

Auctions for Universal Service Subsidies

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Abstract

The Telecommunications Act of 1996 requires that telephone service be available in high-cost areas at rates that are “affordable” and “reasonably comparable” to those charged in low-cost areas. It also requires that carriers serving high-cost areas at below-cost rates be compensated with explicit and sufficient subsidies. This paper analyzes an auction mechanism for the allocation of such subsidies. It shows that auctions may lead to higher social welfare levels than those generated by uniform subsidy schemes in a wide range of circumstances. It also shows, however, that auction designs aimed at stimulating competition among several subsidized carriers may be particularly vulnerable to collusion.

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1 Introduction

This paper studies some of the advantages and limitations of auction mechanisms for the allocation of subsidies.

In particular, I consider the Universal Service subsidies mandated by the Telecommunications Act of 1996.¹ Section 254 (“Universal Service”) of the Act requires, roughly speaking, that “core” telephone services be available at the same “affordable” rates throughout the United States and that explicit subsidies be used to compensate carriers in high-cost areas.²

Soon after the passage of the Act, the Federal Communications Commission (FCC) began to consider “distributing high-cost assistance on the basis of competitive bids.”³ The FCC, in its May 1997 *Report and Order on Universal Service*, decided to adopt initially a different subsidy scheme,⁴ but it also reiterated its interest in the use of auctions for Universal Service subsidies and the need for further study on the matter.

The goal of this paper is to help satisfy that need by making two contributions to the analysis of “Carrier Of Last Resort” (COLR) auctions, i.e., auctions whose object is the obligation to offer “core” services at a given maximum price.⁵

First, the paper identifies a fairly wide range of circumstances in which COLR auctions can reduce the cost of the Universal Service policy with respect to traditional uniform subsidy schemes. The key conditions for the superiority of auctions are the *heterogeneity* in the cost of serving different consumers (with respect to the level of aggregation at which the regulator’s information is sufficiently accurate) and the possibility of *subcontracting* after the auction.

Second, the paper shows that attempts to design COLR auctions that provide good *incentives for quality of service* (i.e., using per-subscriber subsidies and appointing several COLRs per service area) may be particularly vulnerable to *collusion*

¹Hereinafter referred to as “the Act.”

²See Section 2 for a more extensive description of the parts of the Act related to this paper.

³Paragraph 35, *Notice of Proposed Rule Making and Order Establishing Joint Board*, CC Docket No. 96-45, March 8, 1996. State regulators (e.g., the California Public Utility Commission) have also been studying the possibility of auctions for universal service subsidies.

⁴See Section 2 for a description and critique.

⁵A more general discussion of the issues involved in the design of auctions for Universal Service subsidies is provided in Sorana (1998). I note here that neither Sorana (1998), nor this paper discuss the rationale of the Universal Service policy goal *per se*, the (Universal Service) subsidization of school, libraries, and health care providers, or the division of labor between Federal and State regulators.

among bidders. The problem is that the use of per-subscriber subsidies increases the range of possible punishments for those who defect from collusive agreements. The appointment of several COLRs per area makes things worse by reducing the cost of carrying out such punishments. In some cases, *competition in the market* after the auction and *competition for the market* in the auction are mutually incompatible, but this paper also shows that some modifications in the auction rules may sometimes alleviate this problem.

The idea of using auctions to allocate subsidies is a novel one, but auctions are definitely not new to regulators. The seminal paper by Demsetz (1968) showed that franchise auctions can achieve the second-best average-cost pricing solution for natural monopoly when the regulator cannot use direct subsidies.⁶ The problem discussed in this paper is, in a sense, the polar opposite. The regulator knows the price it wants consumers to pay, but does not know how much to pay firms for charging such a price. Moreover, the regulator can pay firms directly, but cannot grant them protection from competitors in any market.

