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THE QUALITY OF REGULATION IN REGULATING QUALITY: A Proposal for an Integrated Incentive Approach to Telephone Service Performance

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1. Introduction

This article surveys the post-divestiture trend of service quality in the public telephone network and proposes an incentive system for assuring such service quality, while providing greater flexibility to telephone companies in reaching high quality standards. The approach could be part of a price formula involving inflation and productivity; it could also be applied under different regulatory arrangements.

The importance of understanding and measuring the quality of telecommunication services has grown with the turn towards price formulas and incentive forms of regulation and away from pure rate-of-return systems. A price-based regulatory mechanism provides incentives to cut cost, which is good up to a point, but may also lead to undesirable corner-cutting. Any price-based regulation, including a moratorium approach such as New York's, is relevant only in reference to some quality measure. Otherwise, where competition is inadequate, a hidden price increase could be imposed through quality deterioration, or improvements may be forsaken because no financial reward for them is forthcoming.

For a long time, service quality was a subject discussed in the context of the AT&T divestiture. It was greatly feared that a more competitive and decentralized environment would lead to serious service degradation because the local exchange companies would be starved for investment funds. But though many people still firmly believe that these fears have become a reality, there is little evidence to support this view. Section 2 of this discussion provides information on the trend of a quality. The absence of divestiture-induced calamities does not prove that there should be no concern, nor does attention to quality imply that it has deteriorated. In a transmission sequence of multiple carriers, a signal quality will not normally be better than its "weakest link." Hence, a bottleneck carrier with

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inferior quality could obviate the efforts of the carriers for higher quality, especially if they compete with each other. Thus, through "quality-matching," overall quality would decline. This would not be the case in a monopoly system with end-to-end responsibility, because a sequential upgrade of quality in the various network element would make more sense. This is a long-term problem that may not be reflected in the data.

The absence of a proper incentive structure in a new regulatory system could lead, over time, to a slide in quality and the aggregation of deficiencies. These can, at some point, accelerate; the experience of telephone service problems in New York City in the early 1970s is a lesson worth remembering. Much better than overcoming crises in the future would be to institute a rational system today that would reward quality, discourage decline, and permit reasoned managerial planning.

The article, in its Part 4, proposes such a mechanism that could be integrated in a more general price-cap formula. Before moving to the proposal itself, the context will be set by discussing the conceptual difficulties of dealing with quality (Part 2), and providing empirical evidence for the experience of the post-divestiture years (Part 3).

2. The Quality Quagmire: Definitional Dilemma and Measuring Morass

Measuring the quality of telephone service seems to be a deceptively straightforward empirical question. But the difficulties start with the basic definition. The term "quality' has many dimensions: reliability, accuracy, security, simplicity, flexibility, speed, availability, responsiveness, courtesy—to name but the most obvious (Richters and Dvorak, 1988, 24-35). It also covers many sub-systems, such as transmission, switches, directory service, repair, technical support, coin telephones, etc. Next, there are measuring problems. Some of the quality dimensions can be measured directly and objectively; others only indirectly; still others require subjective assessments that may well change over time.

On the positive side, quality is one issue whose analysis is not stymied by a scarcity of data, at least not on the supply side. To the contrary. For their own operational use, the Bell Operating Companies routinely and continuously collect well over 100 service measurements. The costs of these measurements is part of operations and difficult to identify, but it has been estimated as high as several hundred million dollars per year (Gryb, 1990). On the other hand, information about the demand side—price-quality valuation and tradeoffs by end-users—is limited.

But the main problem is not data but the conceptual ability to handle them, and of linking them to broader regulatory policy.

A literature survey on the subject of telecommunications modernization by the state regulatory commissions' think tank NRRI includes in a 23 page bibliography no citation on service quality (Lawton, 1988, 87-114), indicating the absence of

policy analysis articles on the subject. There is, of course, in-house work by telcos, but most is not publicly available, and the work is of a traffic-engineering or operations research type with little regulatory reference. (For an excellent exception, see Buzas, Lynch, and Berg, 1989.)

Part of the problem is that economic analysis does not provide unambiguous answers on what to expect to happen to quality—whatever socially optimal quality is—as regulatory restrictions are being reduced. "Economists now have at their disposal a well-developed body of analysis dealing with price and quality behavior in various market structures, but they have no comparable body of analysis relating to the qualitative and alterable attributes of products that consumers value." (Sheshinski, 1976) This has led to disagreement even on basic points. Starting with Wicksell (1934) and Chamberlin (1948), the literature held that a monopolist would provide lower quality then a competitive industry with similar cost conditions. (Dorfman and Steiner, 1954, 826-836; Rosse, 1972; Panzar, 1975; Spence, 1975, 417-429) But this thinking was challenged by Swan and then Levhari and Peles who found market structure to have no impact on quality. This non-intuitive result was first viewed as depending on seven strict assumptions, but subsequent work (Schmalensee, 1979, 177-196) showed that several of them could be relaxed. Swan's argument still holds under certain conditions, including constant returns to scale. One view is that a regulated monopoly, having to lower rates, may also lower quality. But this, too, has been disputed. Some authors found that price regulation or a maximum price ceiling may actually improve quality (Schmalensee, 1970, 54-64; Besanko, Donnenfeld and White, 1988, 411-429). For example, an unregulated monopolist sets quality especially low for those users who hold weak preference for quality in order to be able to charge an extra premium to users with a high quality preference. If a price cap is set on the latter price, the lower quality of the option will rise. But other analyses found that under certain conditions price regulation lowers quality (Kihlstrom and Levhari, 1977, 214-234).

The only thing these studies seem to agree on is to treat quality as a one-dimensional variable for analytical convenience. For regulation, however, such simplification does not work. Thus, the economic literature is of only limited help. Taking instead an empirical look at the telecommunications sector, it is plain that liberalization of entry and competition has led in recent years to manifestations of rivalry in quality.[1] For example, AT&T's 1989 advertising includes claims that MCI's fax network leads to 87% more unreadable pages than if AT&T had been chosen. US Sprint, similarly, stressed the signal quality of its all-fiber network that lets the user "hear a pin drop"—until it was challenged on the accuracy of that claim. But it should be noted that user choice need not necessarily be used to select higher quality. Given the option, many customers could well select lower technical quality if the price is right. Some users prefer a jalopy to a Cadillac.

