listed above), the regulator faces a second task of determining what it might cost today to re-acquire and install each network component. Given the pace of technical change and the fact that much of the ILECs' embedded network dates from twenty or more years in the past, current price analogs may be nonexistent.[30] Whole vintages of equipment are no longer generally available, or are currently transacted only for scrap purposes. This may be due to technological improvements that have rendered older equipment obsolete (*e.g.*, analog switches) or health and safety regulations that now prohibit the use of certain equipment (*e.g.*, telephone poles treated with creosote preservative). Thus, the regulator will be faced with large inventories of in-place equipment for which there is no sensible reproduction cost. In these instances, either the cost of such equipment would need to be ignored, or hypothesized.[31] And without any necessary grounding in efficiency, these hypothesized values would be little more than arbitrary – and likely far in excess of current costs to replace efficiently the capabilities provided by the embedded network. Because of the arbitrary nature of the ILEC-proposed methodologies for valuing embedded plant, prior empirical analysis of the likely accuracy of these valuation methods is impossible.

(FCC, February 25, 1999) and FCC, *Second Report and Order* in CC Docket No. 99-137 and *Order* in CC Docket No 99-117 and AAD File No. 98-26, 16 FCC Rcd 4083 (released November 7, 2000) (*Audit Report*). A similar audit of GTE's property records by the FCC and the regulatory commissions of Arkansas, Missouri, Nebraska, Ohio and Pennsylvania found equally alarming equipment shortages. (*Audit Report* at ¶¶ 8-10 and accompanying footnotes) As a result of these accounting record deficiencies, the FCC directed its Common Carrier Bureau "to work with the RBOCs to evaluate and improve the accuracy of their property records and accounts … ." (*Audit Report* at ¶ 13) I am not aware of any actions or progress that the FCC or the RBOCs have achieved or reported in implementing this directive.

[30] At an average depreciation rate of 7.4%, the economic life of an average asset in the RBOCs' networks is 13.5 years. *See* note 32, *infra*. Analysis of historical rates of additions to and retirements from RBOC telecommunications plant suggests that the most cable and wire facilities (which constitute the RBOCs' largest plant accounts) remain physically in their networks for thirty years or more. *See* Declaration of Richard B. Lee attached to AT&T *Comments* in WC Docket No. 03-173 at 12 (filed December 16, 2003).

[31] *See* SBC *Comments* at 27 (stating that "UNE rates set under this [forward-looking actual cost] approach would reflect the present cost of building and maintaining the ILEC network as it will be constituted (excluding any obsolete facilities) at the midpoint of a three-year 'planning period' of network evolution … ."); and Exhibit A, "The Economics of UNE Pricing," by SBC affiants Debra J. Aron and William Rogerson at 43 ("To deal with the fact that some types of equipment used in the network are no longer commercially available, this rule would have to be modified to allow for functionally equivalent equipment that is currently available to be substituted for equipment that is no longer available.")

More amenable to empirical analysis is the rump portion of the ILECs' "actual forward-looking cost" concept dealing with forecasted changes to the embedded capital plant. Although the proposed three to five year time horizon permits this piece to capture as forward-looking incremental only those costs pertaining to the 21% to 32% of total plant that may actually be added or replaced during this period, this horizon is as far as the ILECs and FCC suggest should be scanned for cost development purposes.[32]

5. Empirical analysis of forecast accuracy

The following analysis examines past forecasts of capital expenditures by the RBOCs, and through the prism of history, evaluates how well these forecasts have succeeded at estimating accurately future capital expenditures. The data are taken from quarterly earnings reports, investor bulletins, or Securities and Exchange Commission ("SEC") 10K or 10Q reports published by the RBOCs. Typically, an RBOC's fourth quarter earnings report details its achieved level of capital expenditures for the just-completed calendar year and provides its first forecasts for its expected level of capital expenditures over the upcoming calendar year. These fourth quarter reports are published one or two months after the close of the quarter in January or February. RBOCs also usually update their initial calendar-year-ahead forecasts in their first, second and third quarter financial reports. The RBOC may state these capital expenditure forecasts either in point (single value) form, or by providing a range of expected values.

Securities laws require that the information provided to investors in these financial reports be the most accurate known to the firm. The 10K and 10Q reports provided to the SEC must be certified as correct by both the chief executive and chief financial officers of the firm, and these certifiers are subject to severe personal criminal and civil penalties if these reports make any knowing misrepresentations of the company's financial circumstances.[33] Thus, we assume that the capital expenditure forecasts presented in these reports represent the companies' best estimates.

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[32] Over the years since the 1996 Telecommunications Act was passed, the RBOCs have filed Automated Reporting Management Information System ("ARMIS") reports to the FCC listing depreciation and amortization expense that has averaged, roughly, 7.4% of the their Total Plant In Service (data available from the FCC's ARMIS 43-02 Uniform System of Accounts report at: http://svartifoss2.fcc.gov/eafs/adhoc/table_year_tab.cfm?reportType=4302). Thus, the fraction of the RBOCs' total plant that may need to be replaced ranges from 20.6% over three years to 31.9% over five years.

[33] Current requirements for certification of the accuracy of information contained in financial statements and penalties for knowing false certifications are provided in Sections 302 and 906 of the Sarbanes-Oxley Act of 2002 (available at: http://www.law.uc.edu/CCL/SOact/soact.pdf) and in the SEC rules implementing this Act (available at: http://www.sec.gov/news/press/2003-39.htm). SEC rules in effect prior to Sarbanes-Oxley also required truthful financial disclosures

Tables 1a, 1b, 1c and 1d provide, quarter by quarter, the forecasted capital expenditures and the realized capital expenditures of BellSouth, Qwest, SBC and Verizon. Qwest's figures are for its total holding company. The figures presented for BellSouth and SBC exclude the wireless subsidiaries of these firms. The figures presented for Verizon focus strictly on its domestic wireline operations.

The first column in these tables lists the quarter when the capital forecast was made. The next three columns provide the company's forecast for its capital expenditures over the target calendar year ("CY"). If the company provides only a point forecast, its value is entered in the "Mid" column. If the company provides a forecast range, the low and high values of the range are entered; and the average of the low and high is computed and entered in the "Mid" column.[34] The levels of achieved capital expenditures are entered in the fifth and sixth columns. The first of these two columns provides the expenditures reported for the particular quarter, the second reports this expenditure figure on a calendar year to date ("YTD") basis. Columns seven and eight compute the ex post accuracy of these capital expenditure forecasts. Column seven provides the dollar error in the company's full CY forecast as of each particular quarter. Column eight provides the corresponding percentage error of the forecast.

