“Incentive Regulation, Capital Recovery and Technological Change in Public Utilities”

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INCENTIVE REGULATION, CAPITAL RECOVERY
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RESPONSIVE STATE REGULATORY SCHEMES FOR LEC'S

Following the apparently successful introduction of price-cap regulation for privatized telecommunications in the United Kingdom, this innovation has spread to other industries in the U.K. and is finding increasing adoption in the U.S. as well. Because of its apparent benefits, there is an increased interest in its application to local exchange carriers (LECs). This paper argues that, while some form of "incentive" regulation may offer benefits to LECs and their ratepayers, price-cap schemes as currently being implemented do not provide sufficiently powerful incentives for efficiency and are not responsive to the problems faced by LECs. Our basic proposal is to extend the standard price-cap framework to make it more responsive to capital recovery considerations, which are so central to innovation and efficiency in telecommunications. We argue that current price-cap proposals do not provide appropriate incentives for investment in product and process innovations and that the resulting under-investment can lead to significant welfare losses from lower efficiency, higher prices, and less product innovation. The central difficulty in designing responsive proposals to promote innovation is to link the regulated firm's benefits to those delivered to the customer, while protecting the consumer and potential entrants against monopoly power of the incumbent and while avoiding excessive transactions costs in the implementation of the scheme. The scheme we propose appears worthy of consideration on these dimensions.

The paper is divided into 5 sections. Section 1 is by way of introduction. Section 2 examines a number of basic principles that need to be satisfied if a regulatory scheme is to be "efficient and responsive." We argue that these principles are not particularly revolutionary. Indeed, quite the opposite; they derive from some basic notions in economic theory and regulatory practice. Section 3 presents a critique of some of the principal existing structures of regulation, including price caps and rate-of-return (RoR) regulation. In Section 4 we present our proposal which we argue is consistent with the principles articulated in Section 2 and superior to current alternatives. Section 5 is a discussion of desirable extensions of the present work. A numerical illustration of the operation of the scheme is provide in the Appendix.

1. Introduction

Price-cap regulation was introduced for British Tel and AT&T to promote innovation and flexibility in an industry characterized by increasing competition and technological progress. Since its initial implementation, many regulators and regulatory scholars have hailed price-cap regulation as a successful innovation in regulation. The initial adoption in this country by the Federal Communications Commission (FCC) has been followed by several state commissions, notably California, with variations on the basic price-cap theme. However, closer examination of these price-cap proposals reveals that price-cap regulation in the U.S. has undergone significant changes from the original British Tel plan. Some argue that these changes and subsequent developments in the operation of the British Tel plan attenuate the incentives for efficiency that were supposedly a major feature of price-cap regulation. Others argue that the changes were necessary to accommodate the broader array of companies to which price-cap regulation was to apply in the U.S. and to assure both viability for the companies and some benefits for their ratepayers.
The changes to the original British Tel plan are taking price-cap regulation back in the direction of traditional rate-of-return (RoR) regulation which they were intended to replace. As we will explore in more detail in Section 3 below, RoR features centrally in several of these schemes. Essentially, price caps apply in many of these schemes unless the earned RoR is deficient or excessive, with relief for the company and ratepayers triggered by particular levels of RoR. Thus, as in traditional RoR regulation, a target RoR has to be determined, but now with acceptable bands of variability within which price caps apply. The key difference from traditional RoR regulation is that price caps provide pricing flexibility in return for the major concession of “guaranteed” real price reductions. The point of bounds on acceptable RoR is that these can override the price caps where needed to keep the company operating within acceptable limits from the point of view of the capital market or its ratepayers. A purist form of price caps would attempt to impose market discipline and would imply an immutable commitment to the price-cap trajectory for a specific (and significant) period of time.

The issue of attenuating the efficiency of price caps by imposing upper and lower bounds on RoR is an important one to try to understand. It would appear that there is a major concern on the part of companies and the capital market with commitment by the regulator to price caps. In brief, if the company "does well," will the regulator renege? This concern has caused companies to seek a concession at the bottom end of the range whereby they can seek relief from a price cap that has resulted in their earning a deficient rate of return. In effect, imposing an acceptable band for RoR is a recognition of several features of the institution of regulation. First, neither regulators nor companies can control all contingencies which may affect the earnings of the regulated company, so that reserving a contingent response to adjust ex post outcomes to maintain acceptable performance (as measured by RoR) is to be expected. Second, regulators must continue to exercise vigilance over the sectors they regulate, and the pure ex ante commitments required by price caps -

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1 The federal and state schemes for LEC’s involve a number of features. The most notable of these is that the price cap is coupled rigidly with the company’s rate of return. For example, the California plan sets the initial price cap based upon an 11.5% rate of return. If the company drops 300 basis points below this for two years in a row, it is allowed to seek a hearing to review the level of the price cap. If its ROR exceeds 13%, it is allowed to keep half of the profits in excess of 13%. If the ROR exceeds 16.5% it has to give back any excess. Introducing limits on the rate of return at the upper or lower end attenuates the incentives of the company for efficiency, since in the one case it does not get to keep the benefits of its efficiency while at the other end it does not fully bear the consequences of its inefficiency.

2 In other words, by letting the company keep all its gains, subject to the price cap, pure price caps would institutionalize "regulatory lag" for a specific period.

3 The issue of commitment and RoR has been a concern under traditional RoR regulation where formal bands were not established. Thompson [1987, p40] argues “The general conclusion that emerged from this analysis was that the lower control should be ‘tight’ and the upper control ‘loose’. This kind of regulation would tend to minimize both the cost of capital and revenue requirements.” For further details see also Thompson [1991].
no matter how carefully conceived - are thus perceived as relinquishing control of the regulated firm. Thus, if one attributes some wisdom to the historical evolution of price caps as implemented in the U.K and the U.S., it appears that bands on acceptable RoR are required to ensure feasibility.

In spite of the intended purpose of price caps to increase flexibility and decrease regulatory transactions costs, if upper and lower limits on RoR are imposed (as is likely required to ensure feasibility), then the new schemes may require many of the traditional regulatory burdens on companies and commissions as under traditional RoR regulation. So the advantage of reduced regulatory transactions costs, sometimes touted as an advantage of price caps, may be considerably less than originally envisaged. In addition to this problem, many questions have been raised with respect to the efficiency consequences of price caps. In brief, in what we refer to as the "Penny-wise, Pound-foolish Theorem" [Crew and Kleindorfer, 1991], while price caps can be efficiency enhancing, they need not be. If regulators set too low an initial cap for certain market baskets, or they require too high a rate of productivity offset (the X-factor in the price-cap formula), then the company will find reduced incentives to invest because of anticipated under-recovery of its capital. The consequence of this penny-wise, pound-foolish regulation would be that consumers will not get the benefits of cost-saving or service-enhancing innovations, and the company will see its markets eroded through competition because of inefficient pricing.