Furthermore, the advantages of competition may be partly or fully offset by reducing overall economies of scale and scope, and by adding technical incompatibilities and planning problems—between different networks, between networks and customer equipment, and between equipment types. And while these

arguments have lost weight by some self-serving use in the past, they cannot be ignored.

The quality question gets further tangled in the issue of overcapitalization. In the United States, under the rate-of-return regime, it was alleged that regulated utilities had incentives to overcapitalize and to gold-plate, because they arguably could obtain an assured return, in contrast to, for example, expenses on labor: the Averch-Johnson effect. A more competitive regime may well reduce such incentive to overcapitalization and lead to an economically more efficient, but lower quality system.[2] Is this necessarily bad?

Another problem is that customer sovereignty may lead to technical solutions that improve some features, while reducing others, with an indeterminate impact on overall quality. For example, a private packet network provides control and flexibility, but can also cause transmission impairments, such as speech clipping, clicking, and echoes due to packet discarding, misdelivery, and congestion delay (Takehashi, 1988, 17-23). From the perspective of the actual users of this network, overall quality may have declined, while the advantages are reaped by other parts of their organization.

To complicate things still further, quality is not a static concept but a relation between performance and requirements. Since the latter are rising, what constitutes good quality is a moving target. What was good enough yesterday may not be enough today, and not just because we tend to take past luxuries soon for granted, but also because past standards move from being merely convenient to being vital. Society depends more and more on the availability of telephone service. An example follows.

In 1988, fire destroyed an Illinois Bell telephone exchange in the Chicago suburb of Hinsdale. As a result, communications between regional air traffic controllers and O'Hare Airport, the nation's largest, were closed down, as were hotel and airlines reservation centers, mail order sales facilities, and the national reservation system for 12,500 florists—on Mother's Day (Block and Levine, 1988, 9-10).

Similarly, one-third of regional Illinois automated bank teller machines ceased to function, and hundreds of financial institutions had serious problems in their electronic transfers, with some having to resort to cellular phones operated by the Federal Reserve from a van on a classified and shifting street corner. It took several months to fully restore service at Hinsdale.

A similar demonstration of vulnerability occurred when, in 1985, a computer breakdown at the Bank of New York, lasting less than a day, caused a cash deficit that required the bank to borrow $24 billion overnight from the Federal Reserve Bank (letter from Levine to Hesser, 1988). One can imagine the impact of a more extended breakdown lasting longer and affecting other institutions, as would be the case if telecommunications were to fail.

Vulnerability has also been added by fiber optic transmission. While fiber optic lines are more weather resistant than microwave links, they carry much more traffic and are much harder to repair, so that the failure of such a high-capacity system is

potentially more disastrous than that of microwave and coaxial systems (Kraushaar, 1988).

By becoming increasingly dependent on high-tech communications flows, advanced societies also put themselves at risk. In consequence, demands on several dimensions of service quality increase because failure becomes unacceptable.

3. Quality: An Empirical Look at the Post-Divestiture Trend

3.1 A Lost Golden Age?

We can now move to the next section of this discussion and deal with the empirical question: Has service improved or declined in the U.S. in recent years? An important observation at the outset is that, contrary to the nostalgia for the Bell monopoly, there never was a golden age of quality. In the late 1960s and early 1970s, several major cities experienced serious service problems. For example, the state's major local exchange carrier New York Telephone's service quality declined, largely due to conservative demand forecasting by AT&T's headquarters, maintenance problems, and skills shortages. The *New York Times*, in an editorial in August, 1969, called telephone service "miserable," "wretched," and "the worst in the memory of older New Yorkers...." Figure 1 shows a major peak in consumer

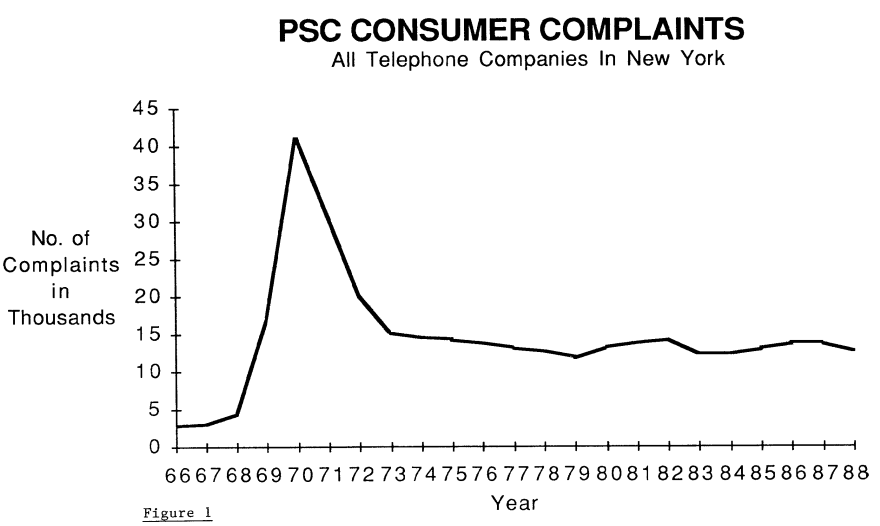


Figure 1

Source: New York State Public Service Commission, Consumer Service Division

complaints at that time (preceding much of deregulation, and suggesting that there was a fertile ground for the entry of new service and equipment providers). Notice, too, that the number of complaints has held steady in the past decade of deregulation and divestiture, despite the slightly and steadily increasing number of subscribers.

The first beneficiary of the quality crisis of the early 1970s was the New York State Public Service Commission (PUC) itself, whose telecommunications staff was almost quadrupled by Gov. Rockefeller from an inadequate 25 to 95.

One of the early things the new staff did was to develop telephone service standards, which were at the time, 1972, probably the nation's strictest and were criticized as such by the telephone industry.