The Universal Service problem is better viewed as a procurement problem. Essentially, the regulator wants to procure the services of one or more COLRs, i.e., one or more firms who stand ready to provide telephone service of a given (minimum) quality at a given (maximum) price. COLR auctions are, admittedly, a rather peculiar sort of procurement auctions. The regulator is not really interested in the presence of COLRs *per se*, but in their effects on social welfare. This will ultimately depend on market outcomes that the regulator cannot fully control. For example, the regulator may be unable to (costlessly) observe the quality of service provided by the COLRs because consumers, not regulators, are the ultimate receivers of that service.⁷ For the same reason, the impossibility of granting monopoly franchises marks another difference with standard procurement auctions. COLRs will get their revenues not only from the regulator (the Universal Service subsidy), but also from consumers and this fact significantly alters the firms' strategic possibilities.

The first paper advocating the use of COLR auctions for the allocation of Uni-

⁶Laffont and Tirole (1993) provide a modern treatment and extensive references to the literature on franchise bidding. Spulber (1989) provides an interesting alternative approach to franchise competition in which the regulator controls the bargaining between consumers and producers.

⁷In a one-shot model this would be equivalent to unverifiability of quality in standard procurement problems. In a repeated game context, however, it leads to more severe problems that are discussed in Section 4 below.

versal Service subsidies is Salant (1996).⁸ A more recent discussion of the issues involved in the design of such auctions is in Sorana (1998). Kelly and Steinberg (1997) discuss a possible implementation of a simultaneous ascending COLR auction with combinatorial bidding.

Milgrom (1997) adopts an optimal mechanism design framework and argues that the number of COLRs per service area should be determined as a function of the firms' "bids."⁹

Anton, Vander Weide, and Vettas (1997) also discuss auctions for Universal Service subsidies, but they use a different specification of COLRs' obligations than the one used in this paper. They assume that the winner of the auction has the obligation to provide service at the same price prevailing in another ("urban") market where, after the auction, the firm may compete Cournot-style with some of the other bidders. This somewhat unrealistic specification¹⁰ can be seen as an attempt to capture in a static framework the regulators' dynamic adjustments of the "affordable price" to the prices charged in low-cost areas and the corresponding reactions of those firms who may be active in both areas. Their results, however, seem quite sensitive with respect to alternative (possibly more realistic) specifications of the model.¹¹

The plan of the paper is as follows. Section 2 gives some institutional back-

⁸Weisman (1989) also mentions the possibility of putting the COLR obligation up for auction. Weisman's focus, however, is not on the Universal Service obligation, but on the obligation to provide back-up facilities (see also Weisman, 1994).

⁹Milgrom's model, although independently developed, is very similar to Dana and Spier's (1994) model of auctions for licenses. Both models are part of a growing literature on regulation with endogenous market structure that also includes Auriol-Laffont (1992), McGuire-Riordan (1995), Riordan (1996), and Wolinsky (1997).

¹⁰Firms are unlikely to be asked to submit bids for an obligation that will be fully specified only later as an equilibrium outcome in another market. Moreover, there is no guarantee that the final price will be "just, reasonable, and affordable". In COLR auctions, instead, the price constraint for the winner of the auction is specified before bidding occurs.

¹¹For example, "a central result of the paper" is that there may be "a perverse incentive for each firm to lose the auction for the rural market in order to gain the more profitable position of serving only the urban market. Equilibrium bidding then leads to a subsidy that compensates for the strategic disadvantage associated with winning. As a result, both firms ultimately benefit and earn the higher profit . . . Further, the urban market has higher prices and lower quantities relative to those of unconstrained oligopoly competition (Cournot) in the urban market." (p. 13). If the Cournot game in the urban (low-cost) market is played before the auction and the resulting price is used to define the price constraint in the rural (high-cost) market, however, there would be no "perverse" incentives in the auction.

ground. Section 3 compares COLR auctions and uniform subsidy schemes. Section 4 studies collusion in COLR auctions for per-subscriber subsidies. Section 5 concludes with a summary and some avenues for further research.