The average percent accuracy of the firm's CY forecasts is computed immediately below columns seven and eight. These forecast error averages are computed in two different ways. The first column computes an average of the absolute values of the percent forecast errors. The second column calculates an average of the squared percent forecast errors using the root mean squared ("RMS") statistical computation technique.[35] These averages are computed both for all available forecasts, as well as for just the 1-quarter-ahead forecasts, the 2-quarter-ahead forecasts, the 3-quarter-ahead forecasts, and the 4-quarter-ahead forecasts.

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in company statements and reports, but may have lacked the severe personal financial and criminal penalties for violation that are provided by Sarbanes-Oxley.

[34] Beginning with its forecasts for 2003, instead of providing a direct forecast of its capital expenditures, BellSouth projects a ratio of its capital expenditures to its total operating revenue. Because BellSouth continues to provide forecasts for its total operating revenue, it is possible to generate the implied forecasts for its levels of capital expenditure.

[35] Each of these measures of average error is relevant for the purpose of evaluating the accuracy of interconnection and UNE pricing. To the extent that CLECs are reasonably risk-neutral, absolute error may be the more relevant metric because it "values" the first percentage point of error the same as the second, third or nth percentage point of error. But to the extent that capital markets are not willing to provide unlimited CLEC financing, or that bankruptcy imposes substantial deadweight transactions costs, large percentage errors may be of greater relative concern than small percentage errors. If this is the case, then the squared error metric may be more relevant because it "values" the nth percentage point of error less than the (n+1)th percentage point of error.

Table 1a shows that the average absolute error over all of BellSouth's available forecasts is 10.8%, and its RMS error is 16.5%. When the calculation is restricted to just the 1-quarter-ahead forecasts, the average absolute error is 4.1% and the RMS error is 5.0%. Two quarters out, BellSouth's forecasts degrade to 5.2% average absolute error and 6.8% RMS error. Three quarters out, the corresponding forecast errors are 17.4% and 19.9%. Four quarters ahead, BellSouth's average absolute forecast error is 16.4% and its RMS error is 24.8%. Tables 1b, 1c and 1d show similar figures for Qwest, SBC and Verizon. Each of these firms' capital expenditure forecasts show substantial and increasing error as the period ahead increases from 1 to 4 quarters. Just 4 quarters out, average forecast error typically reaches 20% or more. Figures 1a, 1b, 1c and 1d provide graphical depictions of the accuracy of each of the RBOCs' short-term forecasting experience.

Because of the similarity in pattern and level of the forecast errors across all four RBOCs, it is useful to pool these error observations. The results of this pooling are presented in Table 2. Over all four RBOCs and all four quarters-ahead observations, capital forecast errors average 13.3% on an absolute basis and 17.3% on an RMS basis. Their pooled 1-quarter-ahead average absolute error is 7.3% and RMS error is 9.1%. On a 2-quarter-ahead basis, the pooled average absolute error rises to 9.0% and the RMS error is 10.5%. At 3-quarters-ahead, the average absolute error is 15.9% and the RMS 18.4%. These pooled RBOC error levels mount to 21.1% and 25.9% when the forecast is made just 4-quarters-ahead. This forecast error progression is illustrated in Figure 2.

But the "actual forward-looking cost" concept proposed by the ILECs is not a 1- to 4-quarter-ahead concept, but a medium-run, three to five year-ahead concept. Furthermore, legal/regulatory mechanisms surrounding interconnection and UNE rate-setting typically require these prices to be based on record data that are at least one year old. And these prices generally remain in effect for approximately three to four years. Given this environment, it is essential that any capital spending forecasts to be used as inputs into the ILECs' proposed medium-run "actual forward-looking cost" basis for UNE or interconnection pricing extend accurately for a minimum of three to five years into the future.

I use the series of 1-, 2-, 3- and 4-quarter-ahead capital forecasts presented in Tables 1a, 1b, 1c, 1d and 2 to extrapolate the forecast errors that may be expected if capital expenditure estimates must be developed for 2, 3, 4 and 5 years ahead. There are many statistical models for such an extrapolation. Because of the percent forecast error appears to increase as a function of the lead-time in forecast, I choose simple linear regression:

$$\text{PercentForecastError}(t) = \alpha + \beta\, t + \varepsilon, \quad t = \text{quarters' of lead in forecast.}$$

For each RBOC, and for all four RBOCs together, I regress both the average absolute percent error and the RMS percent error experienced by the firm(s) for given forecast lead-times against the length of this lead-time (expressed in terms of quarters-ahead). Tables 1a, 1b, 1c, 1d and 2 display the slope and intercepts from these regressions.[36] Despite the fact that each of these ten regression estimates is developed from only four data points, their precision is quite satisfactory. Of the ten separate slope estimates, two are significant at the 1% level or better, three at the 5% level and four at the 10% level. Furthermore, the linear fits of these regressions are very good. Three of the ten regressions display R-square values between 0.95 and 1.00, two between 0.90 and 0.95, four between 0.85 and 0.90 and one between 0.80 and 0.85.

The following table summarizes the extrapolated forecast errors in RBOC capital expenditures. In addition to yearly error estimates, I also calculate the average error that would exist over 1- to 5-year-ahead estimates.[37]

Time Horizon of Forecast	Expected Percent Forecast Error				
	BellSouth ABS / RMS	Qwest ABS / RMS	SBC ABS / RMS	Verizon ABS / RMS	All RBOCs ABS / RMS
1- year-ahead	18% / 25%	25% / 27%	19% / 23%	21% / 25%	21% / 25%
2-years-ahead	38% / 54%	45% / 49%	34% / 41%	43% / 52%	40% / 48%
3-years-ahead	58% / 83%	66% / 72%	48% / 59%	65% / 80%	59% / 72%
4-years-ahead	77% / 112%	87% / 94%	63% / 77%	87% / 107%	79% / 95%
5-years-ahead	97% / 141%	108% / 117%	77% / 95%	109% / 134%	98% / 118%
1-5 year average	58% / 83%	66% / 72%	48% / 59%	65% / 80%	59% / 72%

Note, that these regression extrapolations all display the axiomatic characteristic that more distant forecasts are less accurate than nearer-term forecasts. Graphs of these regression lines are included in Figures 1a, 1b, 1c, 1d and 2. Because the four RBOCs are so similar in their forecast accuracy patterns, the subsequent analysis in this paper will be based on a simplified, conservative interpretation of the error results from the pooled forecasts. In particular, the analysis will assume that 1-year-ahead capital forecasts have

[36] Because of the my general analytic focus on the pooled forecast experience of all four RBOCs, Table 2 also reports more detailed statistical results for the pooled regressions.