Also instituted was an exemplary monitoring system which created incentive for better service to avoid negative publicity, and established the Basic Service Index (BSI) with customer rebates of up to 20% (out of telephone companies profits) if service quality in their central office drops to "weakspot" levels for three consecutive months or more, and not due to natural disasters. The BSI, the first plan in the U.S. to provide an automatic link of service deterioration and rates, consists of numerical scores for exchanges (above about 3,000 lines) for five (now seven) factors: customer trouble reports; equipment irregularities; overflows; dial tone speed; and incoming matching loss.

For all the telcos' dire predictions, only about $200,000 were actually rebated to customers during 1972 and none since then, even though the standards were twice tightened and broadened, most recently in 1989.

3.2 Post-Divestiture Quality Trends

3.2.1. Federal

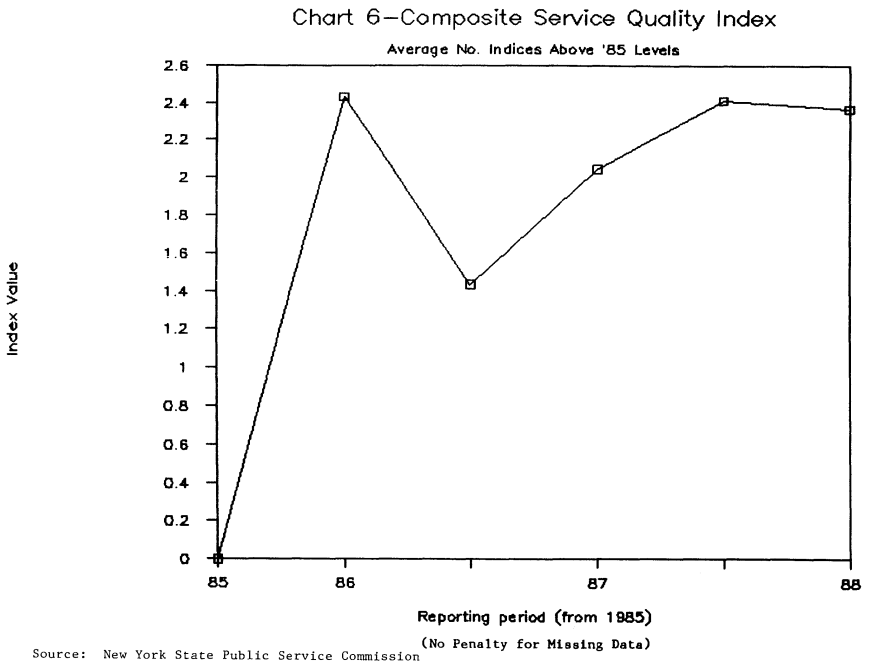
This brings us to the present. What has happened in recent years? Since telecommunications are regulated by at least 52 different entities, consistent data on national trends in service performance are difficult to come by. The FCC, commendably, has collected data since 1985, a highly complex task (Kraushaar, 1989). These are its broad findings: since divestiture, the (subjective) satisfaction of large users has greatly increased from 90.3% to 94.5% in 1988, while that of small businesses has risen slightly to 94.2%. Residential customers' level of satisfaction has remained relatively flat, but still high, at 93-94%.

Using more objective technical measurements, the percent of entities meeting FCC dial tone standards has gone up[3] from 97.6% in 1985 to 98.8% in 1988.

Similarly, transmission quality (consisting of signal noise, balance, loss, and distortion) has somewhat improved (from 90% to 94.3% of entities meeting objectives), and percent of call completion (network blocking) is slightly up, to a high 99.1.

On the other hand, the manpower-intensive on-time completion of service orders slightly declined for residential users, decreasing from 98% in 1985 to about 97% in 1988 while remaining generally flat around 98% for business users.

Figure 2



Source: New York State Public Service Commission

Figure 2 provides the FCC's overall assessment of service quality. The index chosen, however, is extremely simple measure—a summary of the five factors described above, each rating a +1 or -1 if it has moved either up or down since 1985. Overall, the FCC index shows an increase in quality, especially initially. And it concludes: "The composite average index...reveals that typically service is as good or better than in 1985..." (Kraushaar, 1989).

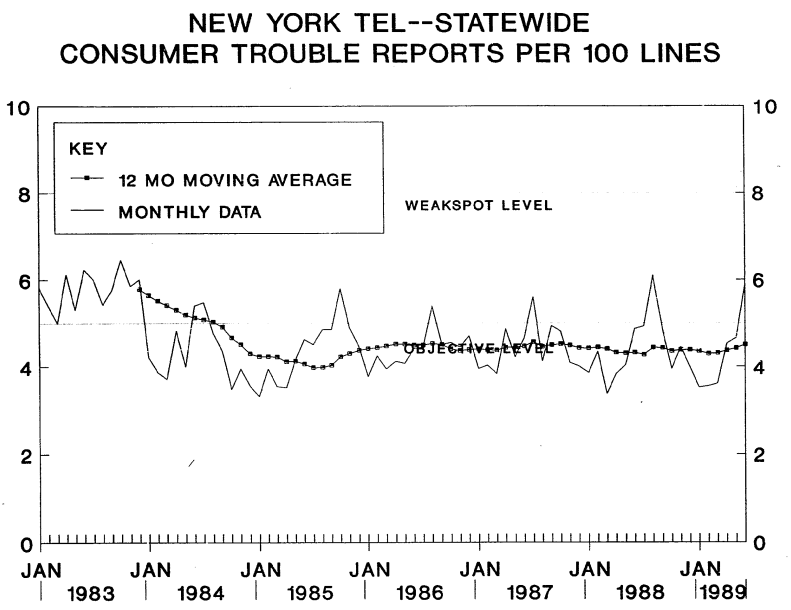
3.2.2. The States

Most of service quality monitoring has been at the state level. In quality measurement, several of the states have more experience and involvement than the FCC.

Data will be provided for two states whose data collection is especially strong: a time series for New York, and a cross-section for Florida. (New York PSC, 1989).