2 Universal Service After the Act

The Telecommunications Act of 1996 has fundamentally changed the Universal Service policy of the United States. The Act has given the goal of Universal Service its strongest and most explicit endorsement ever:¹²

“ UNIVERSAL SERVICE PRINCIPLES. The Joint Board and the Commission shall base policies for the preservation and advancement of universal service on the following principles:

1. QUALITY AND RATES. Quality services should be available at just, reasonable, and affordable rates.
2. ACCESS TO ADVANCED SERVICES. Access to advanced telecommunications and information services should be provided in all regions of the Nation.
3. ACCESS IN RURAL AND HIGH COST AREAS. Consumers in all regions of the Nation, including low-income consumers and those in rural, insular, and high cost areas, should have access to telecommunications and information services, including interexchange services and advanced telecommunications and information services, that are reasonably comparable to those services provided in urban areas and that are available at rates that are reasonably comparable to rates charged for similar services in urban areas.”¹³

At the same time, the Act has given the final blow to the traditional way of pursuing the Universal Service goal. The old web of implicit cross-subsidies and, in particular, the practice of mandated geographic price averaging by large regulated

¹²It must be noted that the term “Universal Service” was originally used in the sense of “universal network interoperability.” The current meaning (access to telephone services for everybody) emerged only in the last three decades (see Mueller, 1997).

¹³Section 254(b). The Act has also introduced a new Universal Service goal that will not be considered in this paper: “Elementary and secondary schools and classrooms, health care providers, and libraries should have access to advanced telecommunications services.”

monopolies, have not been merely undermined by the lifting of legal entry barriers;¹⁴ they have been clearly repudiated in favor of the (Universal Service) principle of explicit subsidies:

”SPECIFIC AND PREDICTABLE SUPPORT MECHANISMS. There should be specific, predictable and sufficient Federal and State mechanisms to preserve and advance universal service.”¹⁵

The design of the Universal Service policy can be thus divided in three parts: the definition of the Universal Service obligation (i.e., the set of subsidized “core services” and the “affordable price” at which they must be available), the design of the tax scheme used to finance the Universal Service Fund, and the design of the subsidy scheme that will use those funds to guarantee the satisfaction of the Universal Service obligation. These three components are surely related and, in principle, should be decided simultaneously. The complexity of the issues involved, however, suggests that addressing them separately is a practical necessity.

The FCC has already defined the set of “core services” that will be supported at the federal level:

“[W]e define the ‘core’ or ‘designated’ services that will receive universal service support as: single-party service; voice grade access to the public switched network; Dual Tone Multifrequency (“DMTF”) signaling or its functional equivalent; access to emergency services including, in some circumstances, access to 911 and Enhanced 911 (“E911”); access to operator services; access to interexchange service; access to directory assistance; and toll-limitation services for qualifying low-income consumers.”¹⁶

¹⁴Section 253 (Removal of barriers to entry) states in its opening paragraph:

“No State or local statute or regulation, or other State or local legal requirement, may prohibit or have the effect of prohibiting the ability of any entity to provide any interstate or intrastate telecommunications service.”

Actually, the Act (Section 271) requires that Bell operating companies take a series of steps to open their own intraLATA (local service) markets to competition before they can enter the interLATA (long distance) market.

¹⁵Section 254(b). Some forms of explicit subsidies were already in place before the passage of the Act (see FCC, 1996). Incidentally, the Act never mentions the word “subsidy” and uses expressions such as “support payments” or “high-cost assistance” instead. I will use all these terms interchangeably.

¹⁶Paragraph 56 of the Report and Order on Universal Service; 47 Code of Federal Regulations, Section 54.101(a).

The details of the contribution scheme for the Universal Service Fund have not yet been settled, but (like the determination of the “affordable” prices) they will be determined independently of the subsidization scheme. We can thus focus on the latter.

2.1 The FCC’s *Universal Service Order*

The sums required to satisfy the Act’s Universal Service goal are hard to quantify, but they are certainly considerable. A study by the Telecommunications Industries Analysis Project gives an estimate of five billion dollars per year for the subsidy from urban (generally low-cost) consumers to rural (generally high-cost) ones, but this does not consider the further requirement that prices be “affordable” (see Weinhaus *et al.*, 1995). It is of course impossible to quantify the effects of this requirement until the regulatory authorities specify what “affordable” really means. If it meant the conservation of the present patterns of subsidization (e.g., from long-distance to local service), then the total amount of subsidies could reach twenty billion dollars per year.