[37] Interconnection and UNE rate schedules generally are set by state regulators with an expectation that they will remain in effect for three to five years. Thus, interconnection and UNE prices set pursuant to the “actual forward-looking cost” methodology will, on average, be subject to the same average error that exists in RBOC 1- to 5-year-ahead capital expenditure forecasts.

an expected error of 20%; 2-year-ahead forecasts have an expected error of 40%; 3-year-ahead forecasts, 60%; 4-year-ahead, 80%; and 5-year-ahead, 100%. Thus, for a period between 1 and 5 years in the future, the average expected forecast error will be assumed to be 60%.

6. Implications of forecast inaccuracy for pricing

The expected levels of inaccuracy in RBOC capital forecasts are likely to have a severe impact on implied levels of interconnection and UNE pricing. First, if prices are to be based on the economically-supported concept of incremental cost, errors in estimated medium-run incremental capital-related costs appear likely to average 60% or more.[38] Capital-related costs amount to about 70% of the total forward-looking cost of local telephone networks.[39] Thus, depending on how interconnection and UNE prices are constructed, forecast errors in just the capital component of local network costs could result in an expected average medium-run error of over 42% in total local network costs that would form the basis for interconnection and UNE rates. Even if prices are to be set on the basis of short-run incremental costs, capital expenditure forecasts for 1- to 2-year-ahead periods still have an expected error of, roughly, 30%. This corresponds to an expected error in short-run incremental cost pricing of 21%.[40]

Employing the ILEC-proposed medium-run "actual forward-looking cost" method limits the degree to which inaccuracy in capital forecasts infects UNE pricing – but only because the bulk of the "cost" basis for such pricing is the non-incremental costs associated with embedded plant that will not be replaced over the medium run. These latter, non-incremental costs will account for, roughly, 80% of capital costs.[41] The balancing 20% of capital costs will be subject to an average forecast error of 60%. Thus,

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[38] Forward-looking capital-related costs include depreciation of the purchase price for capital assets, payment of a return to the financiers of this capital, payment of income and excise taxes associated with this capital to government authorities, and payment of the costs to maintain, operate and repair this capital.

[39] Forward-looking models of local telephone networks (such as the FCC's Synthesis Model adjusted to report UNE costs) generally find that capital-related costs amount to about 70% of total costs.

[40] Note, that over the year 2000 to 2003 period, RBOC forecasts of capital expenditures have consistently been overestimates. Thus, over this period, interconnection and UNE prices would have consistently been set higher by these percentage values than actual capital expenditures would have justified, ex post. Given that RBOCs historically have tended to underforecast their demand for ratemaking purposes, the likely upwards error in the resulting interconnection and UNE prices will be even more pronounced. See note 43, infra.

[41] Based on RBOC depreciation histories discussed in note 32, supra, roughly 79% of RBOC plant will not be incremental over a three-year period and 68% over a five-year period. Thus, medium-run (1- to 5-year-ahead) non-incremental capital is, roughly, 80% of total capital.

because capital-related costs may amount to about 70% of total local UNE costs, the overall breakdown would be: 30% of costs that are non-capital-related, 56% (= 0.70×0.80) of costs that are non-incremental embedded capital plant reproduction costs, and 14% (= 0.70×0.20) of costs that are medium-run incremental capital costs – with this last category being subject to an expected error of 60%, or an overall pricing error of ±8.4% (= $0.14 \pm (0.60 \times 0.14)$).

But even these estimates of the inaccuracy and instability in interconnection and UNE pricing that would result from employing a medium-run capital expenditure forecast-based methodology are understated significantly. First, the expected forecast error is understated because in addition to forecasting total local network costs, the ILEC medium-run pricing concept also requires it to provide a medium-run forecast of expected usage demand. This is because under the ILEC "actual forward-looking costs" concept, interconnection and UNE prices would be set as the quotient of forecasted cost and forecasted demand. Thus, not only is the estimate of capital expenditure and total capital costs subject to forecast error, so is the price equation denominator of forecasted demand. Together, the combination of an uncertain cost numerator and an uncertain demand denominator will likely combine to make the price quotient even less accurately forecast.[42] Indeed, when the RBOCs were under rate-of-return regulation and were required to forecast their access minutes for tariff purposes, their year-ahead forecasts were short by a weighted average of almost 7%, and individual company forecasts were short by as much as 22%.[43]

A second reason why the foregoing analysis has understated the likely error in medium-term forecast-based interconnection and UNE prices for individual elements is because the forecast errors that this paper's analysis presents are based on each RBOC's company-wide forecasts of its capital expenditures – but interconnection and UNE prices must be developed on the basis of far more granular costs. In particular, each

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[42] This will be true so long as the capital expenditure and demand forecasts are not highly positively correlated.

[43] FCC, Memorandum Opinion and Order, Annual 1990 Access Tariff Filings, CC Docket No. 90-320 (released June 21, 1990) at ¶ 418 ("In 1987, every LEC underforecast demand, by as little as 1.04 percent to as much as 21.81 percent. Overall, the LECs underforecast 1987 CCL MOU by 16.124 million MOU, or 7.97 percent. Similarly, in 1988, all but four of the LECs underforecast demand, with the overall underforecast being 19.960 million MOU, or 8.69 percent. In 1989, the forecasts improved, with an overall underforecast of 10,305 million MOU, or 3.93 percent. However, 37 of the 42 LECs still underforecast in 1989."); and at ¶ 427 ("We have analyzed the LECs' forecasts using a combination of "report card" tests and trend analysis. … This weighting scheme allows the LECs credit for improvements they make in their forecasting methodology over time. This weighted average indicates that only one LEC has overforecast for the past three years, and that overall the LECs have underforecast by 6.91 percent.")

