NOTES ON COMPETITIVE LOCAL EXCHANGE SERVICE

Michael H. Riordan[1]

Columbia University

Preliminary Draft: June 15, 2003

Prepared for Conference on "Designing Russia's Telecommunications Regulatory Reforms: Theory and International Experience"

Moscow, June 27-28, 2003

1. Introduction

Competitive local exchange service in the United States is based largely on access to unbundled network elements (UNEs). According to the Federal Communications Commission (FCC, 2002), approximately 50% of competitive local exchange service uses unbundled loops that are leased from incumbent local exchange carriers (ILECs). Moreover, most of that uses unbundled loops in combination with unbundled switching and other UNEs, including on the entire platform of unbundled network elements (UNE-P). UNE-P is the fastest growing means of competitive local exchange service.

The 1996 Telecommunication Act of 1996 required ILECs to provide access to UNEs to competitive local exchange carriers (CLECs). The FCC interpreted the unbundling requirement to include UNE-P, and the U.S. Supreme Court upheld that interpretation. Critics argue that competitive local exchange competition based on UNE-

[1] Anna Rose Armentia Bordon provided helpful research assistance.

P allows CLECs to at best duplicate the ILEC's service at a favorable wholesale price. Defenders argue that UNE-P allows the CLEC to improve the quality of service. I examine aspects of this debate in the context of a simple theoretical model.

Armstrong's (2002) recent survey of the economics of access pricing addresses product selection in only a limited way. Armstrong's model assumes that product selection is tied to a more fundamental choice of technology. Thus, for a CLEC requiring access to the ILEC's network, product characteristics are given. Armstrong's analysis also is limited by the assumption that consumers are homogeneous, which gives the market model a winner-take-all character.[2] Armstrong's analysis focuses on how the access price influences a CLEC entry decision and technology choice, and concludes that the Efficient Component Pricing Rule (ECPR) provides the correct entry incentives for a CLEC requiring access to the ILEC's network, but may cause the CLEC inefficiently to choose a "bypass technology", i.e. opt for a facilities-based solution that does not require UNEs.

In contrast to Armstrong's model, I allow a CLEC using UNE-p to select the quality of its product, assume that consumers have heterogeneous preferences over product characteristics, and, for simplicity, assume that a bypass technology is not economically viable. I focus on how the wholesale price influences a CLEC's entry and product selection decisions, and conclude that the wholesale price must be discounted below the ECPR level if it is to encourage entry and product improvement by the CLEC. An implication is that the wholesale discount should be positive only in markets that are

[2] I refer to Armstrong's (2002) "unit demand model". Armstrong (2002) also studies a "competitive fringe model" that treats product differentiation is a general way as an approach to Ramsey pricing; Laffont and Tirole (2002) contains a similar analysis.

large enough to support efficient entry, assuming that the CLEC's initial disadvantage is not too prohibitive.

The model also yields an interesting conclusion about the distribution of gains and losses from CLEC entry. If the ILEC is compensated for market entry by an increase in the regulated retail price, then consumers on average are made worse off by CLEC entry, even some consumers gain from having more choice. Thus CLEC entry will benefit consumers as a class only to the extent they are stockholders in the CLEC industry. Any efficiency gains and more accrue to the CLEC.

2. Market environment

I consider an ILEC providing a retail service at a regulated price $\overline{p}$ and a constant average variable cost c. The ILEC has not flexibility to alter this price either upward or downward. The ILEC is required also to provide to a CLEC access to its network facilities at a regulated wholesale price w. The CLEC also directly incurs the unit cost c to provide a retail service. I also assume for simplicity that the ILEC incurs no direct costs in providing the wholesale service.

The ILEC and CLEC are not necessarily equally efficient, even though the same technology underlies the ILEC's wholesale and retail services. More precisely, the basic service offered by the CLEC is inferior by an amount $\delta \geq 0$ along a product dimension that I call "convenience". The relative inconvenience of the CLEC's retail service for example might reflect the ILEC's brand superiority, or it might be because the ILEC is less than fully cooperative in providing the wholesale service. This issue is a matter of considerable debate before the FCC and state public utility commissions (PUCs).

