EFFECTS OF INCREASED SUBSCRIBER-LINE CHARGE ON TOTAL SURPLUS AND GNP

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This paper provides rough estimates of how increases in the telephone subscriber-line charge in 1984, 1985, and 1986 affect total surplus and the gross national product (GNP). Only direct effects are considered; that is, we do not try to account for the effects of changes in the price of telephone service on prices and output quantities in other sectors of the economy. We find that the effects are large, and the effect on GNP is comparable to what Wharton Econometrics estimated.[1]

Background and Perspective

When telephone service in the U.S. was a regulated monopoly, local service was partially subsidized by revenues from long-distance service, which was therefore priced above cost. Now that competition has arrived in the long-distance market, which has the effect of driving prices toward costs, such a subsidy has become untenable.

In 1984, therefore, the Federal Communications Commision started to phase in a subscriber-line charge that businesses and residence subscribers pay to the local exchange carriers (LECs). It correspondingly began reducing the access charges that interexchange carriers (IXCs) pay to the LECs for interstate toll traffic. The subsidy has been embodied in these access charges.

Since June 1, 1986, the subscriber-line charge has been:

- $6.00 per line per month for multiline business service
- $3.00 per line per month for embedded Centrex
- $2.00 per line per month for single-line business and residential service
- Waived for low-income households that subscribe to the local telephone company's Lifeline service.

As subscriber-line charges that customers pay partially replace the access charges that IXCs pay, the price of interstate service should be reduced and that of local service increased, at least relative to what these prices would otherwise have been. As prices are thus brought more in line with costs, allocative efficiency should increase.

Wharton Econometric Forecasting Associates, Inc.—using the Wharton Econometrics Long-Term Model—has estimated how these changes and further anticipated increases in the subscriber-line charge should affect the U.S. economy.[1] Their calculations show beneficial results of a magnitude that many people find surprising. For example, they conclude that the steps taken in the subscriber-line charge program during 1985 and 1986 result in a $6.0 billion increase in real GNP (cumulative, over a three-year period) measured in 1985 dollars.

A motivation of this paper was to test the plausibility of such results. (However, we can only test direct effects, because we have not used anything like the Wharton Long-Term Model to see how the effects of changes in telephone prices ripple through the entire economy.) Because we are interested in plausibility, rough approximations suffice for our current purposes.

We calculated the effect of a change in subscriber-line charge on total surplus and then on GNP. We found that the Wharton estimate of the GNP effect is plausible.

Total Surplus

A common measure of social welfare is *total surplus*.[2,3] Roughly speaking, the total surplus that the production and sale of a commodity generates is the difference between what consumers are willing to pay for the commodity and its cost to produce.

Assume that there is only one IXC, which is regulated. Let

A = total access charges paid by IXC to LECs. We take A to be fixed.
p = price (index) of interexchange toll.
q = quantity (index) of interexchange toll.
D = demand function for interexchange toll; that is, $q = D(p)$.
C = cost function for interexchange toll, including the cost of capital.

Suppose that regulation is instantaneous and accurate; i.e., that the IXC must set its price, p, to produce zero net profit. In other words, it makes a rate of return on capital equal to the cost of capital. Then, for a given A, we determine p and q by the pair of equations

$$q = D(p) \tag{1}$$

$$pq - C(q) - A = 0 \tag{2}$$

Consider a change in subscriber-line charges, with a corresponding change in total access charges from A_0 to A. We want to calculate the resulting change in total surplus (also known as "social welfare"). The monthly charge for local service will increase, while the price of interexchange calls will decrease. We assume that the demand for local service is not affected. (This should slightly *underestimate* the effect of the change in subscriber-line charge on total surplus.) Then, the only changes in output and cost, and hence in total surplus, are those in the interexchange sector.

Let P denote the inverse of the demand function, i.e.,

$$p = P(q)$$

Let Q_0 and Q denote the interexchange outputs that correspond to A_0 and A, respectively. Then, the total change in surplus (*welfare*) is

$$W(A) = \int_{Q_0}^{Q} [P(q) - C'(q)]\, dq$$

$$= \int_{Q_0}^{Q} P(q)\, dq - \int_{Q_0}^{Q} C'(q)\, dq \tag{3}$$

This is the area between the demand curve and the marginal-cost curve, as q varies from Q_0 to Q; see Figure 1. (We drew the figure for the case where price exceeds marginal cost, which we believe is true for interexchange service.)