The Act specifies that Universal Service subsidies will be paid out of a Universal Service Fund financed by mandating contributions from providers of interstate telecommunications services. Such a restricted tax base means that the social cost of Universal Service subsidies is likely to be very large.¹⁷ It is therefore very important to choose a subsidization scheme that, while respecting the letter and the spirit of the Act, also tries hard to minimize the total amount of subsidies.

As mentioned in the Introduction, the FCC has shown considerable interest in the use of auctions to allocate Universal Service subsidies, based on the belief that “competitive local exchange markets may develop even in high-cost areas.”¹⁸

The FCC, however, felt that it did not have enough information to formulate an operative bidding proposal within the time constraints of the Act’s implementation schedule and decided to begin with a more traditional policy.

According to the FCC’s *Report and Order on Universal Service*, Incumbent Local Exchange Carriers (ILECs) will maintain most of their current regulatory apparatus and, in particular, their COLR obligation. The same per-subscriber subsidy

¹⁷The mandatory contributions required by the Act are not considered “taxes” from a legal point of view. But, as the saying goes, “by any other name, a tax would still distort the same.”

¹⁸Paragraph 37, *Notice of Proposed Rule Making and Order Establishing Joint Board*, CC Docket 96-45, March 8 1996.

will be paid to any carrier that serves a consumer in a supported area and it will be calculated “by determining the forward-looking economic cost of providing the supported services reduced by a nationwide revenue benchmark calculated on the base of average revenue per line” (par. 223).

This policy has at least one fundamental flaw. Even if the regulator had accurate information about the average cost of serving a given area,¹⁹ it will rarely have much information about the cost of serving individual market segments, let alone individual consumers. If there is enough cost heterogeneity among consumers, “cream-skimming” by competing carriers may reduce the COLR’s average revenue per-subscriber. More generally, a national revenue benchmark may have little to do with what a carrier can get in a given high-cost area.

As a consequence, this approach cannot ensure that the support payments in a given area will be “sufficient” (as required by the Act) and that the area will be voluntarily served by some carrier.

Although the FCC’s plan may be a reasonable way to determine the amount of federal support to the States’ Universal Service policies, it does not seem appropriate for the actual determination of the support received by any given carrier. That will require, at least, that the “national revenue benchmark” be substituted by the “affordable” price the regulator wants to implement.

The FCC plan, however, would still fail to take seriously into consideration the fact that, in passing the Act, Congress intended to promote a national policy framework that is not only “pro-competitive”, but also “deregulatory.”²⁰ The FCC plan, instead, does not seem to reduce the ILECs’ regulatory burden. On the contrary, it relies on imposing asymmetric (hence not “competitively neutral”) obligations upon ILECs, without the guarantee of sufficient compensation.

3 COLR Auctions vs. Uniform Subsidies

This section does take the deregulatory intent of the 1996 Act seriously and compares two “competitively neutral” mechanisms for high-cost support: COLR auctions and voluntary uniform subsidy (VUS) schemes.

A VUS scheme pays the same subsidy for any consumer served at no more than

¹⁹This is quite unlikely. See Dippon and Train (1998) for a glaring example of the unreliability of engineering cost models.

²⁰See H.R. Rep. No. 104-458; Preamble to Pub. L No. 104-104, 110 Stat 56, 1996.

the regulated price, without imposing any other obligation.²¹ It is “voluntary” because neither the incumbent nor any other firm is obliged to set a low price. It is “uniform” because it does not discriminate across firms.

The goal of this section is to show that COLR auctions can lead to lower subsidies and, more generally, higher welfare levels in a wide range of circumstances.

It is quite obvious that the two mechanisms cannot be ranked on theoretical grounds alone. A COLR auction would be of limited value if only one firm could reasonably offer service in the area.²² On the other hand, a VUS scheme based on wildly inaccurate cost estimates may make a COLR auction attractive even with a modicum of potential competition.