There are *M* consumers. The consumers have heterogeneous preferences about convenience, and therefore value the CLEC's service differently. A type θ consumer is willing to pay an additional $\theta\delta$ for the incumbent's service in order to avoid the inconvenience. I assume for simplicity that consumer types are distributed uniformly on the interval $[0,1]$.

3. Price competition only

If the CLEC offers its service at price *p*, then all consumer types $\theta < \frac{\bar{p}-p}{\delta}$ demand service from the CLEC. The market share of the CLEC is $s = \min\left\{\max\left\{\frac{\bar{p}-p}{\delta}, 0\right\}, 1\right\}$. The complicated notation simply reflects the possibility that all or no consumers might subscribe to the CLEC's service, depending on the sign and magnitude of the price difference. The key point is that the CLEC gains market share by undercutting the ILEC's price, and attracting those consumers who are least concerned about inconvenience. The ILEC and CLEC share the market if the price difference is sufficiently small, i.e. $0 < \bar{p} - p < \delta$. The corresponding profit of the CLEC is $\pi = (p - w - c)sM$.

The optimal price for the CLEC is $p = \frac{\bar{p}+w+c}{2}$, assuming that the ILEC and CLEC share the market. The corresponding market share and profit of the CLEC are $s = \frac{\bar{p}-w-c}{2\delta}$ and $\pi = (\frac{\bar{p}-w-c}{2})^2 \frac{M}{\delta}$. These results presuppose the ILEC is passive, i.e. both $\bar{p}$ and *w* are determined by regulation and do not vary with the CLEC's market share.

The CLEC gains market share and profit the greater is difference between retail operating profit $(\bar{p} - c)$ and wholesale operating profit (*w*). With some abuse of

language, I refer to that difference $(\overline{p} - w - c)$ as the "wholesale discount". The efficient component pricing rule (ECPR) would set the wholesale discount to zero. At this wholesale price, the CLEC cannot profitably gain a positive market share by undercutting the ILEC's price. Thus ECPR would foreclose the CLEC if price were the only open avenue of competition.[3] The FCC has rejected ECPR as an appropriate basis for determining *w*, in favor of methodology that bases *w* on an estimate of forward-looking economic cost. It is generally agreed that the FCC's preferred methodology results in a lower value of *w* in most local markets than would ECPR.

The profit of the incumbent is $\overline{\pi} = (1-s)(\overline{p} - c)M + swM$

$= (\overline{p} - c)M - \pi - s(\overline{p} - p)M$. Thus price competition simply shifts profit from the ILEC to the CLEC and to consumers. The consumers gain from the lower price offered by the CLEC.[4] Moreover, CLEC entry is inefficient because of the greater inconvenience of the CLEC's service. Any consumer gains necessarily are at the expense of the ILEC. Moreover, it can be shown that consumers on average are worse off if the ILEC is compensated for lost market share with a higher regulated retail price, i.e. CLEC profit is entirely at the expense of consumers. Thus there is not much point in competition if the CLEC is unable offer a better service, unless it is to convert ILEC profit to consumer surplus.

[3] I am assuming that the ILEC and CLEC are equally adept retailers, i.e. both incur a cost c. A CLEC who is a more efficient retailer would be able to compete under ECPR if δ were not too large.

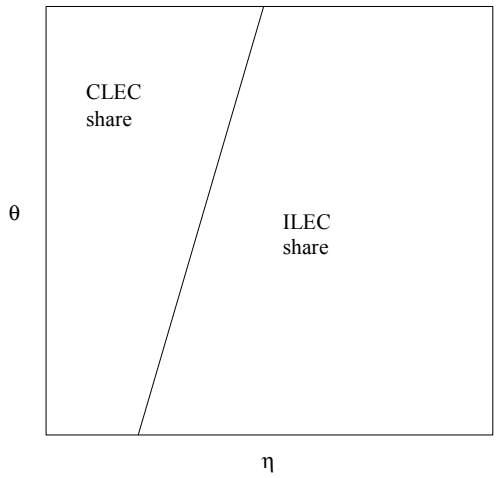
[4] [Cite Yale Braunstein on consumer gains in California.]