Increasingly, it is becoming clear that the implementation of price caps requires balancing a number of competing factors inherent in the above listed possible pitfalls of poorly specified price caps. Sensitivity to these pitfalls is not apparent in the literature or in many of the proposals offered by state commissions to date. On the contrary, the design of many of these proposals seems to lack any coherent logic or principles other than finding a scheme to replace RoR regulation. Issues of quality of service, of capital recovery, of long-run viability of the company, of total consumer welfare, and of efficiency in general seem to be documented in the arguments for these proposals only in a very loose fashion. In view of these problems, it would appear that these latest proposals, while offering some improvement over existing methods of regulation, may miss an opportunity to put the major part of telecommunications, the LECs, on a sounder basis.

Later in this paper we propose an extension to traditional price-cap regulation that provides incentives for the LECs for efficiency and benefits to consumers from enhanced efficiency and quality of service. In this context, efficiency means not only the traditional allocative efficiency, but more importantly X-efficiency and dynamic efficiency.\(^4\) In an industry like telecommunications, the opportunities for dynamic efficiency are apparently considerable with advances in digital electronics and optical fiber. However, regulation can, and traditional RoR regulation does, significantly reduce incentives for the adoption of innovations, thereby encouraging a low level of dynamic efficiency on the part of regulated companies. With the current opening up of world markets to competition, the U.S. can not afford to ignore inefficiencies and let countries like Japan gain a lead in the

\(^4\) X-efficiency refers primarily to the internal efficiency of the firm during a period. Dynamic efficiency refers to improvements in efficiency over time, usually from the introduction of new technologies and services.
telecommunications field where the U.S. has been the world leader. Nor can a state commission ignore efficiency for long in this world. Jobs will go to places with good infrastructure. Modern industry, especially complicated manufacturing and service industries, require first-class telecommunications.

2. Principles for the Design of Responsive Regulatory Alternatives for LECs

While most economists would, at least initially, be disappointed in the apparent attenuation of efficiency incentives and movement away from "pseudo-competitive-market" discipline embodied in the purist price-cap proposal, this is probably inevitable for reasons of regulatory control and uncertainty. In particular, despite the significant competition the LECs are facing in certain parts of their business, they still have considerable monopoly power in their traditional business of providing POTS. Thus, there is little chance that the LECs will be able to get their core business deregulated in the way CATV managed to do. This research will therefore accept the first basic principle that any proposed regulatory scheme(s) should provide some protection against the exploitation of monopoly power. Protection against monopoly power, in the current proposals, takes the form of some limit on the RoR earned and sets limits on prices. If RoR is excessive, the firm has to share its gains partially or completely with ratepayers. On the issue of price control, price-cap regulation provides protection for the ratepayer by setting maximum limits on allowed price increases and some protection against predatory pricing by giving credit in the price-cap formula for price decreases only within a limited band.

In view of the limit at the upper end on its earnings, the company will require a floor to its RoR to allow it to return to the commission for rate relief. This is the second basic principle of proposals directed at a fair sharing of risks and returns between the company and its ratepayers.

The form that these two basic principles take in the proposal is important. The nature of the "sharing rules" employed is important for the efficiency of the proposal. In addition, the nature of the price adjustment formula is important, and especially the flexibility incorporated in the price adjustment formula, including the offset X and Y factors in the price-cap formula.

The third basic principle of the approach is that the initial level of the price cap should enable changes in the existing price structure in the direction of efficient pricing of services over the term of the price-cap contract. In view of the current structure of rates whereby basic local service is apparently subsidized by long distance and other services, the current LEC proposals may exacerbate this inefficiency. By taking the current price structure and lowering real prices by the rate of the X-factor per year, local service may be required to become even cheaper in real terms, necessitating an increase in any subsidy flow. This occurs because reductions in the price of any service in excess of a certain amount (often 5%) do not count toward the price-cap index. The scenario where this is most likely to provide a benefit for the company and its consumers is where the elasticity of demand for competitive services is very high and the elasticity of local service is very low.

The fourth basic principle is that capital recovery and service quality should be
addressed explicitly to ensure that the company faces appropriate incentives for efficient product and process innovation and that consumers are offered continuing high-quality service, especially for those services for which competition is absent. This principle is particularly important in the context of the dynamic efficiency aims of the proposal. In Crew and Kleindorfer [1991] we show that setting either initial price caps or the X-factor "productivity offset" improperly can lead to incentives for companies to underinvest with consequent efficiency losses for consumers who would have to pay higher prices because of lack of cost-reducing innovations or forego the benefits of service-enhancing innovations.

The fifth basic principle is that continuing regulatory oversight must be prima facie evident to assure consumers that companies are not making excess profits, that quality of service is maintained, and generally that regulators have not abdicated their responsibilities to assure protection of the public interest. Regulatory oversight and control are clearly of continuing importance to the public and must be maintained. The issue of quality monitoring is especially important in this regard since there would be some incentive for quality erosion in monopoly markets of the LECs under price caps, especially if the company is confronting competition in some of its markets and would like increasing pricing flexibility in those markets. A contribution to achieving necessary returns across both monopoly and competitive markets would be is to spend less on quality and service enhancements in the monopoly markets, e.g., by slowing investments in new technologies for these markets.

The sixth basic principle is that the regulatory scheme should economize on transactions costs. This could be particularly important in cases where a regulatory regime involved, for example, high costs of monitoring standards or productivity, and where transactions cost rich procedures were triggered by shortfalls in the RoR.

Current proposals, which do not incorporate these basic principles, are seriously deficient to the extent that they provide neither protection to the consumer nor incentives for efficiency to the company. For example, if initial price caps are set at such a level that the company is required to cut prices of competitive services dramatically and RoR declines, the company must then seek an adjustment to the price cap. However, in the intervening period, under competition, the only flexibility remaining could well be in the monopoly sector, i.e., the company would have flexibility ex post only to raise the price of monopoly services. It would be very hard for a commission to reject such an increase and the increase would be higher than required if the price cap were set correctly in the first instance. These cross-subsidy and efficiency issues are not currently well understood in the discussion or literature of price caps. We would plan to provide analysis and simulations of various price cap proposals to provide orders of magnitude for the numbers involved.