First, notice that, integrating by parts

$$\int_{Q_0}^{Q} P(q)\ dq = \int_{Q_0}^{Q} d[P(q)q] - \int_{Q_0}^{Q} qP'(q)\ dq$$

$$= P(Q)Q - P(Q_0)\,Q_0 - \int_{Q_0}^{Q} qP'(q)\,dq \qquad (4)$$

Second, notice that

$$\int_{Q_0}^{Q} C'(q) = C(Q) - C(Q_0) \qquad (5)$$

If we substitute equations (4) and (5) in (3), we get

$$W(A) = [P(Q)Q - C(Q)] - [P(Q_0)Q_0 - C(Q_0)] - \int_{Q_0}^{Q} qP'(q)\,dq \qquad (6)$$

But by the rate-of-return constraint, equation (2),

$$P(Q)P - C(Q) = A$$

$$P(Q_0)Q_0 - C(Q_0) = A_0$$

Hence,

$$W(A) = A - A_0 - \int_{Q_0}^{Q} qP'(q)\,dq \qquad (7)$$

To estimate the effect of small changes in A, we now calculate the derivative of W. If we write $Q(A)$ for Q, to show its dependence on A, then from equation (7),

$$W'(A) = 1 - Q(A)P'[Q(A)]Q'(A) \qquad (8)$$

Another way to write this is also convenient. Define

$$\phi(A) = P[Q(A)]$$

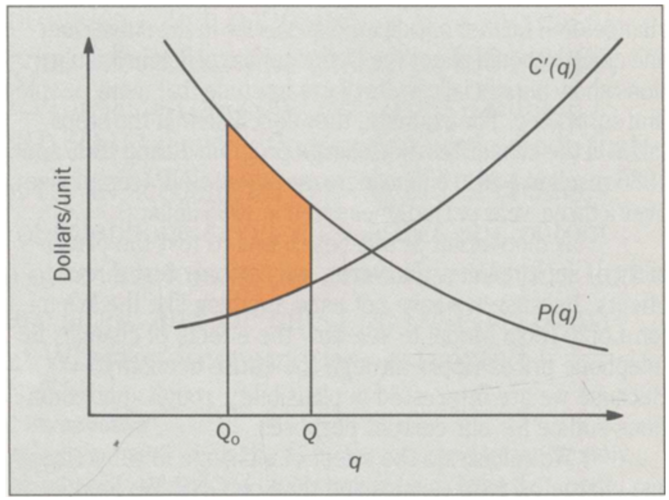

Figure 1. Positive change in surplus (shaded area). Q_0 and Q represent the interexchange outputs when total access charge is A_0 and *A*, respectively. *C′*(*q*) is cost, and *P*(*q*) is the inverse of the demand function.

which expresses the dependence of the interexchange price on A. Then,

$$\phi'(A) = P'[Q(A)]\,Q'(A)$$

and thus from equation (8)

$$W'(A) = 1 - Q(A)\phi'(A)$$

$$= 1 - \phi(A)Q(A)\left[\frac{\phi'(A)}{\phi(A)}\right] \qquad (9)$$

Now notice that

$$\phi(A)Q(A)$$

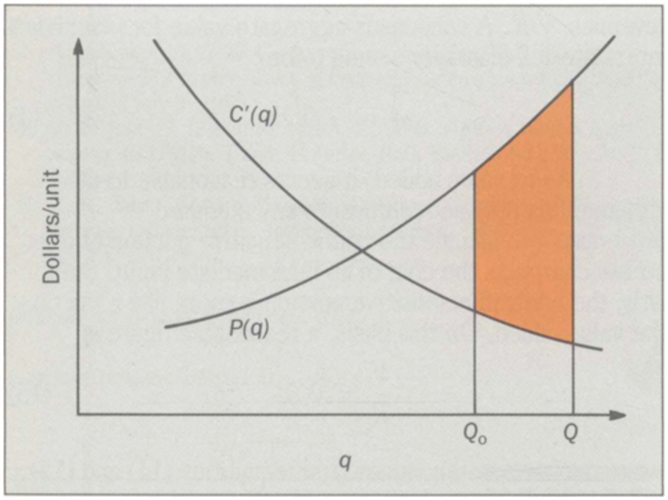

Figure 2. Negative change in surplus (shaded area). Q_0 **and** Q **represent the interexchange outputs when total access charge is** A_0 **and** A**, respectively.** $C'(q)$ **is cost, and** $P(q)$ **is the inverse of the demand function.**

is the total interexchange revenue that corresponds to A, and

$$\left[\frac{\phi'(A)}{\phi(A)}\right] \times 100$$

is the percentage change in price, per dollar increase in A.