4. Quality improvement

I suppose that the CLEC improves its service by an amount q along a second dimension that I call "quality". A type η consumer values quality improvement by an amount ηq, and consumer types are distributed uniformly on $[0,1]$. I continue to assume the CLEC service is less convenient. Thus consumers have heterogeneous preferences over two product characteristics, and I assume for simplicity that θ and η are distributed independently in the population of consumers.

To improve quality the CLEC incurs a fixed $r(q)$. I assume for simplicity that this cost function is quadratic, i.e. $r(q) = \frac{k}{2}q^2$. A lower value of k indicates greater opportunities for quality improvement.

If q is sufficiently small, then the CLEC's market share is $s = \frac{\overline{p} - p}{\delta} + \frac{q}{2\delta}$. This formula for market share presumes that $\delta - q > \overline{p} - p > 0$ which holds if q is sufficiently small. The restriction is illustrated in the figure below, which divides consumer types into those who purchase from the CLEC and those who purchase from the ILEC. If q = 0, then the line would be vertical with its horizontal location equal to $\frac{\overline{p} - p}{\delta}$. An increase in q rotates the line to the right leaving its horizontal location at the base of the unit square unchanged, assuming p does not change.



A sufficiently small q means that the line that divides the two groups of consumers intersects the lower and upper boundaries of the unit square. This implies that the elasticity of demand for the CLEC's service is positive for consumers of any type θ.

The following technical assumption assures that q is appropriately small over the relevant range.

Technical Assumption: Let $m \equiv \frac{M}{\delta}$ and $\lambda \equiv \frac{2m}{8k-m}$. Then $0 < \lambda < 2$ and

$0 < \frac{1}{2}\left(1+\frac{3}{2}\lambda\right)(\overline{p}-w-c) < \delta$.

The reason for technical assumption will be clearer in light of the equilibrium analysis, but basic idea is that it guarantees that $\delta - q > \overline{p} - p > 0$ at the equilibrium values of p and q derived below. Note that condition implies that the CLEC shares the market with ILEC, which requires $\delta > \overline{p} - p + \frac{1}{2}q > 0$. The assumption also implies that the wholesale discount is non-negative, i.e. $(\overline{p}-w-c) \geq 0$.

The parameter λ is featured in many formulas below. The parameter is higher the larger is the market and the greater are the opportunities for product improvement.

CLEC profit is $\pi = (p - w - c)(\overline{p} - p + \tfrac{1}{2}q)m - \tfrac{k}{2}q^2$ where $m = \tfrac{M}{\delta}$ and $r(q)$ is the cost of quality improvement. For a given value of *q*, The CLEC's profit-maximizing price is $p = \tfrac{1}{2}(\overline{p} + w + c) + \tfrac{1}{4}q$ and the wholesale discount is $p - w - c = \tfrac{1}{2}(\overline{p} - w - c) + \tfrac{1}{4}q$. Thus a higher quality garners a larger market share and fetches a higher price. Note also that $\overline{p} - p = \tfrac{1}{2}(\overline{p} - w - c) - \tfrac{1}{4}q$, i.e. the CLEC discounts its price below the ILEC only if quality improvement is sufficiently small.

The CLEC's maximized profit for a given quality improvement is $\pi = [\tfrac{1}{2}(\overline{p} - w - c) + \tfrac{1}{4}q]^2 m - \tfrac{k}{2}q^2$. This function is concave in *q* if $m < 8k$, which is implied by the technical assumption.