In concluding our discussion of principles underlying regulatory innovations, we should note that not all of the above principles may be accomplished completely by any single proposal. Some tradeoffs may be required in using these principles as benchmarks against which to assess various alternatives.
3. Critique of Some Existing Incentive-Regulation Proposals

In this section we critique the efficiency and incentival properties of some of the new forms of regulation that are currently being employed to regulate telephone companies. We are not concerned with reproducing the details of the schemes, but rather in providing a critique of their efficiency consequences and the possible pointers they can provide for the proposal we develop in Section 4.

Rate-of-Return Regulation

Let us briefly mention RoR regulation since it is the existing benchmark and therefore useful for assessing alternative forms of regulation. RoR regulation apparently served telephone companies and consumers fairly well for over half a century. However, some of the features that had contributed to its success became the major source of its problems in recent years. Probably RoR's greatest achievement was that it provided an orderly and acceptable social mediation process that balanced the interests of consumers and the firm. As long as inflation was low, technological change was rather orderly and linear and call volume grew steadily, both companies and consumers benefited from falling real prices due to the significant scale economies that prevailed for most of the period. Regulation was a success story. It did not matter very much if a company failed to meet its RoR in a particular period. It could be fairly confident that this could be remedied in the next period. Similarly prices could be kept low by stable depreciation rates which rested on the foundation of long service lives for plant and equipment and the understanding that under-recovery could be rectified in future periods.

This all changed under the weight of several significant changes which occurred in the 1970s and 1980s. These included inflation, rapid technological change and competition. Inflation rates have been unstable over the last twenty years. They have been historically relatively high by U.S. standards, making long periods of rate stability - in our opinion one of the hallmarks of RoR regulation - hard to achieve. Even more significant, technological change in telecommunications technologies became much more rapid and sweeping changes in telecommunications regulation allowed competitive entry into many of the markets which had traditionally been the sole business of the telephone companies. With entry by competitors the traditional regulatory contract that was central to the success of RoR regulation began to erode. To the extent that the regulator could not successfully guarantee

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5 The methodological basis of the analysis of this section relies on Crew and Kleindorfer [1986, pp. 146-85].

6 For a powerful defense of traditional regulation, where the regulator is seen as an "administrator" of the regulatory contract, see Goldberg [1976]. One explanation for the many changes and fine-tuning undertaken in several jurisdictions to the original British Tel price-cap scheme is that these changes were required in order to fit the different technology and market conditions of the multiple contexts to which price-caps have been applied in the U.S. and to assure continuing regulatory oversight (i.e., the continuation of an "administered contract").
the firm its exclusive franchise free from competition by entrants, its control over the price structure was called into question. The various cross subsidies, that had become a significant feature of RoR regulation, were not sustainable as entrants sought to skim the cream leaving the incumbents with only the bulk of the cross-subsidized products. Similarly, not just cross-subsidies between products but inter-generational cross-subsidies were highlighted by the forces of competition. A key area where this was evident was in capital recovery. Depreciation policies corresponding to the era of lower technological progress and no competition began to lead to reserve deficiencies for several LECs. In effect, charging lower than economic depreciation rates represents a form of inter-generational cross-subsidy; future customers pay for under-recovery of capital by current ratepayers. This kind of inter-generational cross-subsidy was feasible in the past. But competition will not allow such cross-subsidies to exist. Indeed, if reserve deficiencies do accumulate, they may never be eliminated. In this case, it is the shareholder who has to pay for the shortfall, but this cannot continue in the long run as the stock market re-evaluates the risk of telephone companies relative to other investment opportunities.

Rapid technological change and competitive entry were the primary reasons why RoR was challenged as an efficient governance structure for telecommunications. But there are other reasons why, in these circumstances, RoR regulation might have become outmoded. The process of setting rates under RoR regulation was always somewhat cumbersome since it usually involved a formal rate case. Regulatory transactions costs were manageable under the stable conditions prevailing prior to 1970. But when rapid technological change and competition became the rule of the day, the transactions costs of traditional rate-case regulation became increasingly significant. With entrants attacking the firm’s most profitable markets, the ability to react by cutting prices immediately is clearly paramount. Thus, regulatory institutions allowing more price flexibility were needed to replace the price setting mechanisms of the traditional rate case proceeding of RoR regulation.

With RoR regulation under these kind of pressures it is not surprising that additional criticisms raised by economists from time to time also resurfaced. These included the notion that RoR regulation attenuated incentives for internal and dynamic efficiency. Internal efficiency is also referred to in the literature as X-efficiency, while dynamic efficiency refers to the efficiency of product and process innovations over time.7

In summary, RoR’s failure to protect the firm from entry, its failure to provide adequate capital recovery, its weak incentives for internal efficiency, its rigid price and cross-subsidized price structure and the consequent high transactions costs it generates are all serious problems which make the search for alternative governance structures one of continuing concern. We will now critique some of the alternatives to RoR regulation which have been proposed. All of the ones we examine have major problems, as we will now see prior to developing our own scheme in Section 4.

7 Internal or X-efficiency relates mainly to minimizing the cost of a given output, as discussed in Leibenstein [1966]. The X-factor in the price-cap formula focuses on both increases in X-efficiency, in Leibenstein’s sense, as well as increases in dynamic efficiency brought about by technological change.
British Telecommunications (BT): a Model for PCR?

Following the sale of 50.2 percent of the equity of BT in November 1984, the privatized BT continued as the monopoly supplier of local and most long-distance service in the United Kingdom. Throughout its subsequent history BT has been subject to price-cap regulation (PCR). The initial price-cap formula was RPI-X, where RPI is the equivalent of the CPI and X is the productivity deduction. The formula proved to be a great success for BT, so much so that when it came up for review after the initial 5-year period the X-factor was raised to 4.5 percent and was raised to 5.5 percent in 1991. While this may appear like a huge burden, the pricing flexibility allowed to British Tel is considerable, as indicated by their price changes in the fall of 1991.

The success of PCR in the case of BT has almost certainly provided some motivation for the widespread application of PCR in U.S. telecommunications and elsewhere. Proponents would argue that the promised incentives for X-efficiency claimed for PCR have resulted in actual improvements in internal efficiency for BT to the benefit of customers and BT. PCR resulted in real price reductions in telecommunications services and BT did very well too. PCR, by allowing BT to keep its gains (over the X-factor) from innovation and cost reduction for a five-year period, encouraged internal efficiency. While BT did have problems of service quality, at least initially, the regulator acted to monitor and enforce quality standards. The incentives for lowering quality in uncontested markets under PCR is an important lesson to take away from the BT experience.