The interesting fact shown in the model below is that a COLR auction may lead to higher welfare levels than a VUS scheme even if the latter is based on very accurate cost estimates. The crucial ingredients for this result are the heterogeneity of consumers (in terms of the cost to serve them) and the regulator’s inability to obtain sufficiently disaggregated data. The intuition can be briefly summarized as follows. A VUS scheme pays a uniform level of subsidies for all consumers in a given area. The cost of serving these consumers, however, generally varies in a manner that is not fully observable by the regulator. Even if the regulator knew the distribution of service costs, but not the cost of serving any individual consumer, a VUS scheme would have to pay an amount that is sufficiently large to cover the highest cost consumers. The equilibrium level of subsidies with a COLR auction, instead, will depend on the (second) lowest average costs for the area.²³ This may well be less than the lowest cost for the most costly consumer in the area.

Given the goal of this section, the model below will be somewhat biased against COLR auctions. First, I will only consider the best possible VUS scheme, i.e., the one that pays the minimum subsidy for which the service area would be served at the regulated price or less. Second, I will only consider a simple COLR auction (without combinatorial bidding) that always appoints a single COLR per area and never imposes a maximum acceptable bid.²⁴ Third, I will consider a “purely high-

²¹A possible alternative would be to pay the same per-subscriber subsidy only to firms that accept the COLR obligation. This intermediate case between COLR auctions and VUS schemes is not discussed in this paper.

²²But it could be of *some* value even then! See the discussion of subcontracting below.

²³The precise definition of “average” depends on the structure of subcontracting.

²⁴Possibly the best comparative advantage of uniform subsidy schemes is that they can exploit the potential productive efficiency of *niche* carriers, i.e., firms that may be very efficient at serving a subset of the market, but very inefficient at serving the whole market as a COLR. A COLR auction

cost” service area, i.e., a service area in which no consumer could be profitably served at the regulated price without a subsidy.²⁵

3.1 The Model

Consider an area that hosts a unit mass of consumers. All consumers have a rigid unit demand for the service to be procured, but they differ in the cost to provide them with such service. Let $\{q_1, q_2, \dots, q_M\}$ be vector of shares of the M classes of consumers ($\sum_{h=1}^M q_h = 1$), N be the number of firms and c_h^f be firm f 's (constant marginal) cost of serving a consumer of class h .²⁶ Let $\eta(h)$ be the firm that is most efficient at serving class h and $c_h^{(i)}$ the cost of serving a consumer of class h for the i -th most efficient firm at doing so. For simplicity, I will assume that, for all h , $c_h^{(1)}$ is strictly less than $c_h^{(2)}$.

As mentioned above, I will assume that all consumers are “high-cost”: for all f and h , $c_h^f > p_r$, where p_r is the regulated price. As a consequence, subsidized firms will be the only sellers.²⁷ The firms’ products are perfect substitutes and firms will compete in price à la Bertrand.²⁸

All this information is common knowledge for the firms, but is ignored by the regulator.²⁹ The regulator is thus obliged to pay the same subsidy for all consumers

that appoints a single COLR per area cannot do the same - unless one considers the possibility of subcontracting. The absence of a maximum acceptable bid makes the contrast even starker: the comparison is between a VUS set by a well-informed regulator and a COLR auction designed by a regulator with no information at all.

²⁵If the service area contained also low-cost consumer, COLR auctions for lump-sum and for per-subscriber subsidies would no longer be equivalent. It would then be possible in most (but not all) cases to reduce the equilibrium level of subsidies in COLR auctions by paying them on a per-subscriber basis (see Sorana, 1998).

²⁶The role of the (unrealistic) assumption of additive costs is to guarantee the existence of a competitive equilibrium in the case of VUS schemes and the existence of a pure strategy Nash equilibrium in the case of COLR auctions. Although not strictly necessary for this purpose, it greatly simplifies the analysis without introducing any obvious bias in favor of COLR auctions. It may actually introduce yet another bias against auctions because economies of scope could be dealt with more effectively with combinatorial auctions (e.g., a Vickrey-Clark-Groves mechanism) than with uniform subsidies (see Krishna and Perry, 1998).