In New York, as can be seen in figure 3, consumer trouble reports per 100 lines of New York Tel service have largely been flat (at about 4.2) since 1986 (New York PSC, 1989). They were slightly higher than in 1985, which was, however, a much better year than 1983 and 84 (and much lower than the early 1970s; see figure

Figure 3

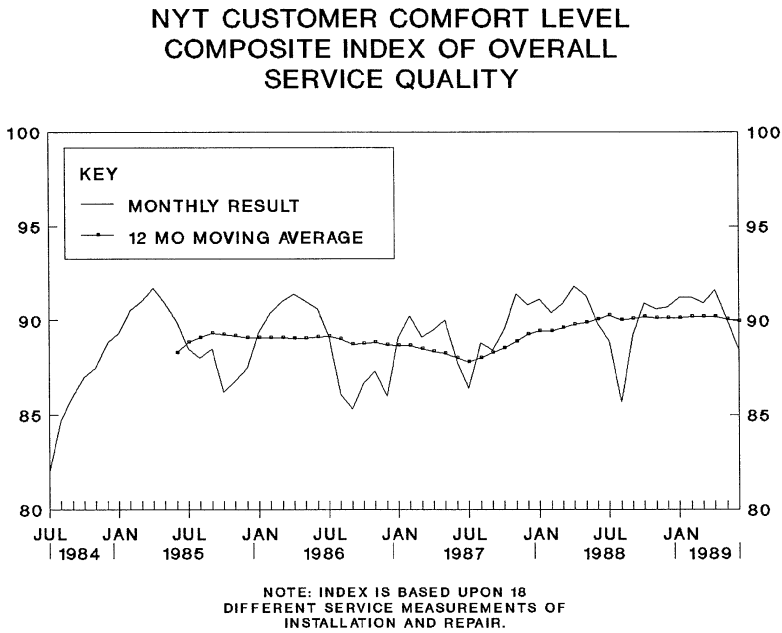


Source: New York State Public Service Commission, Consumer Service Division

1). The number of lines out of service for over 24 hours has declined, after an initial increase, to almost its 1984 level, which was lower than 1983.

NY Tel's own surveys indicate that its largest customers today are much more satisfied (98%) with service than immediately after divestiture (65%); that medium-size businesses' level of satisfaction has held steady; and that small users' "comfort level" has slightly improved, after an initial gentle slide (figure 4). Aggregate data, however, may mask localized deterioration. In New York, this was a particular problem in the City outer boroughs of Brooklyn, Queens, and the Bronx. Quality declined there until 1987, prompting regulatory intervention and company commitment, which led to quality improvements to levels superior to those in 1985. Furthermore, the complaint rate to the PSC is higher for NY Tel (about 1.2 complaints/year per 1,000 lines in 1988) than it is for the independent telcos (the six largest of which range between .3-.6 complaints/year per 1,000 lines for the same period). Also, the trend for these companies is to a lower complaint rate, while NY Tel's is flat. Furthermore, since rates have been stable in the past two years, complaints over billing are likely to have dropped off. Thus, a flat overall complaint rate may include an increase in complaints over quality. There have also been problems in NY Tel's on-premises visits, a labor-intensive service.

Figure 4



Source: New York State Public Service Commission, Consumer Service Division

Missed home service calls increased (from 10% to 15%), especially at first after divestiture, with some improvement since.

But with these qualifications, it appears that most quality measures have stayed stable and even improved slightly. A recent staff report on service quality to the New York Commission (second quarter, 1989) shows an overall improving trend for consumer trouble reports; only four of 654 offices experienced three consecutive-months "weakspot" level service in the first quarter of 1989. "This result was the best first quarter result since divestiture..." (New York PSC, 1989).

The second state for which good information—in this case cross-section data—is available is Florida.

The Florida PSC tested for comparative quality measures for 13 long-distance companies (table 1). The firms uniformly perform at a much higher level than the required 90% call completion rate (1 minus network blocking probability), with the best performer US Sprint at 97.45%, and the lowest Telecommunication Service Corp, at 94.11%. AT&T, for all of its economies of scale, is ranked only fourth with 97%. But the differences are really quite small.

Table 1. Quality for Long-Distance Companies

IXC	% Completions	Noise (Metallic)	Noise (Impulse)	Insertion Loss
American Telephone & Telegraph	97.00	17.0	5	2.5
United States Transmission Systems, Inc.	96.69	18.0	0	2.0
MCI Telecommunications, Corp.	96.69	13.0	0	2.0
Microtel, Inc.	96.18	12.5	0	2.0
Metromedia Long Distance, Inc.	96.73	21.0	3	2.1
SouthernNet Services, Inc.	96.73	9.5	0	2.1
Telus Communications, Inc.	96.56	15.0	2	0.5
Telecommunications Service Corp.	94.10	13.0	4	2.1
Transcall American Inc.	96.51	11.5	1	2.3
South Tel, Inc.	97.37	17.5	2	2.0
United Telephone Long Distance, Inc.	97.06	12.5	0	2.0
U.S. Sprint, 97.45	11.8	0	2.0	
Western Union Telegraph Co.	95.85	31.0	1	1.8

Source: Florida PSC, Various Tables 1989.

Table 1 compares transmission performance of the long-distance companies for noise and loss. (Lower numbers generally indicate better quality.) According to these figures, AT&T does not perform all that in these measures in comparison with some of its competitors.

When it comes to billing accuracy, only one firm (Southern Net) was found to be overtiming. Four firms were undertiming (including Southern Net). And three companies, including Western Union, apparently did not bill for completed calls!

The Florida PSC also collected comparative data for four local exchange companies. For dial tone delay, answer time (operators, directory assistance, etc.), directory assistance, service availability, etc., the quality of service was found to be substantially above required standards. For public telephone service, however, it was often below standards.

The Florida figures do not provide a time trend, but they show that, whether quality has gotten better or worse, it has almost always been very high in relation to standards.

3.2.3 International

It is also useful to briefly compare the U.S. data with other countries. (See more generally, Noam, forthcoming.)

In Great Britain, the establishment of an independent regulatory oversight agency revealed the serious service problems of a telephone system with a history of antiquated plant and traditional management. Oftel, the regulatory body, received so many complaints that it considered instituting damage liability against

British Telecom. A BT line averaged a technical problem every two years, ten times the rate of the Bell companies in the U.S. Even BT conceded the fault rate to be two to three times higher than in the US. (Hudson, 1987).