AT&T: PCR for the Dominant Inter-Exchange Carrier

Effective in 1990, PCR was applied to AT&T by the Federal Communications Commission employing a formula very similar to that applied to BT of CPI-X. The cap applied at first only to AT&T's inter-state revenue. AT&T still had to seek approval of individual state commissions for authorized intra-state traffic. AT&T's plan differed from BT's in other major respects as well. AT&T was subject to a restriction on the extent it could reduce its prices and have them "count" in the price cap index. Any reductions exceeding 5 percent were limited to 5 percent for purposes of calculating the index. Individual price increases over 5 percent were not allowed. These truncation rules were intended to promote price stability, a continuing concern of regulators and the public.

These restrictions were not particularly severe given the disadvantages of RoR regulation for AT&T. The considerable regulatory transactions cost of RoR, including the delays in responding to (unregulated) competitors' price cuts, made PCR a bargain for AT&T, and the company became a formidable competitor, leading the way with innovative pricing, new service offerings, and aggressive marketing.

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PCR Spreads to State Commissions, Notably, California

With the success of PCR for BT and for AT&T, imitations became popular with price-cap schemes taking various forms in several states, e.g. Florida, Kentucky, Tennessee, Alabama and Michigan. These plans incorporated a number of features including a concern for service standards and often at least mention of the objective of increased efficiency.

The most significant development for PCR at the State commission level occurred when the California Public Utilities Commission apparently abandoned traditional RoR regulation in favor of PCR for the two largest companies, Pacific Bell and GTE. However, California style PCR was a hybrid. It incorporated many of the features of RoR regulation. It divided services into groups including "monopoly" services which were allowed to change each year based upon the GNP Deflator (usually denoted GNPPP) minus a 4.5% productivity factor. Thus, prices of basic services would be required to fall in real terms. In the next group, "semi-competitive," some freedom is allowed to move prices up and down with ten days notice. For "fully competitive" services the company is allowed complete freedom of pricing. RoR enters the scheme in that the company is expected to earn a rate of return of 11.5%. Profits between 11.5% and 13% are retained by the company. Profits above 13% are shared equally between the company and ratepayers to a maximum of 16.5%. Profits above 16.5% are to be returned entirely to ratepayers. Profits below 8.25% on its combined monopoly and semi-competitive business for two consecutive years would allow the company to seek relief from the PUC.

From a company perspective, the California plan provides some relief in terms of price flexibility, but in return it places rather strong restrictions on RoR, on both the upside as well as the downside, and requires a fairly high X-factor. Perhaps more importantly, the California scheme fails to recognize the significant capital recovery problems faced by the companies. Higher depreciation rates are not allowed, and yet basic rates are required to fall 4.5% in real terms, implying that significant innovation and investment are required.

Price-Cap Regulation for LECs

The FCC has now approved PCR for the inter-state revenue of the LECs. This means primarily their access charges collected from AT&T and other inter-exchange carriers. The FCC scheme, like the California scheme, is a hybrid of PCR and RoR. It has an X-factor of 3.3% and a rate of return of 11.25% with equal sharing for earning 1% to 5% above this level. The FCC plan has some apparent flexibility in that it allows a company to take a 4.3% productivity offset in return for being allowed to raise its RoR by 1 percent. We argue below that this feature of the FCC plan is inefficient. Increasing the X-factor without adjusting the initial price cap deprives the company of the pricing flexibility that it needs to achieve

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9 Included in the monopoly group are local service, intra-LATA toll and local operator service.

10 Market Rate of Return of 11.5% may be changed if yield on 30-year treasury bonds increases/decreases by 250 basis points.
the higher allowed RoR. Thus, increasing the X-factor without increased pricing flexibility provides only illusory access to higher returns.

Like California, the FCC LEC plan also has a floor on earnings. If earnings drop more than 1% below the 11.25% RoR for one year, then rates are adjusted to bring up the RoR. The scheme contains price bands of plus or minus 5%. It also contains a factor to allow for growth of traffic. Since the LECs will benefit from the growth in traffic generated through economies scale and scope, an adjustment is made to share the benefits of growth in traffic between the LECs and the long-distance carriers.

The FCC's LEC plan has some interesting features, including the self-selection of target ROT in return for accepting a higher X-factor. On the other hand, the FCC's LEC plan does not control for quality nor does it encourage innovative pricing such as pricing by time-of-day in access charges.\textsuperscript{11} Clearly, the plan's main function is to simplify the regulatory process and to promote a reduction in carrier access charges in real terms, objectives which do seem compatible with the plan. Moreover, given that there exists potential competition from bypass and significant pressures on price (and quality) in any case, the FCC's LEC plan objectives appear broadly compatible with competitive and economic realities faced by the LECs in the access market.

**Overall Assessment of Existing Plans**

The success of PCR for BT and AT&T and the adoption of the plan for the LECs does not necessarily mean that PCR for intra-state rates will increase efficiency for LECs. Indeed the likelihood that a scheme like that proposed in California will enhance significantly efficiency is small, since it takes little account of the underlying economic realities. For one thing, it implies that the price of basic service will fall in real terms. Unless there are major productivity enhancements in the offering for basic service this implies a larger level of cross-subsidy from competitive services. Unless prices of these are currently drastically out-of-whack the likelihood that this can happen under competition is small. In addition, it fails to take into account inadequate capital recovery by LECs. In some instances this is particularly severe in the case of LECs with large depreciation reserve deficiencies and low rates of depreciation compared with other companies using digital and similar technologies, e.g. IBM. Without cash flow to replace their assets companies will not be able to offer the

\textsuperscript{11}Note that the issue of innovative pricing is related to that of new products pricing. In both cases, significant changes occur in the price structure of a given basket of services. If there are not explicit provisions to reward movement toward desirable pricing or service innovations, PCR can actually discourage such innovations. For example, if in moving to time-of-day pricing, average (quantity-weighted) price over time is used in the price-cap formula, and if the current more elastic and competitive market is the daytime market for the service in question, then there will be less incentive to move to TOD pricing for the service under PCR since PCR would not give full credit to the needed price reductions in the daytime market, but would smooth these in with price changes in the evening market. A similar story could be told for the introduction of new services as refinements of existing services to meet competitive offerings.
high quality service that competitors will be able to offer.

Current price caps are seriously deficient in their treatment of incentives for efficiency. The FCC's LEC plan does have the interesting feature of allowing LECs to reveal their best estimate of their productivity and earn a higher RoR as a result. We will develop truthful revelation mechanisms further in Section 4. However, our main concern will be how to deal with technological change and competition and how to determine efficient capital recovery policies.

4. A Proposal for Responsive Incentive Regulation

We now develop a proposal for responsive incentive regulation. We are motivated by the design principles discussed in Section 2 and the experience with PCR reviewed in Section 3. While we are interested in a pragmatic proposal consistent with current regulatory practice, we aim also to provide an efficient approach to the problems of capital recovery, competition and technological change which have been inadequately addressed in previous approaches to incentive regulation, including the price-cap proposals reviewed above.