RBOC operates, on average, about 3500 wire centers.[44] Each wire center may be assumed to consist of about four outside plant sectors, plus its central office equipment. Thus, RBOC-wide capital forecasts reported in the foregoing data implicitly are (and for UNE rate-making purposes, may need to be) developed by aggregating the capital forecasts for each of these 17,500 (= 3500 $\times$ 5) separate costing and rate-making subdivisions. If each of a company's n (=17,500) individual subdivision forecast percentage errors have the same mean value μ and same variance, σ^2, then the standard deviation of the forecast error for each individual cost component could be as high as 132 ($\approx \sqrt{17{,}500}$) times as large.[45] Hence, the proposed medium-run "actual incremental cost" methodology will result in individual element prices whose errors are vastly less stable than even the errors in the company's overall capital forecast.

7. Concluding remarks

This paper has examined the ability of regulators to implement a methodology for pricing interconnections and UNEs based on the adjusted embedded network methodology as has been proposed by the ILECs. Such a methodology would combine forecasts of ILEC telecommunications plant adjustments and expenditures over a medium-run period of between three and five years with either the historical cost (or some synthetic re-costing to "current") of the ILECs' embedded plant that would not be subject to augmentation or replacement over this period.

While embedded network costs calculated on either a historical or re-priced basis are not properly part of the incremental cost of interconnection and UNEs that must undergird any system of economically efficient prices; the former component of forecast plant expenditures is potentially admissible for use in a medium-run pricing scheme – but only if it provides reasonably accurate and stable estimates of actually resulting

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[44] *See* FCC, *Trends in Telephone Service*, August 2003, Table 17.1 (reporting 14,352 RBOC central offices in 2002), available at: http://www.fcc.gov/Bureaus/Common_Carrier/Reports/FCC-State_Link/IAD/trend803.pdf .

[45] This result derives from one of the most basic theorems in probability and statistics, the Central Limit Theorem. This theorem states that as a sample size n from a population with a mean of μ and a variance of σ^2 becomes large, the distribution of the sample mean becomes approximately normal with mean μ and variance σ^2/n.

plant expenditures. The empirical data reported in this paper suggest that these capital expenditure forecasts are severely inaccurate – even over very short time horizons. And these data appear to constitute the best predictions available to the ILEC insiders, let alone to regulatory commission or intervener outsiders. Thus, on this basis alone, the adjusted embedded network methodology proposed by the ILECs seems not to be a wise replacement for TELRIC – regardless of whether this proposal is advisable from the point of view of efficient pricing and welfare economics.

Table 1a

BellSouth Capital Expenditures and Forecasts: 2001 - 2003
(dollar figures in billions)

Report Date	Forecast Low	Forecast High	Forecast Mid	Achieved Qtr	Achieved YTD	CY Forecast Error Dollar	CY Forecast Error Percent
	Forecast for CY 2001						
4Q2000	*$5.500*	*$6.000*	*$5.750*			-$0.247	-4.1%
1Q2001	*$5.500*	*$6.000*	*$5.750*	$1.690	$1.690	-$0.247	-4.1%
2Q2001	*$5.500*	*$6.000*	*$5.750*	$1.667	$3.357	-$0.247	-4.1%
3Q2001	*$5.500*	*$6.000*	*$5.750*	$1.367	$4.724	-$0.247	-4.1%
4Q2001				$1.273	**$5.997**		
	Forecast for CY 2002						
4Q2001	*$5.300*	*$5.500*	*$5.400*			$1.615	42.7%
1Q2002	*$5.200*	*$4.400*	*$4.800*	$1.005	$1.005	$1.015	26.8%
2Q2002	*$3.700*	*$3.900*	*$3.800*	$1.023	$2.028	$0.015	0.4%
3Q2002	*$3.700*	*$3.900*	*$3.800*	$0.835	$2.863	$0.015	0.4%
4Q2002				$0.922	**$3.785**		
	Forecast for CY 2003						
4Q2002			*$3.282*			$0.082	2.6%
1Q2003			*$2.516*	$0.631	$0.631	-$0.684	-21.4%
2Q2003			*$2.844*	$0.729	$1.360	-$0.356	-11.1%
3Q2003	*$2.844*	*$3.063*	*$2.954*	$0.764	$2.124	-$0.246	-7.7%
4Q2003				$1.076	**$3.200**		

		Percent Error Avg ABS	Percent Error RMS
All forecasts		10.8%	16.5%
1-quarter-ahead forecasts		4.1%	5.0%
2-quarter-ahead forecasts		5.2%	6.8%
3-quarter-ahead forecasts		17.4%	19.9%
4-quarter-ahead forecasts		16.4%	24.8%
Slope		0.0494	0.0723 **
Intercept		-0.0155	-0.0393
Estimated forecast errors	1	3.4%	3.3%
(at given number of quarters ahead)	2	8.3%	10.5%
	3	13.3%	17.8%
	4	18.2%	25.0%
	5	23.1%	32.2%
	6	28.1%	39.5%
	7	33.0%	46.7%
	8	37.9%	53.9%
	9	42.9%	61.2%
	10	47.8%	68.4%
	11	52.7%	75.6%
	12	57.7%	82.9%
	13	62.6%	90.1%
	14	67.6%	97.3%
	15	72.5%	104.6%
	16	77.4%	111.8%
	17	82.4%	119.0%
	18	87.3%	126.3%
	19	92.2%	133.5%
	20	97.2%	140.7%

Table 1b

Qwest Capital Expenditures and Forecasts: 2001 - 2003
(dollar figures in billions)

Report Date	Forecast for CY 2001 Low	High	Mid	Achieved Qtr	YTD	CY Forecast Error Dollar	Percent
4Q2000			*$9.500*			$1.329	16.3%
1Q2001			*$9.200*	$2.943	$2.943	$1.029	12.6%
2Q2001	*$8.800*	*$9.000*	*$8.900*	$2.616	$5.559	$0.729	8.9%
3Q2001	*$8.800*	*$9.000*	*$8.900*	$2.232	$7.791	$0.729	8.9%
4Q2001				$0.380	**$8.171**		
	Forecast for CY 2002						
4Q2001	*$4.000*	*$4.200*	*$4.100*			$1.234	43.1%
1Q2002	*$3.100*	*$3.300*	*$3.200*	$1.196	$1.196	$0.334	11.7%
2Q2002	*$3.000*	*$3.100*	*$3.050*	$0.618	$1.814	$0.184	6.4%
3Q2002	*$3.000*	*$3.100*	*$3.050*	$0.504	$2.318	$0.184	6.4%
4Q2002				$0.561	**$2.866**		
	Forecast for CY 2003						
4Q2002	*$2.200*	*$2.900*	*$2.550*			$0.445	21.1%
1Q2003	*$2.425*	*$2.940*	*$2.683*	$0.450	$0.450	$0.578	27.4%
2Q2003			*$2.500*	$0.490	$0.940	$0.395	18.8%
3Q2003			*$2.500*	$0.550	$1.490	$0.395	18.8%
4Q2003				$0.615	**$2.105**		