Table 2. Performance Comparison: New York Telephone Company vs. British Telecom

	New York Tel	British Telecom
Operator Response	Average 4 sec.	87% within 15 sec.
Long Distance Blocking	<1%	3.6%
Service Orders Filled	92% within 5 business days	62.2% withing 8 business days
Complaints to Company per Line	.04	.22
Complaints Cleared	75-80% within 24 hours	74% within 5 hours 90.2% within 2 days

Source: BT and Communication to the author by NYT, 1988.

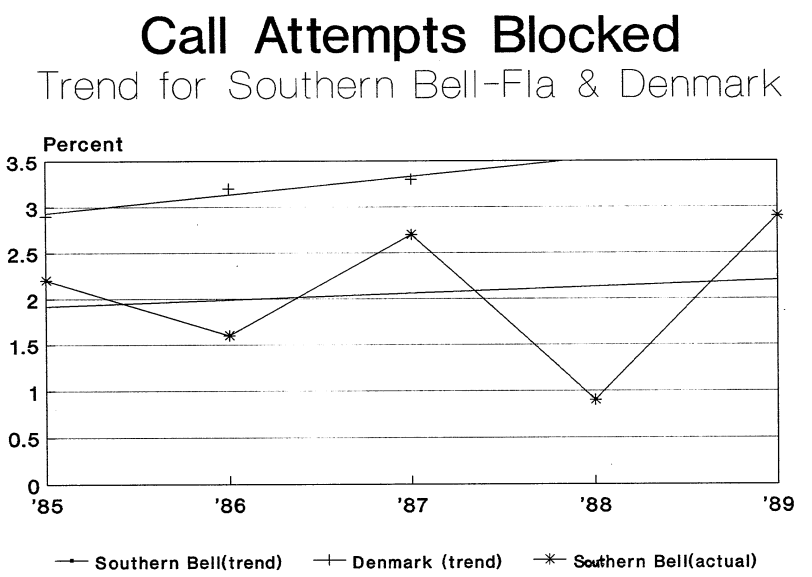
Table 2 provides a service quality comparison. Of all telephone calls made to operators in March, 1988, 86.7% were answered by BT within 15 seconds. In comparison, New York Telephone reported that in July, 1988 calls to operators were answered within four seconds on average. Of long-distance call attempts, less than 1% of the failures were attributable to New York Telephone. In contrast, 3.6% of long-distance calls failed because of BT. In the same year, 62.2% of BT telephone orders were filled within eight working days. There were 0.22 complaint reports received per telephone. Of those, 74% were cleared up within five hours and 90.2% within two working days. For NYT, approximately 92% of telephone orders were filled within five business days. There were 0.04 complaints received per telephone line, and of these 75-80% were corrected within 24 hours.

Particular serious problems existed in the UK for coin telephones. A 1985 survey by the Daily Mail showed almost 60% of public telephones out of order at any given time. Oftel commissioned its own study, which found a still extraordinary rate of 50%. Over two years of effort aimed at improving this dismal state produced improvements: at the end of 1987, Oftel found 23% of public phones out of order, and less than 10% by mid 1988 (Oftel, 1988). In 1988, service complaints began to decline somewhat. Problems remained for directory inquiries (20-25% failures), complaints handling, and telephone selling.

As a second country, Denmark is described briefly, because its telecommunications system is similar in structure to that of the U.S.—several regional exchange companies and a national interexchange carrier. But there is no competition and little deregulation outside of customer premises equipment (CPE) and value added networks (VANs).

Blockage for Danish test calls declined up to 1983, but increased again thereafter. A comparison with the U.S. company Southern Bell (figure 5) shows the Danish blockage probability to be about 50% higher, and worsening at a faster rate.

Figure 5



Source: Florida PSC: Danish Ministry of Transportation & Communication

4. Instituting an Integrated System of Quality Incentives

We can now move to the next section and propose an operational way to integrate quality performance with regulatory policy.

Is quality regulation necessary? We have found that service quality, on the whole, has not deteriorated. If it ain't broke, why fix it? The answer is that quality is presently fairly strictly regulated in numerous, usually disconnected, and inflexible ways that make the achievement of overall enduser satisfaction more costly than need be. Quality performance is rarely integrated with economic performance, except for truly substandard situations. The traditional approach reflects a technological rather than economic outlook. Ideally, the two would be merged. Furthermore, if regulation continues to be shifted in many jurisdictions from that of rate of return to prices, quality performance is under pressures not experienced in the past. Spence, for example, finds attractive second-best benefits of rate-of-return regulation to quality performance, which presumably would be lost without such regulation (Spence, 1975, 417-429). In the local exchange and the distribution plant where most quality problems occur, alternative user choices do not yet appear available in most instances to protect quality through competition.

Furthermore, the network system is non-transparent to most of its users. In a transmission chain of several carriers, which one is to be blamed for faulty quality? This difficulty to identify the culprit can encourage "free riding" by a carrier to weaken the quality of its own link. This, in turn, can lead to a quality downgrading by other carriers, since it may make no sense to provide quality at a level higher than the weakest link. Indeed, competitive forces and the absence of an end-to-end responsibility may reduce quality to that lowest performance level.

Finally, there may be selective quality deterioration possibly in poor neighborhoods, which must be identified and dealt with.

One should not assume, a priori, that higher quality is always better. Under many circumstances, it would be best if several quality options would be available to users at different prices. User choice would then settle many quality issues. However, for most services it is not feasible to provide a "Chinese menu" of quality grades. Furthermore, user choice may impose negative externalities: in an interconnected network, one subscriber's low-quality choice negatively affects those who call her. A's fax transmission may take twice as long if B chooses a poor grade of service. Thus, certain basic levels of quality should be protected, while higher grades should be left to choice, where technically feasible.

On the whole, the data presented in the previous section indicate that along several dimensions, service quality in the past six years following divestiture has improved in the U.S. for large users and has remained basically stable for residential users. Several other quality variables, however, have declined. And while they appear to be fewer, such judgment is subjective to some extent. How then can one evaluate the trend of overall service quality? To do so requires us to find some global quality measure, and this will be done in the following. Where economists think about quality they invariably assume, for mathematical convenience, a single dimension measure. The marketing literature is more helpful here (Louviere, 1984; Lynch, 1985, 1-19). This discussion has benefitted from the excellent work by Buzas, Lynch, and Berg (1990). But it differs from it in the treatment of weights, adds the connection of quality to incentives which the authors do not reach, provides floors and caps, and an adjustment mechanism for variance.