²⁷In the context of this section, this assumption reduces the COLR auction to a standard procurement auction. As far as auctions are concerned, in fact, we could set $p_r = 0$ without further loss of generality.

²⁸Cournot competition would lead to higher subsidies in the case of VUS schemes.

²⁹We could equally assume that the regulator knows the cost structure, but cannot distinguish the different consumers classes.

if a VUS scheme is used. I will impose the same constraint on COLR auctions by having a single auction for the whole area.³⁰

3.2 Uniform Subsidy Scheme

The first point to note is that

Proposition 1 *A voluntary uniform uubsidy scheme must pay at least*

$$\underline{S}^{VUS} \equiv \max_h \min_f (c_h^f \Leftrightarrow p_r) \quad (1)$$

per consumer if the Universal Service goal is to be satisfied.

The proof is obvious: If a lower subsidy $S < \underline{S}^{VUS}$ was paid, then the classes of consumers for which $\min_f c_h^f > (p_r + S)$ would not be served.

A subsidy equal to \underline{S}^{VUS} may actually be enough to achieve the Universal Service goal. Given the assumption of Bertrand competition, it would be an equilibrium for each consumer of class h to be served by $\eta(h)$ at price $p_r \wedge (c_h^{(2)} \Leftrightarrow \underline{S}^{VUS})$. This price may be negative. Even if negative prices are not allowed and there are no other ways in which firms can compete away their subsidy (e.g., quality increases), the efficient rationing of firms would still be an equilibrium. Other rationing schemes would lead to lower production efficiency, but would not affect the minimum level of subsidies.

Note, however, that there may be other equilibria in which firms forsake the subsidy and sell prices above p_r .³¹

3.3 COLR auctions without subcontracting

Consider now a COLR auction without the possibility of subcontracting the production of services to some or all consumers classes. Since all consumers are “high-cost”, the winner of the auction, sole COLR and only recipient of subsidies, will not face any competition after the auction and serve the whole market. Therefore it does not matter whether subsidies are paid on a lump-sum or per-subscriber basis. Since we are also assuming that bidders have complete information, there is no essential

³⁰In the procurement context, we might think that the buyer simply does not know how to decompose the system to be procured into its more basic parts.

³¹See Sorana (1998).

difference between the various standard auction formats and we can restrict our attention to second-price auctions.

Since there is a unit mass of consumers, the cost of the COLR obligation for firm f is then equal to its average cost minus the price it can charge consumers $\sum_{h=1}^M q_h(c_h^f \Leftrightarrow p_r)$. In a second price auction, firms bid their true valuation, so we have

Proposition 2 *If subcontracting is not allowed, a COLR auction will be won by the firm with the lowest average cost and the subsidy will be equal to the second lowest average cost*

$$S^{NS} \equiv \left(\sum_{h=1}^M q_h c_h^f \right)^{(2)} \Leftrightarrow p_r \quad (2)$$

A COLR auctions without subcontracting will be cheaper than even the cheapest VUS scheme if and only if there is a class of consumers that cannot be served for less than the second-lowest average cost.

Roughly speaking, COLR auctions without subcontracting have a comparative advantage over VUS schemes when firms are similar (in the way they rank consumer classes in terms of cost) and consumers different (in terms of the minimum cost to serve them). Similarity in cost structure, however, become much less important if one considers the possibility of subcontracting.

3.4 COLR auctions with subcontracting

Under our hypotheses, a VUS achieves an efficient allocation: each consumer class is served by the firm that is most efficient at doing so and there is no need for subcontracting.