		Percent Error Avg ABS	RMS
All forecasts		16.7%	19.5%
1-quarter-ahead forecasts		11.4%	12.6%
2-quarter-ahead forecasts		11.4%	12.6%
3-quarter-ahead forecasts		17.2%	18.7%
4-quarter-ahead forecasts		26.8%	29.2%
Slope		0.0522 *	0.0562 *
Intercept		0.0364	0.0421
Estimated forecast errors	1	8.9%	9.8%
(at given number of quarters ahead)	2	14.1%	15.4%
	3	19.3%	21.1%
	4	24.5%	26.7%
	5	29.7%	32.3%
	6	35.0%	37.9%
	7	40.2%	43.5%
	8	45.4%	49.2%
	9	50.6%	54.8%
	10	55.9%	60.4%
	11	61.1%	66.0%
	12	66.3%	71.6%
	13	71.5%	77.3%
	14	76.7%	82.9%
	15	82.0%	88.5%
	16	87.2%	94.1%
	17	92.4%	99.7%
	18	97.6%	105.3%
	19	102.8%	111.0%
	20	108.1%	116.6%

Table 1c

SBC Capital Expenditures and Forecasts: 2001 - 2003
(dollar figures in billions)

Report Date	Forecast Low	Forecast High	Forecast Mid	Achieved Qtr	Achieved YTD	CY Forecast Error Dollar	CY Forecast Error Percent
	Forecast for CY 2001						
4Q2000			*$13.124*			$1.935	17.3%
1Q2001	*$12.000*	*$13.000*	*$12.500*	$2.807	$2.807	$1.311	11.7%
2Q2001			*$12.000*	$2.937	$5.744	$0.811	7.2%
3Q2001		*est*	*$12.000*	$2.352	$8.096	$0.811	7.2%
4Q2001				$3.093	**$11.189**		
	Forecast for CY 2002						
4Q2001	*$9.200*	*$9.700*	*$9.450*			$2.642	38.8%
1Q2002	*$8.000*	*$9.000*	*$8.500*	$1.765	$1.765	$1.692	24.9%
2Q2002		*$8.000*	*$8.000*	$1.731	$3.496	$1.192	17.5%
3Q2002		*$8.000*	*$8.000*	$1.502	$4.998	$1.192	17.5%
4Q2002				$1.810	**$6.808**		
	Forecast for CY 2003						
4Q2002	*$5.000*	*$6.000*	*$5.500*			$0.281	5.4%
1Q2003	*$5.000*	*$6.000*	*$5.500*	$0.897	$0.897	$0.281	5.4%
2Q2003	*$5.000*	*$6.000*	*$5.500*	$1.072	$1.969	$0.281	5.4%
3Q2003		*$5.000*	*$5.000*	$1.266	$3.235	-$0.219	-4.2%
4Q2003				$1.984	**$5.219**		

		Percent Error Avg ABS	Percent Error RMS
All forecasts		13.5%	16.8%
1-quarter-ahead forecasts		9.7%	11.2%
2-quarter-ahead forecasts		10.0%	11.4%
3-quarter-ahead forecasts		14.0%	16.2%
4-quarter-ahead forecasts		20.5%	24.7%
Slope		0.0365 *	0.0454 *
Intercept		0.0443	0.0453
Estimated forecast errors	1	8.1%	9.1%
(at given number of quarters ahead)	2	11.7%	13.6%
	3	15.4%	18.1%
	4	19.0%	22.7%
	5	22.7%	27.2%
	6	26.3%	31.7%
	7	30.0%	36.3%
	8	33.6%	40.8%
	9	37.2%	45.3%
	10	40.9%	49.9%
	11	44.5%	54.4%
	12	48.2%	59.0%
	13	51.8%	63.5%
	14	55.5%	68.0%
	15	59.1%	72.6%
	16	62.8%	77.1%
	17	66.4%	81.6%
	18	70.1%	86.2%
	19	73.7%	90.7%
	20	77.4%	95.2%

Table 1d

Verizon Capital Expenditures and Forecasts: 2001 - 2003
(dollar figures in billions)

Report Date	Forecast for CY 2001 Low	High	Mid	Achieved Qtr	YTD	CY Forecast Error Dollar	Percent
4Q2000			*$12.800*			$1.320	11.5%
1Q2001			*$12.000*	$3.339	$3.339	$0.520	4.5%
2Q2001			*$12.000*	$3.067	$6.406	$0.520	4.5%
3Q2001	*$11.660*	*$11.790*	*$11.725*	$2.064	$8.470	$0.245	2.1%
4Q2001				$3.010	**$11.480**		
	Forecast for CY 2002						
4Q2001	*$9.500*	*$10.000*	*$9.750*			$2.773	39.7%
1Q2002	*$8.800*	*$9.300*	*$9.050*	$1.479	$1.479	$2.073	29.7%
2Q2002	*$7.800*	*$8.000*	*$7.900*	$1.696	$3.175	$0.923	13.2%
3Q2002	*$7.380*	*$7.530*	*$7.455*	$1.548	$4.723	$0.478	6.9%
4Q2002				$2.254	**$6.977**		
	Forecast for CY 2003						
4Q2002	*$7.300*	*$7.800*	*$7.550*			$0.730	10.7%
1Q2003	*$7.300*	*$7.800*	*$7.550*	$1.286	$1.286	$0.730	10.7%
2Q2003	*$7.300*	*$7.800*	*$7.550*	$1.733	$3.019	$0.730	10.7%
3Q2003	*$6.800*	*$7.300*	*$7.050*	$1.746	$4.765	$0.230	3.4%
4Q2003				$2.055	**$6.820**		