Using the envelope theorem, the CLEC's marginal return to quality is $\tfrac{m}{2}(p - w - c) = \tfrac{m}{4}(\overline{p} - w - c + \tfrac{1}{2}q)$. Note that the marginal return is increasing in quality over the relevant range and is equal to $\tfrac{m}{4}(\overline{p} - w - c)$ when $q = 0$. Thus the CLEC's marginal incentive for quality improvement is greater the greater is the wholesale discount. The marginal cost of quality improvement is *kq*. Equating marginal benefit and marginal cost implies $q = \lambda(\overline{p} - w - c)$. Thus the CLEC improves quality if and only if the wholesale discount is positive. That is, the ECPR would destroy quality incentives. An implication of this result is that the CLEC has an incentive for quality improvement if and only if the CLEC would gain a positive market share with pure price competition. The possibility of quality improvement does not rescue ECPR as a policy tool to encourage competition.

The technical assumption is now easier to explain. Recall that the formula for CLEC market share presumed that $\delta - q > \overline{p} - p > 0$. Substituting equilibrium values of

p and q into these inequalities implies $\bar{p} - p = \frac{1}{2}\left(1 - \frac{\lambda}{2}\right)(\bar{p} - w - c) > 0$ and $\bar{p} - p + q = \frac{1}{2}\left(1 + \frac{3}{2}\lambda\right)(\bar{p} - w - c) < \delta$. Therefore, the analysis is valid if $\bar{p} - w - c > 0$, $0 < \lambda < 2$, and $\delta > \left(\frac{1}{2} + \frac{3}{4}\lambda\right)(\bar{p} - w - c)$. These conditions explain the technical assumption above.

5. CLEC profit

The CLEC profit from price and quality competition is $\pi = \left[\frac{m}{4}\left(1 + \frac{\lambda}{2}\right)^2 - \frac{k\lambda^2}{2}\right](\bar{p} - w - c)^2 \equiv \lambda k(\bar{p} - w - c)^2$. This profit is proportional to the square of the wholesale discount. The factor of proportionality is increasing in λ, that is, decreasing in k and increasing in m.

I suppose now that the CLEC incurs a fixed cost F to enter a market. Then the net profits of the CLEC are $\lambda k(\bar{p} - w - c)^2 - F$, and the CLEC will decline to enter the market M if $\bar{p} - w - c < \sqrt{F / \lambda k}$.

6. ILEC profit

The ILEC's profit when competing with the CLEC is $\bar{\pi} = wM + (\bar{p} - w - c)(1 - s)M$. For a given retail price, CLEC competition reduces the profit of the ILEC if $w < \bar{p} - c$, that is, the wholesale discount is positive.

One way to compensate the ILEC for this loss is to raise the retail price. Without CLEC competition, the ILEC would earn $\bar{\pi}^* = (\bar{p}^* - c)M$, where $\bar{p}^*$ denotes the pre-entry retail price. Therefore, the ILEC loss due to CLEC entry is $\bar{L} = (\bar{p}^* - \bar{p})M + (\bar{p} - w - c)sM$.

7. Consumer surplus

Consumers benefit directly both from the quality improvement and the price reduction offered by the CLEC. Consumers also suffer a reduced utility from the greater inconvenience of the CLEC' service (δ). The net increase in consumer surplus from consuming the CLEC's service rather than the ILEC's is

$$M \int_0^{\frac{\bar{p}-p+q}{\delta}} \int_{\max\left\{0,\frac{\delta\theta-(\bar{p}-p)}{q}\right\}}^{1} [\eta q - \theta\delta + \bar{p} - p]\, d\eta d\theta$$

$$= m\left(\tfrac{1}{8} + \tfrac{1}{8}\lambda + \tfrac{7}{96}\lambda^2\right)(\bar{p} - w - c)^2 .$$

Consumers also suffer a pecuniary loss of $(\bar{p} - \bar{p}^*)M$ if the ILEC's retail price is increased after CLEC entry. The net consumer gain therefore is

$$m\left[\left(\tfrac{1}{8} + \tfrac{1}{8}\lambda + \tfrac{7}{96}\lambda^2\right)(\bar{p} - w - c)^2 - \delta(\bar{p} - \bar{p}^*)\right].$$