One could, of course, avoid any summary statistic. But this only means that any judgment on quality improvement that goes beyond a single dimension will be implicit and subjective, with an unavoidable result regulatory informational overload, and that inconsistent, inefficient, or unfair decisions may result.

To measure quality in an overall fashion and to link performance with financial rewards and penalties requires the several steps which follow:

Step 1: Selecting quality dimensions.

We must define which dimensions of service are relevant. These dimensions should be preferably those that can be objectively and easily measured, which are subject to the control of the local exchange company, and (to simplify matters), for which performance standards already have been established.[4] A sample of such dimensions is

1. Dial tone delay
2. Call completion
   (a) intra-office
   (b) inter-office
   (c) extended area service
3. Installation lag
4. Repair service
   (a) 24 hour and more restoration
   (b) missed appointments
5. Emergency (911) service conduit
6. Public telephones
   (a) functionality
   (b) availability
7. Response time
   (a) operator
   (b) directory assistance
   (c) business repair office
8. Directory assistance
   (a) search time
   (b) update

For purposes of notation, we designate the various quality criteria by *i*.

Virtually all of these and additional service criteria already are being collected by telcos as part of their operations.

It might be argued that a very short list of criteria may capture the broad trend of quality at greater simplicity (Newstead, 1989). But if an automatic link of quality to financial reward is adopted, as is proposed below, and if one has a list that is too abbreviated, companies would concentrate solely on the few listed criteria and neglect the others. For example, if consumer complaints are the only criterion of an incentive formula, quality may be dropped for operator assistance response time or directory assistance update, since few users would bother to complain about them. Complaints tend to be caused by a significantly deteriorated performance that causes a major inconvenience. Gradual decline, or inadequate service on small matters, will not lead to many complaints, even if it affects millions, while a few hours of service interruption due to a fallen tree can generate numerous complaints. Complaint rates can also be manipulated by organized campaigns.

On the other hand, one can consciously omit certain factors from the list as a policy decision to leave their quality to company discretion or to competitive forces.

It makes sense to have separate lists of criteria for residential service, business service, and public coin telephone. If an automatic link of quality to financial compensation is set, separated quality accounting would prevent residential users from potentially having to cross-subsidize quality improvements aimed at business

customers, and vice versa. Quality performance in coin telephones could be dealt with in a different manner.

Step 2: Define quality standards.

For all or most of the quality criteria, there already exist expected quality standards.[5] We designate them with $S(i)$. The proposal does not aim to modify these standards.

Step 3: Assign weights to quality performance.

The factors of quality defined in Step 1 are not likely to have equal importance. Inadequate functioning of transmission for a 911 emergency service is probably a more serious matter than a slow response time of a business office. Therefore, one should assign weights to the various quality factors. More accurately, the weights should be for deviation from standard, for example, for a 10% and 10% under-performance in response time for business offices.[6]

How can these weights be found?

There are several possibilities.

1. Revealed preference. In a competitive environment, an analysis of user choices could measure the preference for various quality dimensions (hedonic pricing analysis). Unfortunately, such user choice is rarely available to residential customers for local service.

2. User and expert surveys. Users' views need be ascertained, because their perceptions about quality, after all, are the ultimate test. But most users are not likely to have spent much time thinking about dial-tone delay, etc., so there is a need for expert involvement, too. Experts, on the other hand, may overemphasize aspects of little utility to users.

Based on the user and expert surveys, and of industry and outside evidence, a set of weights $W(i)$ for various quality performance can be established by, for example, a Delphi-type convergence process, and by negotiation.[7] They can then be standardized so that their sum equals 1.0.

Once one has set the weights, it is easy to define overall average quality Q^* as the sum of the relative quality performances $Q(i)$ (actual performance $P(i)$ to standards $S(i)$), multiplied by the weight $w(i)$.

$$Q^* = \sum Q(i)\, W(i),$$

where

$$Q(i) = \frac{P(i) - S(i)}{S(i)}.$$

There is a problem that requires an adjustment of the weights. Averages may mask some very low performances. Suppose, for example, that there are three equal-sized exchanges, and their average quality on dial-tone may be 10 seconds.

However, this may be composed of one exchange enjoying a zero-second wait, while the other is struggling with a very poor 20-second wait.

One way to deal with this variance is multiply the average performance for each quality dimension with an adjustment factor $A(i)$, which is equal to 1 when there are no deviations from the average, and is less than 1 according to the negative deviations (in %) weighted by the subscribers involved (in %). For example, a (10, 10, 10) seconds performance gets an adjustment factor of 1 - 0 = 1, while a (5, 10, 15) performance gets an adjustment factor of 1 - (.33 X .5) = .835.

To eliminate purely random deviations around a mean, one should probably drop consideration of the first 10% of deviation.

More formally, the adjustment factor is

$$A(i) = 1 - \sum_{j=-2} R(j)\,[x(ij) - s(i)]^{8},$$

where $R(j)$ denotes the percentage of users for a negative deviation of actual performance X from standards.

Then, adjusted quality is

$$Q'(i) = \frac{[P(i) \cdot A(i)] - S(i)}{S(i)}.$$

And overall quality Q^* is

$$Q^* = \sum Q'(i)\, W(i).$$

Where all standards are met exactly, all $P(i)$ are equal to $S(i)$, all adjustment factors are $A(i)$ are equal to 1, all $Q'(i)$ are equal to 0, and the summary Q^* is also zero. Where there is over- or underperformance, Q^* will be positive or negative, respectively.

Step 4: Monitor quality.

With this system we can now measure quality performance of a company (differentiated for service to residential and business customers, and public coin telephones). If the company's score is zero or positive, it is performing at the required level or above.

It is important to recognize the flexibility of this system; a company may fail one or several quality standards as long as it made up for this through overperformance in other standards. Instead of insisting on meeting every one of many criteria, one can add efficiency and flexibility by requiring instead an overall score. A company would have to meet $Q^* = 0$ (adjusted for variance). If it fails to meet some standards, it can offset this by a higher performance in others. (See also Buzas, Lynch, and Berg, 1990.[9])

If improvements on all dimensions would cost the same, improvements would first be undertaken for factors with a large weight, and where performance varies greatly across exchanges or users. If marginal improvements differ in cost, as seems likely, a company could calculate the optimal quality improvement strategy.