The basic outline of our proposal is this. We propose first that benchmarks for initial prices (or equivalently, the initial price cap), the X-factor and for upper and lower bounds on reasonable rates of return be agreed between the company and the regulatory authority. The process of trueing up initial prices (or the initial price cap) is obviously important to any price-cap proposal, including ours. In our proposal, these initial benchmarks would be used as the starting point for negotiations. The company can accept these benchmarks and price-cap regulation would proceed much the same as under the FCC LEC base plan. Alternatively, we propose that the company be allowed to specify an increase in the initial price cap to accommodate a higher capital recovery and re-investment rate. But in return the company must accept a higher X-factor, where the increment in the X-factor is computed to make consumers at least as well off over the time horizon of price-cap regulation as they would be if the company accepted PCR under benchmark conditions. But if consumers are at least as well off and the company prefers the alternative regime, then the alternative regime must be Pareto superior to the benchmark case. This self-revelation of improvement possibilities by the company is the central feature of our proposal. Let us now proceed to the details of the proposal and its underlying logic.

The proposal provides a basic framework for a responsive incentive regulation scheme

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12 In many of the actual price-cap proposals, notably the FCC and the California plans, scant attention seems to have been given to this problem. Given that existing plans allow for real price reductions and very little flexibility to increase the real price of basic service, it is important to avoid a situation point where basic service is underpriced at the start of the price cap or where there is insufficient flexibility to achieve subsidy-free prices over the period of the price cap because either initial prices or the initial price cap are set too low.

for a LEC's state-regulated revenues. We outline the proposal by indicating its basic properties (P1–P5):

Incentive Regulation for Competition and Innovation

P1. To assure regulatory oversight and control, while providing pricing flexibility to the company, a target level RoR, denoted RT, and acceptable lower and upper bounds (RL < RT and RU > RT) on RoR, should be set such that earnings in any given year below RL can, at the company's option, trigger a rate review and reinitialization of prices, while earnings above RU will be factored into an adjustment of the price cap to return a fraction, denoted α, of these to the ratepayer. The process for setting RT, as well as RL and RU, should follow the established literature on public utility finance.

P2. Service baskets should be defined to distinguish regulated and competitive services. For competitive services, no PCR is needed and the company should have complete pricing discretion for these services. For regulated services, we propose that traditional PCR be used to cap prices (see P3 below). In addition, however, quality of regulated services should be monitored according to agreed standards and reporting, possibly those proposed by the FCC as part of its quality monitoring requirements for local telephone infrastructure. In the event that quality of services is not maintained, the PUC may establish rebate penalties on the basis of unmet service quality standards.

P3. Unless a rate review is triggered by the company in response to a RoR below RL, or unless unmet quality standards trigger penalty rebates, rates will be set at the

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14 Our proposal is crafted toward adapting PCR to the current environment facing the LEC's in the U.S. In other sectors, e.g., electricity and gas, other forms of PCR or regulation may be more appropriate than that proposed here. See Einhorn, Vogelsang and Porter [1989] for alternative proposals for the electricity and gas sectors.

15 Recommended adjustments to the price cap to accomplish this are discussed further below.

16 It should be noted that the standard approaches to setting target RoR must be modified to account for the changes in earnings risk associated with the additional feature of establishing upper and lower limits, with sharing, on the RoR. While the discussion of Thompson [1987, 1991] does not actually model the relationship between the effects of allowed return and bandwidth (RL, RU) on the cost of capital for the regulated firm, it does provide the basis for the financial economist's approach to model this situation.

17 Quality monitoring and quality penalty rebates are already established in New York, e.g., the recently approved agreement between NYPSC and Rochester Telephone Company.
company's discretion, subject to PCR of the traditional form, e.g., based upon a modified Laspeyre Index, as established in the FCC LEC plan for inter-state revenue. However, to allow flexibility in responding to the dictates of technological change and competition, we recommend somewhat greater freedom be allowed the company in adjusting its prices than in the FCC proposal, e.g., instead of the +5% increase foreseen in the FCC plan, a +10% increase over the benchmark GNPPPI-X of the formula should be allowed as long as the PCR index is satisfied (for each service basket), while maintaining the current -5% credit on the decrease side of the PCR index. Thus, our proposal is to adopt PCR in fairly pure form, subject only to an acceptable bandwidth of variability of RoR over the PCR-contract period T. The standard price-cap formula will then apply to each defined service basket:

$$PCI_t = PCI_{t-1}(1 + GNPPPI_{t-1} - X + (\Delta Z/R_{t-1})),$$

where $PCI_t$ is the period t price-cap index relative to the base year (and applicable to prices at the beginning of period $t = 1, 2, ..., T$). $R_{t-1}$ is revenue in period $t-1$, GNPPPI$_{t-1}$ is the GDP deflator, and the adjustment $\Delta Z$ is discussed further below.

P4. The company and the regulator will set a Benchmark Case for the initial price cap ($PCI_0$) and the X-factor ($X_0$). The company may elect to accept this Benchmark Case, in which case traditional PCR will apply with no $\Delta Z$ adjustments.\(^{18}\)

Alternatively, the company may elect a higher productivity offset $X$ (the X-factor in the price-cap formula) and a set of $T$ capital recovery (or depreciation) factors $\delta_0, ..., \delta_T$, where $\delta_t$ is to be thought of as an ex ante agreed adjustment to the price cap to allow the company the flexibility to recover (and reinvest) additional capital. Operationally, once agreed, the company-selected X-factor will be used in the price-cap formula together with a set of $\Delta Z_t$ increments to the price-cap index of the form $\Delta Z_t = \delta_t R_{t-1}$, where $\delta_t$ is the company-selected capital recovery factor for period $t$. In accordance with the theory developed in Crew and Kleindorfer (1991), the $\delta_t$ are constrained to be non-increasing, so that any increments to capital recovery selected by the company tend to increase the front-loading of the company's capital recovery profile. The easiest case to imagine is where only $\delta_0 > 0$, with $\delta_t = ... = \delta_T = 0$. This would have the same effect as increasing the initial price-cap $PCI_0$ by an amount $\delta_0$.