7. Economic efficiency

Entry is efficient if the gain in consumer surplus plus CLEC profit exceeds the ILEC loss. If the ILEC is left whole then $\bar{L} = 0$, and, if price regulation adjusts to satisfy $(\bar{p} - \bar{p}^*)M = (\bar{p} - w - c)sM$, then the consumer gain from CLEC competition is

$$m\left[\left(\tfrac{1}{8} + \tfrac{1}{8}\lambda + \tfrac{7}{96}\lambda^2\right)(\bar{p} - w - c)^2 + \delta s(\bar{p} - w - c)\right]$$
$$= m\left[\left(\tfrac{1}{8} + \tfrac{1}{8}\lambda + \tfrac{7}{96}\lambda^2\right) - \tfrac{1}{2}\left(1 + \tfrac{\lambda}{2}\right)\right](\bar{p} - w - c)^2$$

$$= m\left(-\tfrac{3}{8} - \tfrac{1}{8}\lambda + \tfrac{7}{96}\lambda^2\right)(\bar{p} - w - c)^2 .$$

The expression is negative for $0 < \lambda < 2$, as required by the technical assumption. Thus consumers on average do not benefit directly from CLEC competition if quality improvement is "small" and the ILEC is compensated with a retail price increase.

This leaves open the question of whether the gain to the CLEC exceeds the net consumer loss when the ILEC is left whole. The answer is easy for the marginal market that the CLEC enters. The CLEC exactly breaks even in the marginal market. Therefore, it must be that CLEC entry is excessive at the margin.

The answer is harder for markets that are larger then the marginal one. Summing the components of the change in social welfare gives

$$m\left(-\tfrac{3}{8}-\tfrac{1}{8}\lambda+\tfrac{7}{96}\lambda^2\right)(\overline{p}-w-c)^2+\lambda k(\overline{p}-w-c)^2-F$$

$$=\left[m\left(-\tfrac{3}{8}-\tfrac{1}{8}\lambda+\tfrac{7}{96}\lambda^2\right)+\lambda k\right](\overline{p}-w-c)^2-F$$

$$=\left[m\left(-\tfrac{3}{8}-\tfrac{1}{8}\lambda+\tfrac{7}{96}\lambda^2\right)+\lambda k\right](\overline{p}-w-c)^2-F$$

$$=\tfrac{m}{8}\left(\tfrac{7}{12}\lambda^2-1\right)(\overline{p}-w-c)^2-F\,.$$

The expression $\left(\tfrac{7}{12}\lambda^2-1\right)$ is positive if $\lambda > \sqrt{12/7}$, i.e. the opportunities for quality improvement are sufficiently great. In this case, CLEC entry into markets that are sufficiently large relative to the fixed cost of entry is economically efficient, assuming the wholesale discount is positive.

The conclusion that CLEC entry is socially efficient if $\tfrac{m}{8}\left(\tfrac{7}{12}\lambda^2-1\right)(\overline{p}-w-c)^2 > F$ has a natural interpretation. The left-hand side is the net

value creation from CLEC entry, $M \int_0^{\frac{\overline{p}-p+q}{\delta}} \int_{\max\left\{0,\frac{\delta\theta-(\overline{p}-p)}{q}\right\}}^{1} [\eta q - \theta\delta]\, d\eta d\theta$,[5] and the right-hand size is simply the fixed cost of CLEC entry. Thus CLEC entry is socially efficient if net value creation exceeds fixed cost.

These results have sharp policy implications. Unless *F* is very large, it is socially desirable to increase the wholesale discount in markets with $\lambda > \sqrt{12/7}$ in order to promote CLEC product improvement. This is the condition under which value creation by CLEC entry is positive. This inequality holds if the opportunities for CLEC quality improvement are sufficiently great, the market is sufficiently large, and the inconvenience of the CLEC's service is not too great. If and only if these conditions fail to hold, then it is desirable to prevent entry by setting the wholesale discount to zero as recommended by ECPR.