The case is different for COLR auctions. Unless the same firm is the most efficient provider for each class of consumers, the winner of the auction will benefit from subcontracting to some other firms the production of services for some consumer classes.³²

The possibility of subcontracting surely reduces total production costs. The effect on the equilibrium level of subsidies, however, is less clear. Subcontracting

³²If subsidies are paid on a per-subscriber basis, the winner of the auction would still be the official seller for all consumers.

increases the payoff from winning the auction, but it also increases the payoff from losing the auction. A firm who loses the auction does not necessarily get zero profits, because it can win some contracts at the subcontracting stage. The net effect on the equilibrium level of subsidies will depend on what happens at the subcontracting stage. Milgrom (1987) has shown that, in a single-object auction with complete bidder information, the possibility of resale increases the auctioneer's revenue - even if the auction without resale was already efficient. As shown by Haile (1996), this result is not always robust to the introduction of bidders' uncertainty about the private value of the object. Even with completely informed bidders, subcontracting may increase the cost of procurement if the object of the auction is not a single indivisible good. Kamien, Li and Samet (1989) study a procurement auction for an endogenously determined quantity of a perfectly divisible good with two identical and completely informed bidders. They assume that the bidders' (common) cost function is strictly convex (i.e., there are decreasing returns to scale) in order to create a need for subcontracting and show that subcontracting increases the cost of procurement if winning the auction implies a sufficiently large loss of bargaining power in the subcontracting stage. The model of this section takes the object(s) to be procured as given and assumes that cost functions are linear,³³ but relaxes several other assumptions of the model by Kamien, Li and Samet (1989). First, the object(s) of procurement are not necessarily identical. Second, there can be any number of firms. Third, the firms may have different technologies. Kamien, Li and Samet's results are confirmed, with one exception: if there are three or more bidders, subcontracting may reduce the cost of procurement even if winning the auction implies the loss of *all* bargaining power in the subcontracting stage.

I will make the following assumption on the way subcontracting agreements are reached.³⁴ For each consumer class h , the winner of the COLR auction can either produce the service directly at a cost c_h^f , or run a subcontracting (second-price)³⁵ auction with reserve price equal to c_h^f , or bargain directly with another firm. I

³³Kamien, Li and Samet's assumption of diseconomies of scale is probably appropriate in the context of subcontracting in the manufacturing or construction industries. In the context of COLR auctions, however, the complications are much more likely to arise from economies of scope than from diseconomies of scale. Doing away with the latter, even if not including the former, is therefore a step in the right direction for the purpose of this paper.

³⁴The work of Milgrom (1987) suggests that these assumptions manage to approximate the outcome of any bargaining process with complete information.

³⁵As noted above, given the assumption of complete information, a first-price auction would lead to the same results.

assume that direct bargaining is efficient and that the subcontractor gets a share $(1 \Leftrightarrow \alpha) \in [0, 1]$ of the gains from trade. If a subcontracting agreement is reached, the subcontractor can in turn enter into a further subcontracting agreement via direct bargaining or via an auction. In order to avoid spurious equilibria in which the obligation to serve is endlessly transferred from one firm to another, I will assume that there is time for only a finite number $T \geq 2$ of periods for subcontracting negotiations and in each period there can be at most one auction or one direct bargaining session. For simplicity, I assume that there is no discounting.

We then get the following

Proposition 3 *All firms will bid the same amount (which then equals the level of subsidy):*

$$S^{WS} = \alpha \sum_{h=1}^M q_h c_h^{(1)} + (1 \Leftrightarrow \alpha) \sum_{h=1}^M q_h c_h^{(2)} \Leftrightarrow p_r \quad (3)$$

where $c_h^{(i)}$ is the i -th lowest cost of serving class h .

Proof:

Let $V(f, h, t)$ be firm f 's unit cost of the obligation to provide service for class h when there are $T \Leftrightarrow t$ periods left for subcontracting arrangements. Clearly $V(\eta(h), h, t) = c_h^{\eta(h)} \equiv c_h^{(1)}$ for any (h, t) and $V(f, h, T) = c_h^f$ for any (f, h) .