In general, the higher the $\delta$-factors selected, the higher the required X-factor. The exact relationship between $X$ and $\delta$ is straightforward. Associated with any $(X, \delta)$ pair is a price-cap trajectory $PCI_t(X,\delta)$, $t = 1, ..., T$, with $PCI_t(X,\delta)$ given by

We require that $(X, \delta)$ should be such that $X \geq X_o$, the Benchmark productivity factor

---

\(^{18}\) Adjustments required to accommodate mandated regulatory, accounting or legislative costs would still be allowed, of course, just as in standard PCR.
$$PCI_t(X, \delta) = PCI_{t-1}(X, \delta) [1 + \frac{\text{GNPPI}_{t-1}}{X} - X + \delta_t]$$

(1)

set by the regulator, and that the implied price trajectories associated with the company-selected \((X, \delta)\) leave ratepayers at least as well off as under the Benchmark Case \((X_0,0)\), where \(0\) is a \(T\)-vector of 0's corresponding to the Benchmark Case in which no \(\Delta Z\) increments for capital recovery are allowed. Leaving the ratepayers at least as well off as under the Benchmark Case is specified operationally as equating the NPV of the price-cap index under \(PCI(X,\delta)\) to that under \(PCI(X_0,0)\), i.e., denoting by \(\omega < 1\) the discount factor associated with consumer time-based preferences,

$$\sum_{t=1}^{T} \omega^{t-1}PCI_t(X, \delta) = \sum_{t=1}^{T} \omega^{t-1}PCI_t(X_0, 0)$$

(2)

Ratepayers are at least as well off under \((X_0, \delta)\) as under a price-cap trajectory satisfying (1), with \((X, \delta)\) specified as in (2), if their willingness-to-pay (WTP) for the regulated service basket in question is non-decreasing over time and their consumption of services in this basket is non-decreasing over time. One very good reason why WTP might be increasing over time would be that increased capital recovery and reinvestment would lead to enhanced service quality. In any case, (1)-(2) require that the quantity-weighted average price of the service basket be non-increasing for any feasible \((X, \delta)\) pair which the company may choose.

By a revealed preference argument, the company will also be at least as well off ex ante under the \((X, \delta)\) pair it chooses. Ex post, the company will also be at least as well off provided that it can in fact achieve the increased productivity implied by the \(X\)-factor it chooses. Whether or not the company achieves its chosen \(X\)-factor over time, it must of course abide by the price-cap index implied by its initial choice of \((X, \delta)\), so that ratepayers will indeed benefit if the company selects a higher productivity offset \(X > X_0\).

P5. All new products would be introduced during the price-cap period as tariffed services and there would be no impact on the price cap from these services. At the end of the price-cap period (of \(T\) years) during which the product was introduced, each new product would be reviewed for possible inclusion in a price-cap regulated basket during the next price-cap period.

From the above properties, we see that the essential character of the proposal made here is that PCR is to be envisioned primarily as institutionalizing "regulatory lag" over the period of the PCR contract. Several additional features in this proposal recognize the principles spelled out in Section 2, however. These relate to continuing regulatory oversight, on both profits and quality, and sufficient capital recovery to assure the viability of the company as it attempts to meet prespecified real-price decreases (as measured by \(X\)-factor improvements) through process and product innovations.
Note that while we propose adopting PCR as in the FCC LEC plan, we propose disregarding the FCC plan of company-selected RT and associated X-factors; in our proposal, RT is set initially to achieve a fair rate of return for the company, as in standard RoR regulation. Thereafter, RT remains unchanged over the life of the "PCR contract" unless quality of service declines. The rationale for these recommendations is spelled out in Crew and Kleindorfer (1991), where we show that what the company needs in order to earn its RoR is pricing flexibility, especially in the early years of PCR. If the company does not enjoy such flexibility, then it may not be able to recover its RoR (except from its monopoly customers) because of competition or because of inability to recover capital it might invest in product or process innovations. Thus, allowing the company a higher RoR in return for accepting an increased X-factor, while not adjusting the initial price-cap index, deprives the company of the precise ingredient it needs to achieve the higher RoR, namely pricing flexibility. Our proposal, on the other hand, allows pricing flexibility in the early years in return for accepting a higher X-factor over the horizon of PCR.

Let us now consider a few details related to the above properties.

**Excess Profit Sharing**

First, let us consider the issue of the excess profit share c. Historically this has been set at the 50-50 level and, for reasons of precedent as well as apparent fairness, this seems appropriate. Note, however, that in our proposal there is no upper limit to where sharing stops. That is, the company continues to share at the 50-50 level with ratepayers at all levels of achieved RoR. This is in line with efficiency considerations (see Principle 3 in section 2 above), in that the company should never find it in their interest to engage in waste, which would be the case if an absolute upper bound on their RoR is imposed.

Several recent price-cap proposals differ from our proposal in the way in which sharing is implemented. In the California plan as well as the FCC’s LEC plan, for example, sharing is truncated above a certain RoR. All earnings in excess of this upper limit RoR are returned to the ratepayers. This truncation violates a fundamental principle of efficiency in that the company then has no incentive to achieve productivity increases once it has reached (or approaches) the maximal allowed RoR (in the California plan 16.5%). Clearly, some sharing should continue at all levels of RoR if the company is to be encouraged to be efficient.

Another example of incentivial inefficiency is associated with some recent proposals calling for the company to first receive nothing as its RoR exceeds RT + ΔR the target RoR level, with sharing allowed only above RT + ΔR, where ΔR > 0. The problem here is again that the company has incentives to "hide" its earnings if it expects them to be in the range RT to RT + ΔR. For example, the company’s earnings would be truncated at 12% for the entire region 12% to 13%. Only after its RoR has exceeded 13% would the company begin to share earnings (in excess of 13%) with ratepayers.

It is important to note that if any rebates (e.g., for returns above RU) are accomplished by adjustments to the price-cap index, then these PCI adjustments can have a continuing, multi-period impact on revenues. It is clearly the discounted multi-period
impact that must be considered if any adjustments are made to the PCI. Lump-sum discounts off customer bills without impacting the PCI would not have any continuing effects, of course.

Setting Initial Prices and PCI

Now let us consider the issue of setting initial, “true up” prices, or equivalently setting the initial price cap (PCI). We will assume here for simplicity that the initial price cap is set to unity, PCI = 1 so that all adjustments prior to PCR are in terms of initial prices. As discussed in Crew and Kleindorfer [1991], it is important that initial regulated prices are set high enough to allow capital recovery.

Setting RL, RT, and RU

The target RoR RT should be set based on principles of traditional utility finance, adjusted to account for the upper and lower allowed returns and sharing rules in place (see Thompson [1987]). A reasonable bandwidth RU - RL should be allowed to assure the transactions cost economy of PCR without interventions, rebates etc. In addition, the difference between RT and RL should be sufficiently large (e.g., 3%) to provide strong incentives for the company to meet its chosen productivity objectives.