The results are more quality for the money, and greater managerial flexibility as each company is free to reach the overall score in its own way.

There can also be added flexibility for the regulator body:

1. Some quality dimensions can be taken out of the aggregation and made an absolute requirement with no tradeoff possibility. This may be the case for dimensions considered vital.

2. Some quality dimensions may be deregulated over time and dropped out of the aggregation, without necessarily deregulating others.

It may be objected that the aggregation of performance measures for various dimensions of service is undesirable, because it reduces the transparency of actual performance to commissioners, and because it countenances partial service deterioration as long as it is offset by improvements. And this could divert resources for improvement to the wrong uses.

There are several responses. First, the tradeoff across dimensions is based on a weight scheme that would assure that underperformance in important dimensions of quality would be very costly to the company. Additionally, one can add protections by setting floors on the deterioration of any dimension or by permitting no deterioration at all for some key dimensions. But the tradeoff mechanism as such would permit reaching a given level of overall quality at a lower cost to users, or, similarly, to reach a higher overall quality at a given cost. Second, there is no need to fear that once overall quality is at desired levels, regulators will not be interested in the details. It is the present system that raises an information problem insofar as the flood of the unweighted quality measures cannot be absorbed by regulators.

Aggregating across subscribers[10] can be similarly buttressed by adjustment factors, floors, and exemption from tradeoff. There is plenty of flexibility in the proposed system.

One could, of course, take a different route, that of requiring the performance of every standard for every customer and every service. Such a course may appear equitable, but it can easily lead to less overall quality, and not necessarily to more equity.

Most importantly, a disaggregated approach cannot be practicably linked to financial incentives. Or rather, if several quality dimensions are introduced into the overall price equation as a purported "disaggregation," in actuality an aggregation takes place across the common denominator "dollars," which permits a carrier to engage in tradeoffs anyway.

Step 5: Linking quality performance to financial incentives.

In an environment of price-cap or incentive regulation it is necessary to link quality performance to financial rewards. Otherwise, there is pressure for quality short-cuts. Such linkage was not possible in the past because the multiplicity of quality measures precluded an operational way to accomplish such a linkage, and because rate-of-return regulation put less pressure on cost-cutting. An exception were the customer rebates instituted in 1972 in New York that dealt with serious

and multiperiod deterioration in an exchange. But after 1973, no refunds were ever necessary, and the system must be seen as a safety-net rather than a differentiated instrument.

How can linkage of quality to financial rewards be accomplished? Generally, it means that where aggregate performance improves, there will be added rewards, while there will be negative rewards for underperformance. We should distinguish several situations.

1. Rate-of-return regulation.

Here, one could raise (or lower) allowed RoR for the next period, or permit rates to be raised without the extra revenue being counted against authorized RoR ceilings.

2. Price regulation.

Prices would be affected. If the price formula is such that price change is based on inflation and productivity, it would now also include a quality factor (see below).

3. Hybrid incentive systems.

In a hybrid system such as New York's present system, whose moratorium approach has a price control and a rate-of-return control element, one could establish the incentive in several ways, including:

(a) Raise or lower basic authorized RoR.

Incentives would not be effective unless a company performs above the basic authorized RoR.[11] At present, for example, this incentive would not work for NY Tel.

(b) Provide a different revenue split beyond the RoR. Again, this would be only effective above the sharing threshold.

(c) Accrue a reward or penalty as income, subject to collection (payment) in rates at the next rate change.

(d) Raise or lower maximum prices.

The most direct linkage is through prices: where quality is sub-standard, user prices are cut; where quality is above standard, they may be raised. This is equitable to ratepayers: poor service will cost them less than good service, because it is not the same thing. And it is fair to the company, which gets carrots for quality improvements, and sticks for deterioration. This is the approach recommended. It can be integrated with a more general price formula.

As mentioned above, the financial rewards and penalties should be calculated separately for service to residents, business users, and public coin telephones, so as to avoid cross-subsidization.[12] Where feasible, one could desegregate quality and rewards/penalties for specific services, such as for operator assistance or for repair calls. In most instances, however, payments are for a bundle of services and do not lend themselves to a disaggregation of incentives.

Some may object that, while penalties for sub-standard service make sense, there should be no reward to overperformance. Companies should deliver the best performance they can and expect no added incentives. A related objective is that overperformance is unnecessary, because standards are set just right. Thus, incen-

tives to do better would be simply an encouragement to gold-plating. There are several responses:

1. In the absence of direct user choice for quality options, regulators should help create a tradeoff schedule. Two quotes help make the point.

> Ideally the regulatory authority would manage price-quality tradeoffs by confronting the firm, on behalf of consumers, with a reaction function that reflects rates of substitution between price and quality on the demand side of the market. (Spence, 1975, 428)

> Any regulation scheme which is intended to induce optimal quality as well as quantity decisions must involve prices which are sensitive to quality variations.[13] (Kihlstrom and Levhari, 1977, 225)

2. If overperformance beyond standards is not valued at all, this will be reflected in the weights for such overperformance. Recall also that there is no need to have a symmetry of overperformance to underperformance. In other words, one could value the former only slightly, while attaching great significance to the latter. Gold-plating could also be dealt with by setting ceilings for rewards.

3. It is clear that many of the present standards are in no way an ideal in some absolute sense, but are selected relative to some notion of realistic attainability. A better performance would be of value. For example, a standard that 90% of all service interruptions must be restored within 24 hours is largely arbitrary and related to actual "realistic" ability to restore service. Improvements that would lead to 90% of restorations within two hours would certainly be better if technically and economically feasible. Hence, present standards should not be viewed as a ceiling.

4. The one available empirical survey study (Buzas et al., 1989) concludes that experts value an overperformance as much as an underperformance of similar magnitude.

5. It is short-sighted to be geared only to today's service expectations. As technology is advancing and as complexity is growing, regulators would do well to provide for positive incentives for quality to move forward. To do otherwise could be cutting off one's nose to spite one's face.