		Percent Error Avg ABS	RMS
All forecasts		12.3%	16.4%
1-quarter-ahead forecasts		4.1%	4.6%
2-quarter-ahead forecasts		9.5%	10.2%
3-quarter-ahead forecasts		15.0%	18.4%
4-quarter-ahead forecasts		20.6%	24.7%
Slope		0.0551 **	0.0685 **
Intercept		-0.0146	-0.0268
Estimated forecast errors	1	4.0%	4.2%
(at given number of quarters ahead)	2	9.6%	11.0%
	3	15.1%	17.9%
	4	20.6%	24.7%
	5	26.1%	31.6%
	6	31.6%	38.4%
	7	37.1%	45.3%
	8	42.6%	52.2%
	9	48.1%	59.0%
	10	53.6%	65.9%
	11	59.1%	72.7%
	12	64.6%	79.6%
	13	70.1%	86.4%
	14	75.7%	93.3%
	15	81.2%	100.1%
	16	86.7%	107.0%
	17	92.2%	113.8%
	18	97.7%	120.7%
	19	103.2%	127.6%
	20	108.7%	134.4%

Table 2

Pooled RBOC Capital Expenditures and Forecasts: 2001 - 2003
(dollar figures in billions)

		Percent Error Absolute	Percent Error RMS
All forecasts		13.3%	17.3%
1-quarter-ahead forecasts		7.3%	9.1%
2-quarter-ahead forecasts		9.0%	10.5%
3-quarter-ahead forecasts		15.9%	18.4%
4-quarter-ahead forecasts		21.1%	25.9%
Slope		0.0483 **	0.0585 **
Intercept		0.0127	0.0134
Estimated forecast errors	1	6.1%	7.2%
(at given number of quarters ahead)	2	10.9%	13.0%
	3	15.7%	18.9%
	4	20.6%	24.7%
	5	25.4%	30.6%
	6	30.2%	36.4%
	7	35.1%	42.3%
	8	39.9%	48.1%
	9	44.7%	54.0%
	10	49.5%	59.8%
	11	54.4%	65.6%
	12	59.2%	71.5%
	13	64.0%	77.3%
	14	68.9%	83.2%
	15	73.7%	89.0%
	16	78.5%	94.9%
	17	83.3%	100.7%
	18	88.2%	106.6%
	19	93.0%	112.4%
	20	97.8%	118.3%

Regression on: **Absolute Percent Error**

Regression Statistics	
Multiple R	0.9778
R-Square	0.9561
Adj R-Square	0.9342
Std Error	0.0164
Observations	4

ANOVA

	df	*SS*	*MS*	*F / Sig*
Regression	1	0.0117	0.0117	43.5992
Residual	2	0.0005	0.0003	0.0222
Total	3	0.0122		

	Coeffs	*Std Err*	*t Stat*	*P-value*
Intercept	0.0127	0.0200	0.6318	0.5921
Slope	0.0483	0.0073	6.6030	0.0222

Regression on: **RMS Percent Error**

Regression Statistics	
Multiple R	0.9668
R-Square	0.9346
Adj R-Square	0.9019
Std Error	0.0244
Observations	4

ANOVA

	df	*SS*	*MS*	*F / Sig*
Regression	1	0.0171	0.0171	28.5908
Residual	2	0.0012	0.0006	0.0332
Total	3	0.0183		

	Coeffs	*Std Err*	*t Stat*	*P-value*
Intercept	0.0134	0.0299	0.4473	0.6984
Slope	0.0585	0.0109	5.3470	0.0332