Relating X and δ

The most important aspect of this proposal is the indicated relationship between X and δ if the company elects a higher capital recovery trajectory (δ > 0) than under the Benchmark Case, with an associated higher X-factor than the benchmark X-factor. The company must select an (X, δ) pair when price caps are initiated and after the determination of RT, RL and RU. Equation (2) shows the desired relationship between feasible (X, δ) pairs to assure that ratepayers are at least as well off. If the company believes it can improve its productivity by more than the benchmark rate X by increased capital recovery and reinvestment, then the company (and ratepayers) will benefit by declaring this to be the case and accepting a higher required X-factor in return for the increased capital recovery it is allowed. Once an (X, δ) pair is chosen by the company, the price-cap index is adjusted to accommodate the chosen (X, δ) pair.

To illustrate, suppose that RL, RT, and RU are set at competitive levels and that initial prices are true up as discussed above. Suppose that GNPPP = 0 (no inflation), that PCI = 1 and that the benchmark X-factor for the regulated service basket is set at 3%. Then the PCI trajectory for the Benchmark case is computed from (1) as:
\[
\begin{array}{cccccc}
  t=0 & t=1 & t=2 & t=3 & t=4 & t=5 \\
\hline
\text{PCI}(X_0, 0) & 1.00 & .970 & .941 & .913 & .885 & .859 \\
\end{array}
\]

Table 1: Benchmark Case

Suppose the company believes it can achieve a higher productivity increase if it is allowed a higher capital recovery rate, corresponding to a δ-vector in (1) as follows:\(^{19}\)

\[
\delta_1 = .02, \delta_2 = .01, \delta_3 = \delta_4 = \delta_5 = 0.
\]

Table 2: A Hypothetical δ-Vector

This δ-vector is non-increasing as desired. If the required X-factor were still \(X_0 = .03\), this δ-vector in conjunction with (1) would give rise to the altered PCI trajectory in Table 3.

\[
\begin{array}{cccccc}
  t=0 & t=1 & t=2 & t=3 & t=4 & t=5 \\
\hline
\text{PCI}(X_0, δ) & 1.00 & .990 & .970 & .941 & .913 & .885 \\
\end{array}
\]

Table 3: Price Cap Index for \((X_0, δ) = (.03, δ)\)

The company would clearly prefer this altered PCI trajectory to the Benchmark PCI trajectory. Of course, the company will not be constrained by this trajectory based on the benchmark \(X_0\). Rather, the company will be required to accept a higher X-factor, corresponding to the X which solves (2). For the indicated δ-vector, and for a discount factor of \(\omega = .9\), the solution to (2) is \(X = .4\%), yielding the PCI trajectory in Table 4.

\[
\begin{array}{cccccc}
  t=0 & t=1 & t=2 & t=3 & t=4 & t=5 \\
\hline
\text{PCI}(.04, δ) & 1.00 & .980 & .950 & .913 & .876 & .841 \\
\end{array}
\]

Table 4: Price Cap Index for \((X, δ) = (.04, δ)\)

\(^{19}\) Thus, the 2% increase indicated for year 1 (δ_1 = .02) of the price-cap translates to $20,000 in increased capital recovery for every million dollars of base-period revenue. The reader should note that, because of the required increase in the X-factor, this initial allowed revenue increase must be more than paid back to ratepayers in future years over the life of the price cap, as reflected in Table 4.
From this simple example, we see the essential character of the proposal. By allowing greater price flexibility and capital recovery in the initial period of PCR, the company can achieve larger productivity gains (and is required to if it wishes to depart from the Benchmark Case), and passes these on to ratepayers. It is straightforward to go through the above calculations for other δ-vectors and to check that (2) is satisfied for the resulting (X, δ) pair chosen by the company.

We can also illustrate the proposal graphically. For graphical purposes, we restrict attention to the scalar case in which only δ > 0, with δ = ... = δ = 0. In this case we can simply identify the δ-vector with δ. In Figure 1 we plot various profit and welfare contours as a function of (X, δ). We show the iso-profit contours $\Pi_0$ and $\Pi_1$, where $\Pi_0 < \Pi_1$, and the consumer welfare contours $W_0$ and $W_1$, where $W_0 < W_1$. $\Pi_1$ lies above $\Pi_0$ in (X, δ) space since the company prefers higher pricing flexibility (i.e., higher δ) and lower X. $W_1$ lies below $W_0$ in (X, δ) space since consumers prefer lower δ and higher X (since decreasing δ or increasing X will decrease the PCI as shown in equation (1)).

The benchmark scenario is $(X_0, \delta_0)$ with $\delta_0 = 0$. As shown in Figure 1, the company and ratepayers can both be better off by moving in the direction of the arrow AC. (X, δ) pairs along this arrow are clearly above the profit contour $\Pi_0$ and below the welfare contour $W_1$, indicating increases in both profits and welfare. Improvements are possible for both company and consumers until the point B, i.e., until $(X_1, \delta_1)$. Thereafter, there is no Pareto improvement possible with increasing X. Of course, either the company or the ratepayers could be made better off at the expense of the other, but joint improvement is exhausted at B.

To reiterate, the basic point of this proposal is to allow the company additional flexibility to increase its productivity, with guaranteed benefits to the consumer, with increased pricing flexibility and increased capital recovery and reinvestment.

5. Concluding Remarks and Extensions

This paper has provided a new proposal for incentive regulation which aims to be responsive to the needs of the ratepayer and the company. In so doing, it attempts to avoid many of the pitfalls of existing and proposed plans. The proposal is based upon six basic principles of regulation which relate to fairness and efficiency. While incorporating some of the significant features of other plans, the proposal breaks new ground principally in two respects.

The first innovation of the proposal is that it explicitly addresses the issues of competition and technological change in the context of a regulated telephone company. As has been demonstrated in theory [Crew and Kleindorfer, 1991], capital recovery or depreciation policies take on added significance under technological change. Traditional regulatory policies with long asset lives may have serious adverse consequences for both regulated companies and ratepayers under rapid technological change and competition.

The second feature of the proposal is that it allows the company to achieve higher capital recovery and reinvestment in return for higher productivity offsets (i.e., higher X-
factors) in the traditional PCR formula. The required increase in the X-factor is specified so as to assure that ratepayers also profit from company choices. As in traditional PCR, so with our proposal, the proposal requires care in setting initial prices in order to begin PCR on a solid foundation.

The plan is implemented in three phases:

I. Setting initial prices prior to the initiation of PCR. This involves setting the allowed RoR (including upper and lower limits RL and RU) upon which rates are based. It then requires that individual rates be "trued up," to the extent possible, to reduce or preferably eliminate cross subsidy. This is critical since the price-cap proposal implies a real reduction in prices of equivalent to the X-factor. Given that pricing flexibility is severely constrained by a restricted Laspeyre price index, the company would have little opportunity to raise basic rates once the price cap takes effect.