Importantly, expected quality need not be static. A commission could determine that technological trends lead to quality improvements, and that a company need therefore not be rewarded for matching the general trend. Similarly, a commission could pick a quality improvement it believes to be necessary, particularly in situations of deterioration.[14] This would be captured by reducing the measure for quality performance Q^* by a trend or target factor T.[15]

All this then results in the equation

$$T = I - V + N\,(Q^* - T),$$

where

T = price change
I = inflation = V = productivity change
N = incentive factor
Q^* = quality performance

T = trend factor of quality improvement.

Such adjustment can take place within or outside the sharing price mechanism. If the former is chosen it would halve the incentive, create a discontinuity, and an asymmetry relative to underperformance (though such asymmetry may actually be considered desirable). An alternative is to permit quality-based price adjustments outside an existing sharing mechanism.

Whichever way is chosen, the main question is at what level to set the quality incentive factor N. Set too low, there will be too little positive incentive, and possibly an incentive to gain by lowering quality. Set too high, there could be quality gold-plating, but also excessive penalties in a low-quality situation that could lead to still further underinvestment. There may be instances where quality deterioration accompany financial stress, and where penalties are counter-productive. But such fundamental problems in a company's viability should not be dealt with through the quality variable. They require different responses. Quality must be viewed separately, and setting N becomes partly a policy question, based on the extent of incentive to quality one wishes to provide, and partly a matter of experience. The challenge for policy and analysis is to establish a measure for N which induces optimal quality. Because there is little experience in this, one should add predictability by setting floors and ceilings. This would assure regulators, particularly in an initial phase, that the aggregation of quality will not lead to selective deteriorations that are unacceptable, or to excessive price effects. The model can flexibly accommodate this. Examples for such protections are:

1. A ceiling of maximum 1% price increase per year that are due to quality improvements.
2. A ceiling to RoR changes of a certain number of basis points, perhaps 25 (.25%).
3. A floor of 2% quality decline in a year or some such figure for a multiyear period. Beyond that, the automatic price-reductions would double, for example, and a company-PSC quality improvement schedule be established.
4. An unhitching of some quality dimensions from the aggregate incentive system by setting for them absolute values that must be reached, regardless of offsets. For example, if all reliability is valued to an extent that even a very high weight would not be acceptable as a tradeoff shadow price, it could be set to an absolute value, and any deviations from it would be dealt with outside the aggregate incentive mechanism.

Once the system is established, it should be automatic; this reduces uncertainty and encourages long-term planning.[16]

"Excess" quality improvements could also be carried into other years; one could even contemplate transfers and trade in quality bonuses across companies, within some limits. Or one could conceive, once experience is gained, of bidding mechanisms in which the lowest-cost qualified bidder to improve the quality of a service dimension in non-competitive services is selected.

It must be stressed that these quality incentives and standards should apply only to those services and rates which are still being actively regulated. For unregulated

services, one presumes that competition will provide users with adequate choice. But regulators should still maintain quality reporting and monitoring for a period after deregulation to ascertain the working of market forces for that service. Such monitoring may also lead to public reports that would assist in their choice of service providers, and it would provide data to ascertain that regulated services do not cross-subsidize unregulated ones.

5. Outlook

Although much of telecommunications regulation may gradually be on its way out, as long as monopoly bottlenecks persist, regulatory commissions will play a role. The quality variable, as the other side of the coin to price, requires attention, especially if price regulation is substituted for rate-of-return controls. It is better to provide the right incentives for improvements of quality, instead of micro-managing companies' quality investments and performance along each dimension. These incentives should be clear and automatic, so that companies can plan ahead and deploy resources flexibly. And they should permit regulators to assure a favorable trend of quality development. This proposal is meant to contribute to the development of such a system.

Notes

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1. One should also note that there is some quality rivalry even in a monopoly system through internal performance competition among corporate managers and sub-units.

2. Assuming, as most economists do, that quality is capital-intensive. If it is labor-intensive, the opposite would be the case. In the author's view, many quality dimensions are in the process of becoming labor-intensive rather than capital-intensive.

3. The graph scale is such that the improvement looks more dramatic than it actually is.

4. One could also include more subjective variables, such as company representatives' responsiveness, helpfulness, and courtesy. Measures could be obtained through surveys, and used as the other more technical variables. This would introduce a non-trivial added element of procedure and measurement, however.

5. These have been updated in New York as recently as 1989, and are not likely to require change. Several outstanding issues are under negotiation.

6. Assigning weights to performance relative to standards distinguishes this methodology from weighing factors' importance per se. Under the latter scheme, to find the actual quality score would then require the estimation of a second set of coefficients that would measure the relative significance of deviations from a standard, and a multiplication of the two sets of coefficients. If one omitted that step one would have to implicitly assume (1) linearity (2) equality of seriousness for deviations; and (3) symmetry. The present proposal overcomes these problems by collapsing the two measures into one. It asks, in effect, "How serious is a 10% deviation (or a 20% deviation, etc.) from the expected standard for operator response time?" rather than "How Important are operator responses?"

The weight system can be refined. For example, while some may be linear (e.g. a 20% shortfall has a score twice as great as 10%), it can also be more, or less than that. Furthermore, a 10% underperformance need not be symmetrical in weight to a 10% overperformance.

7. The PSC's BSI weights were arrived at by negotiation.

8. To set even higher disincentives against service variance, one could square the deviations (or factor by another number).

9. Temporary deterioration due to natural catastrophes or work stoppages should be factored out. Further flexibility can be provided by establishing separate schedules for different companies, based on their present performance. In that way, a company does not get specially rewarded for continuing to do what it already does.

10. Of course, this is the situation today, where multiple aggregations are typical within central offices, across central offices, and then across companies.

11. Strictly speaking, a company could be slightly above the authorized RoR, as long as the added incentive puts it above that rate.

12. For coin telephones, where small price changes are difficult, rewards and penalties may be instituted through some form of a more general true-up.

13. Both Spence and Kihlstrom point to the data problems.

14. Alternatively, a commission may conclude that there is gold-plating in some elements, and permit quality reduction by reducing their standards or reducing tradeoff potential.

15. This trend or target variable could be instead introduced into the definitions of standards (*i*).

16. Of course, if unusual events such as a major strike occur, equity calls for reconsideration.

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