Because we are concerned with a *decrease* in A that corresponds to an increase in the subscriber-line charge, equation (9) implies that a decrease in A of Δ dollars will result in an increase of surplus about equal to

$$\left[\text{IX revenue} \times \frac{\text{percent change in IX price}}{100} - 1\right] \times \Delta$$

An Example. Although this example is fictitious, the numbers roughly describe how changes in the 1984 through 1986 subscriber-line charge affected 1985 through 1987 interstate-toll prices. (All figures are in 1984 dollars.)

Thus, we suppose that \$1-billion reductions in A in each of three successive years lead to 5-percent price reductions in each year. We further suppose that annual interstate revenues are \$30 billion. (However, the price reductions did not lead to significant revenue increases in this period, because of changes in other factors that influence demand. But these figures approximate the experience of the total domestic interexchange industry in this period.)

Then, the increase each year in surplus over the *base year* is about

$$\begin{array}{rr} 30 \times 0.05 - 1 = & 0.5 \\ 30 \times 0.10 - 2 = & 1.0 \\ 30 \times 0.15 - 3 = & \underline{1.5} \\ \text{3-year total} & \$3.0\text{ B} \end{array}$$

To conclude this section, we note that a price decrease does not necessarily lead to an increase in surplus. If price is already below marginal cost, a further decrease in price leads to increased output and *decreased* surplus, as Figure 2 shows. This may be the case for local service.

Gross National Product

GNP is defined as the sum of value added by various sectors. Value added is sales (revenue) less the cost of intermediate (manufactured) inputs, or

$$V = R - C_I \qquad (9)$$

where R = revenue = pq. As before, we shall confine our attention to interstate toll. The presence of the access charge necessitates some decisions, as we shall see, about the definition of intermediate inputs.

A change in price produces a change in demand, hence a change in output, and hence a change in costs. Thus,

$$dV = dR - dC_I$$
$$= p\,dq + q\,dp - C_I'\,dq \qquad (10)$$

Let η denote the elasticity of toll demand, defined as the fractional change in demand per unit fractional change in price:

$$\eta = \frac{dq/q}{dp/p} = \frac{p}{q}\frac{dq}{dp} \qquad (11)$$

Then if we substitute from equation (11) into (10),

$$dV = \eta q\,dp + q\,dp - C_I'\eta q\frac{dp}{p}$$
$$= \frac{dp}{p}[(1 + \eta)R - \eta q C_I'] \qquad (12)$$

Now, consider the simple case where the marginal cost of intermediate inputs is constant, so that

$$C_I = C_I'q$$

Then, equation (12) becomes

$$dV = \frac{dp}{p}[(1 + \eta)R - \eta\,C_I]$$
$$= \frac{dp}{p}[R + \eta\,V] = \frac{dp}{p} \bullet R\,(1 + \eta\frac{V}{R}) \qquad (13)$$

Now, return to the example above. We must specify the elasticity, η, and the value added as a fraction of revenues, V/R. A consensus aggregate value for interstate-toll elasticity seems to be

$$\eta = -0.75 \qquad (14)$$

As to value added, it seems reasonable to us—although this may not conform to any standard procedure—to include the traffic-sensitive portion of the access charge as the cost of an intermediate input. Similarly, the nontraffic-sensitive portion is more like a tax on the value added. On this basis, a reasonable figure is

$$\frac{V}{R} = 0.6 \qquad (15)$$

Now use the values from equations (14) and (15) and the parameters of the example. For the increase in value added over the *base year* in each year, we find from equation (13)

$0.05 \times 30\,(1 - 0.75 \times 0.6) =$	0.825
$0.10 \times 30\,(1 - 0.75 \times 0.6) =$	1.65
$0.15 \times 30\,(1 - 0.75 \times 0.6) =$	2.475
3-year total	$4.950 B

or about $5 billion cumulative increase in GNP over the three years, compared to what there would have been without any increase in subscriber-line charges.

This result is not far from Wharton's estimate of $6.0 billion. Were we to consider the effect of the increased price of local telephone service, our result would be reduced somewhat. But our result would be increased by the effect of lower toll prices on all sectors of the economy—i.e., by the multiplier that the Wharton Long-Term Model expresses. One might expect this multiplier to be around 2. Therefore, we are surprised, not that Wharton's results for gain in GNP is so large, but that it is not larger. It may be a conservative estimate.

References

1. Attachment to *AT&T Comments*, filed August 29, 1986, in response to *Further Notice of Proposed Rulemaking*, FCC 86-305, released July 2, 1986.
2. R. E. Just, D. L. Hueth, and A. Schmitz, *Applied Welfare Economics and Public Policy*, Prentice-Hall, Englewood Cliffs, N. J., 1982.
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