Figure 1a **BellSouth Capital Expenditure Forecasting Error**

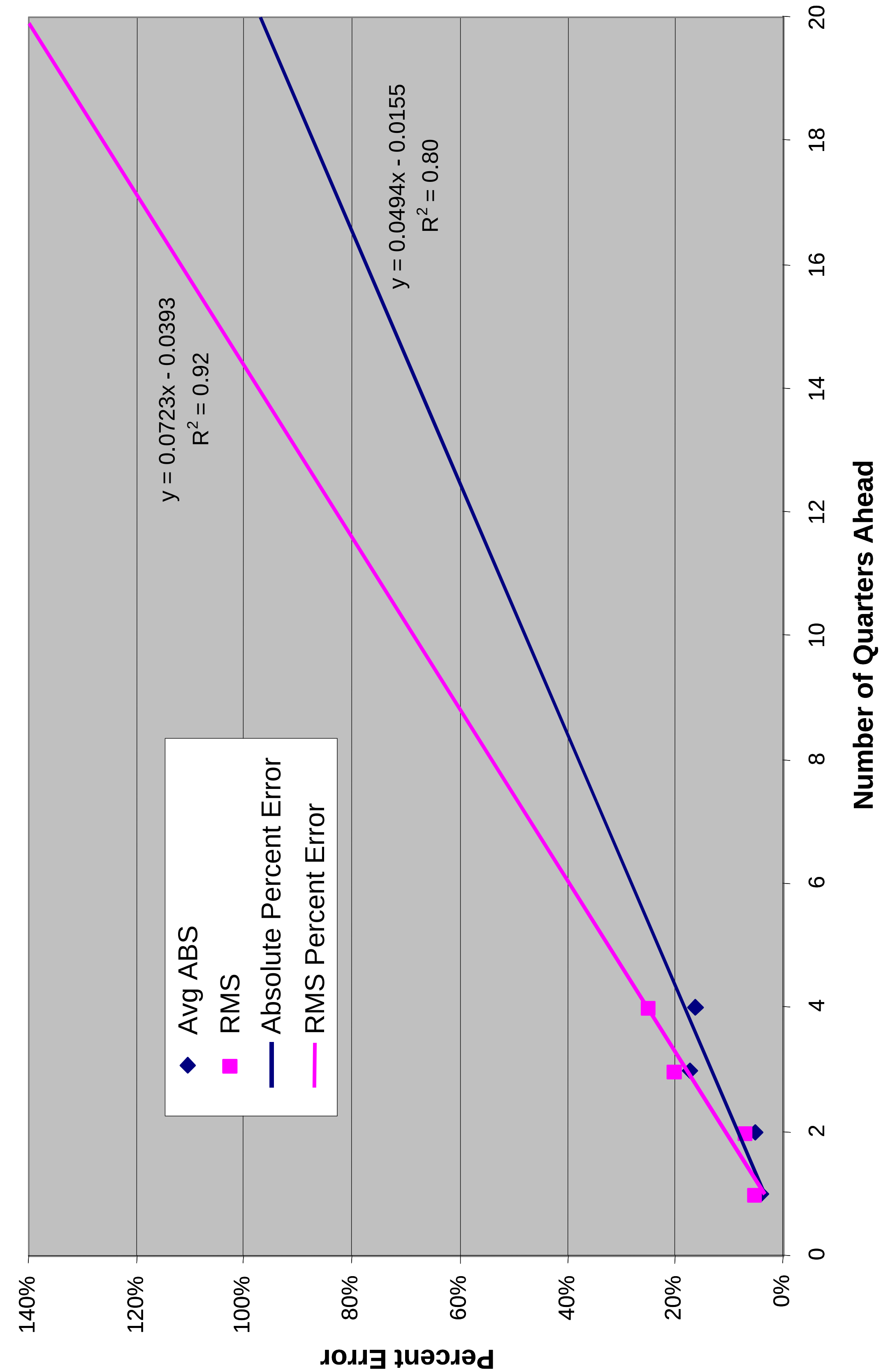

Figure 1b **Qwest Capital Expenditure Forecasting Error**

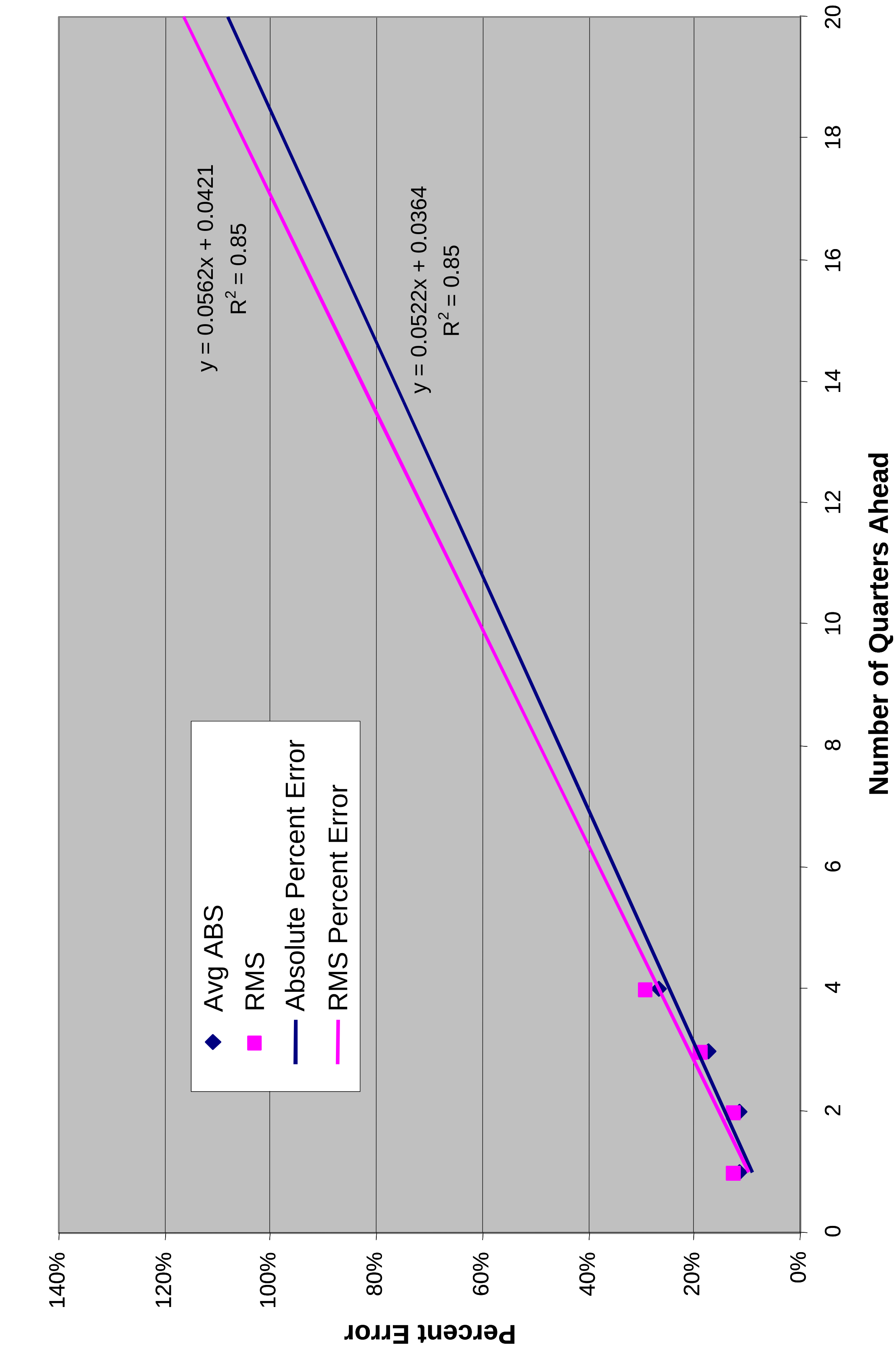

Figure 1c