A necessary condition for the social desirability of CLEC entry using UNE-P is that the opportunities for quality improvement are sufficiently great. If this is the case, and fixed costs of CLEC entry are not prohibitively high, then, roughly speaking, $\overline{p}$ should be higher and *w* lower in larger markets. Serendipitously, this generally is the situation in the United States today, because of how PUCs' different approaches retail and wholesale price regulation. Retail prices tend to be higher in high-density markets due to value-of-service pricing, and while cost-based wholesale prices tend to be lower due to economies of density.

[5] The integration is over the area of consumer types who purchase service from the CLEC, as illustrated in the diagram above. These consumers benefit from quality improvement, but suffer from the greater inconvenience of the CLEC's service.

8. Conclusion

A greater wholesale discount improves a CLEC's incentive for quality improvement. But if the ILEC is compensated by a higher retail price, then consumers on average are become worse off. CLEC entry nevertheless is socially efficient if the CLEC's operating profit is sufficiently high. This would be the case if the opportunities for quality improvement are sufficiently great, and the market is sufficiently large relative to the fixed cost of CLEC entry. Thus a reasonable access pricing policy would set a higher wholesale discount in larger markets where CLEC entry and product innovation contributes more to economic efficiency. ECPR mainly serves to deter entry.

The analysis could be extended to address additional issues that have featured in the telecommunications economics literature and policy debates:

- *Facilities-based competition*. In reality, CLECs have a choice of technologies. They can a provide service by leasing network elements from the ILEC, building their own facilities, or some combination of the two. It is widely thought that facilities-based competition is viable only in the largest markets. Armstrong (2002) observes that cost-based access pricing has the virtue of gives the CLEC correct "make or buy" signals.
- *Price-elastic demand*. About 5% of households in the U.S. lack basic telephone service. In reality, consumers choose whether or not to subscribe to telephone service based on the prices and qualities of alternative offerings. Ramsey-pricing principles for optimal access pricing, as discussed by Armstrong (2002) and Laffont and Tirole (2002), are potentially important. Econometric analyses,

however, regularly show that price elasticity of demand for local telephone service is close to zero.

- *Retail price competition*. In markets where wholesale prices are regulated and CLEC entry has eroded ILEC market share, retail price regulation might seem unnecessary from an economic efficiency perspective. Deregulation that allowed the ILEC's retail price to rise would encourage further CLEC product improvement. If the ILEC were to cut response in response to CLEC competition, however, then the CLEC would have less incentive for product improvement. Similarly, granting the ILEC downward retail price flexibility might deter CLEC entry in some markets.[6] ILEC price flexibility, however, may have the virtue of better matching consumers to products.
- *ILEC product improvement*. The FCC has announced, but not yet released, an order that will relieve ILECs of the obligation to unbundled advanced product technologies. This new regulation presumably is intended to encourage a market environment in which ILECs and CLECs compete over product improvement. Gilbert and Riordan (2003) caution that such market environments can have multiple equilibria with different welfare properties.

[6] See Choi and Stefanidis (2001) for a model of technological competition in unregulated markets for strict complements.

References

Armstrong, Mark (2002), "The Theory of Access Pricing and Interconnection," in M.E. Cave *et. al*. (eds.), *Handbook of Telecommunications Economics*, Elsevier.

Choi, Jay Pil and Christodoulos Stefanidis (2001), "Tying, Investment, and Dynamic Leverage Theory," *RAND Journal of Economics*, 32: 52-71.

Gilbert, Richard J. and Michael H. Riordan (2003), "Product Improvement and Technological Tying in a Winner-Take-All Market," unpublished manuscript.

Federal Communications Commission (2002), *Local Telephone Competition: Status as of June 30, 2002,* Industry Analysis and Technology Division, Wireline Competition Bureau, December.

Laffont, Jean-Jacques and Jean Tirole (2000), *Competition in Telecommunications*, MIT Press.