II. Linking the X-factor with the capital recovery factor, the "Z-factor." The proposal allows the company increased capital recovery but at a price. The price is a higher X. The company proposes a Z-factor, i.e. higher capital recovery, but in return is required to accept a higher X-factor. The required increase in the X-factor is specified so that, over the life of the price cap, the ratepayer is made better off. In effect, the company is offered increased pricing flexibility in the early years in return for guaranteed lower rates in the later years. To achieve this, the company must believe that it can reduce costs, improve service or otherwise increase demands by getting higher capital recovery and putting it to good use in the form of profitable investment. It has to back up its judgement by providing lower prices and at least the same quality. In addition, if it fails to make its RoR, it has limited recourse to the regulator for rate relief. Note that this proposal provides strong incentives for the company to examine how it can best meet required productivity improvements implied by PCR, even if the company elects to remain with the benchmark case in the end.

III. Once the agreement has been struck between the regulator and the company, the contract still has to be administered. However, the design of the proposal attempts to reduce the amount of transactions costs involved in monitoring and administering the contract. A major role exists for the regulator in monitoring quality, and rate base, although not likely any greater than under RoR regulation.

The proposal examined here is not the only means of addressing capital recovery issues. The plan adopted by the Kentucky Public Service Commission (Docket No. 10105, 09/30/91) for South Central Bell (SCB) may also have possible application to this problem. SCB were required to give a rate reduction arising out of earnings in excess of the allowed return. Instead of returning all of the excess revenue to ratepayers in the form of price cuts, SCB was allowed to "...recover its depreciation reserve deficiency over a period of 36 months beginning October 1, 1988." Order, p. 17. The Kentucky approach might be extended by allowing the company either to share with its ratepayers when it over-earns or to use all excess earnings to reduce the reserve deficiency. An extension of the Kentucky plan would seem to be worthy of further research.

In the absence of constructive proposals, the future of telecommunications may be plagued by insufficient capital recovery and investment and, therefore, by lower quality
service and innovation at a time when the information age is demanding better service than ever. For LECs this would mean the loss of scale and scope economies. If these are lost, this is a loss not just to the LECs but also to society as a whole. Our proposal may avoid some of these problems. As a next step, it would be useful to quantify the benefits of this proposal for a specific case, and to determine how these benefits might be shared between ratepayers and the company.
Appendix

Illustrating the Proposed Incentive Regulation Scheme:
The Firm’s Choice of X-Factor and Capital Recovery Factor

If LECs and their ratepayers are to benefit fully from the current technological change increased investment, and therefore more rapid capital recovery, are required. However, given the current climate of price-cap regulation, regulators are unlikely to agree to faster capital recovery unless ratepayers are made better off. This is particularly important because the effect of increased capital recovery is to raise prices initially and lower them later as the productivity benefits of increased capital recovery and investment take effect. But clearly an attractive carrot has to be held out to the regulator if he is going to risk allowing a higher price now on the promise of a lower price later.

In line with the current regulatory mindset on price caps, we argue that the firm should have a higher capital recovery rate and a higher rate of investment if, over the time horizon of the scheme, both the firm and ratepayers are demonstrably better off. This could happen if the additional investment resulting from the increased rate of capital recovery resulted in lower operating costs, a lower cost of capital, or increased quality of service or some combination thereof. In this simple example, technological change is assumed to affect only operating costs. A further simplifying assumption is that there is no demand growth arising from the addition of new product lines or improved quality. In this simple case, meeting the obligations of the X-factor occurs through cost cutting alone. Thus, the firm estimates the effect on variable costs of various levels of investment. The firm then calculates an X-factor that will make both it and the ratepayers better off compared to the Base Case, assuming that demand continues at the same level.20

In Table 1, we show the results of some simulations of the proposed scheme.21 The Base Case assumes a capital recovery rate of 7%, which is reinvested in its entirety, an X-factor of 3% and an implied decline in variable costs of 4.93%. It is important to note that variable costs must decline at a significantly higher rate than the X-factor if the company is to meet the obligations implied by the X-factor through cost cutting alone.

Comparable to the Base Case is the Pareto Neutral Case shown below the Base Case in Table 1. This case assumes an increased capital recovery rate of 9%. Given the rate base of $200, this implies an increase in the initial price cap index of 4%. We compute for this increased capital recovery rate the required X-factor, according to equation (1), which makes ratepayers just indifferent between the this case and the Base Case. This leads to an X-factor of 5.22% and an implied rate of decline of variable costs of 9.55%. If the company can use the increased capital recovery to achieve better than 9.55% decline in variable costs, then

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20 If demand increases with time or willingness-to-pay increases with time, then, as noted in the text, the benefits of the proposed incentive scheme will be even greater.

21 We ignore here capital structure issues. In practice, telephone companies have historically been fairly highly leveraged. This would reduce somewhat the decline in variable costs needed to achieve a given X-factor in the examples below.
both the company and consumers can be better off. If the company cannot achieve this 9.55% decline, then it would be better off staying with the Base Case.

This simulation illustrates that the benefits of technological change will need to flow not just to reducing variable costs but also work through demand, because the kind of cost reductions implied here are probably unrealistically large. Other sources of the benefits other than cost reductions have to be found to give back a significant increase in the X-factor. These include new products, changes in relative prices, growth in revenue of existing products, and substitution of capital for labor.
REFERENCES


Table 1

DEFINITION OF VARIABLES

X = X FACTOR, DVC = DECLINE IN VARIABLE COST, CR = ALLOWED CAPITAL RECOVERY, PR = PROFIT, RB = RATE BASE, AP = ALLOWED PROFIT, RT = TARGET ALLOWED ROR. I = INVESTMENT, IF = INVESTMENT FACTOR, VC = T VARIABLE COST, PV = NET PRESENT VALUE.

BASE CASE

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$341.82 $86.51 $86.51 PV

Notice that for the base case a decline in variable cost of almost 5% is required just to meet the productivity target.

PARETO NEUTRAL CASE (BREAKEVEN) WITH INCREASED CAPITAL RECOV

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$341.82 $86.51 $86.51 PV
\[ A = (X_0, \delta_0) = \text{Benchmark Scenario} \]

\[ B = (X_1, \delta_1) = \text{Alternative Scenario with identical profit and welfare consequences to } (X_0, \delta_0) \]

\[ AC = \text{Direction of joint improvement for both ratepayers and the company} \]

Note: \[ \Pi_0 < \Pi_1, W_0 < W_1 \]

**FIGURE 1**

**ILLUSTRATING RESPONSIVE INCENTIVE REGULATION**