SBC Capital Expenditure Forecasting Error

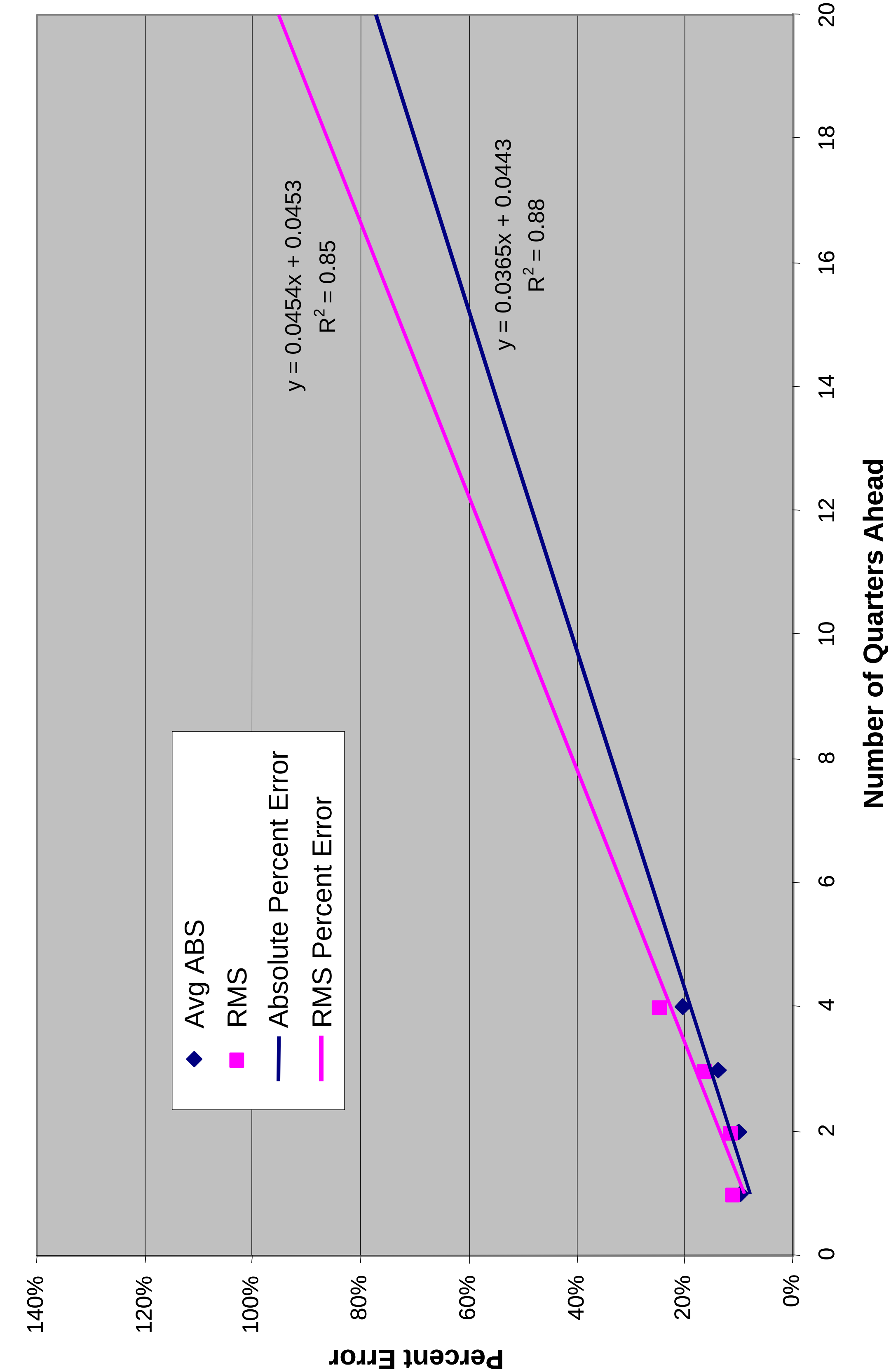

Figure 1d

Verizon Capital Expenditure Forecasting Error

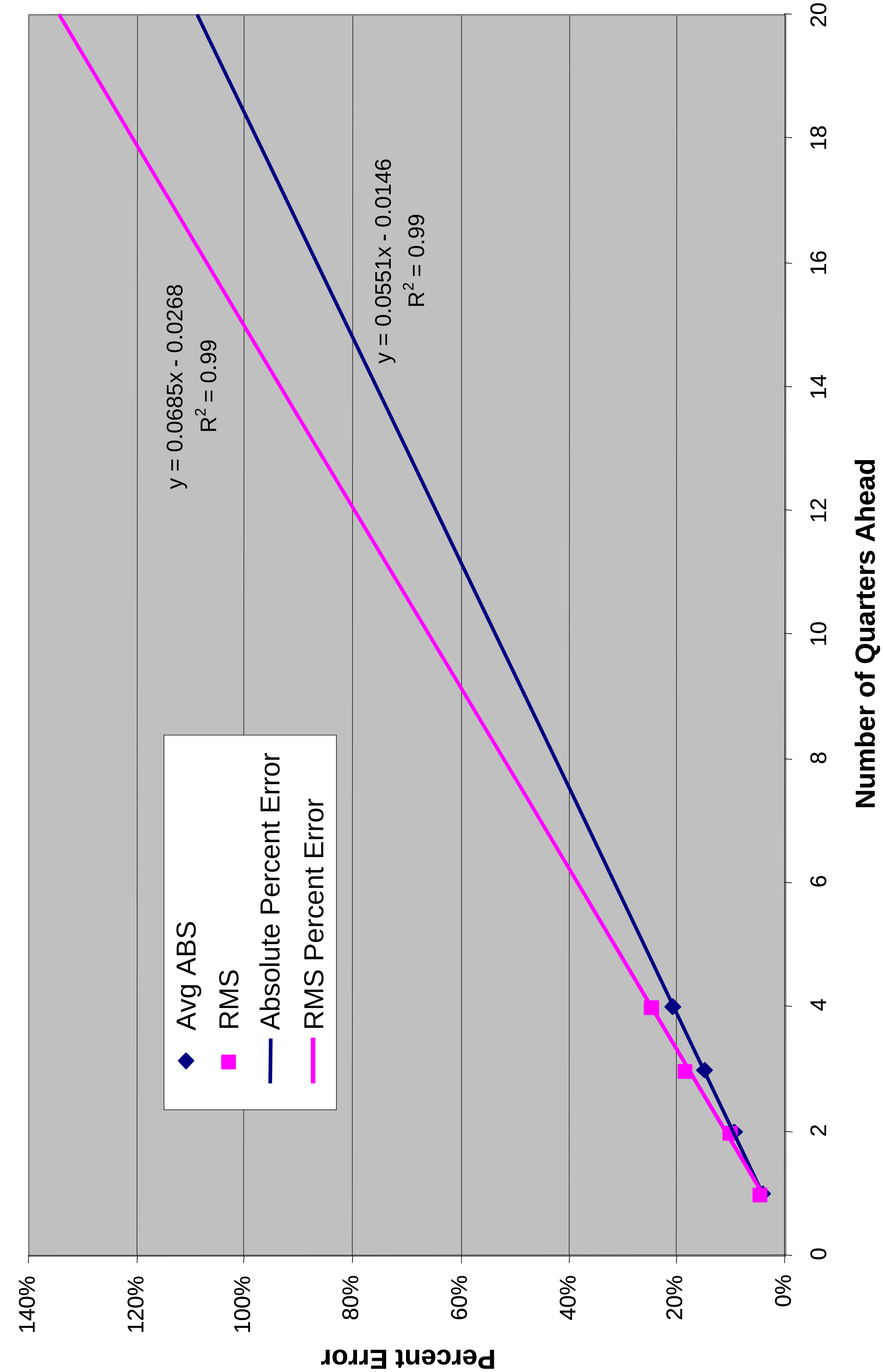

Figure 2 **Pooled Capital Expenditure Forecasting Error**