In period $T \Leftrightarrow 1$, if $f \neq \eta(h)$ has acquired the obligation to produce service for class h , it can fulfill the obligation by negotiating directly with $\eta(h)$ and paying $[\alpha c_h^{(1)} + (1 \Leftrightarrow \alpha)c_h^f]$ per consumer.³⁶ Alternatively, f can run an auction (the last one); everyone would bid $V(f, h, T) = c_h^f$ and the price would be $c_h^{(2)}$.³⁷ We thus have

$$\begin{aligned} V(f, h, T \Leftrightarrow 1) &= c_h^f \wedge c_h^{(2)} \wedge [\alpha c_h^{(1)} + (1 \Leftrightarrow \alpha)c_h^f] = \\ &= c_h^{(2)} \wedge [\alpha c_h^{(1)} + (1 \Leftrightarrow \alpha)c_h^f] \end{aligned} \quad (4)$$

$$V((2), h, T \Leftrightarrow 1) = \alpha c_h^{(1)} + (1 \Leftrightarrow \alpha)c_h^{(2)} \equiv p_h \quad (5)$$

where $V((2), h, T \Leftrightarrow 1)$ is the second lowest cost among $\{V(f, h, T \Leftrightarrow 1)\}_{f=1}^N$ and hence the unit price in an auction for h at the $(T \Leftrightarrow 2)^{th}$ subcontracting period.

³⁶Negotiating directly with any other firm would lead to lower payoffs.

³⁷Recall that the reserve price in a subcontracting auction is assumed to be equal to the buyer's own cost.

Note that $\eta(h)$ can always guarantee itself a price at least as high as p_h just by waiting till the last subcontracting period. On the other hand, every other firm can guarantee itself to pay no more than p_h by running an auction in the $(T \Leftrightarrow 2)^{th}$ subcontracting period. Therefore, the COLR's actual cost of serving a class of consumers for which it is not the most efficient provider is p_h regardless of its actual cost.

The total cost of the COLR obligation for firm f is therefore

$$\sum_{h \in \eta^{-1}(f)} q_h c_h^{(1)} + \sum_{h \notin \eta^{-1}(f)} q_h [\alpha c_h^{(1)} + (1 \Leftrightarrow \alpha) c_h^{(2)}] \Leftrightarrow p_r \quad (6)$$

Similarly, if firm f loses the auction, it will get a total profit equal to

$$(1 \Leftrightarrow \alpha) \sum_{h \in \eta^{-1}(f)} q_h [c_h^{(2)} \Leftrightarrow c_h^{(1)}] \quad (7)$$

Let us go back to the (main) procurement auction. Firm f will bid the difference between its profits in case of loss and its profits (net of the subsidy) in case of victory in the auction.³⁸ This is equal to the sum of the amounts in equations (7) and (6). A little algebra shows that this sum does not depend on f and is indeed equal to (3).

QED.

Remark: Note that *the equilibrium level of subsidies does not depend on whether the regulator runs an auction for each consumer class or bundles several consumer classes together.*

Since both COLR auctions with subcontracting and VUS schemes are technically efficient (i.e., the service of each consumer class is produced by the firm that is most efficient at doing so) and satisfy the Universal Service obligation, it seems reasonable to prefer the mechanism that requires the lowest level of subsidy.³⁹

If α is sufficiently large, then COLR auctions with subcontracting will be better than even the best VUS scheme because $\sum_{h=1}^M q_h c_h^{(1)}$ is always weakly smaller than $\max_h c_h^{(1)}$ and is strictly smaller if there are two consumer classes (i, j) with $c_i^{(1)} \neq c_j^{(1)}$.

³⁸Recall that this is a procurement auction, so the bids represent money that the bidders would receive from the auctioneer.

³⁹But see below for more comments.

Note also that, *if there are more than two firms, subcontracting could reduce procurement costs and COLR auctions could be strictly better than the best VUS scheme even if $\alpha = 0$.*

Remark: Strictly speaking the above judgement makes the implicit assumption that the shadow cost of subsidies is large with respect to the differences between the welfare weights of firms and consumers (provided that consumers get their service at the regulated price). In fact, consumers are definitely worse off with COLR auctions because they all pay p_r and cannot appropriate the excess subsidy for their class with respect to the costliest class. The direction of change is ambiguous for profits: if the non-negativity constraints on price are not binding, the firms get total profits equal to $\sum_h q_h (p_r \wedge (c_h^{(2)} \Leftrightarrow \underline{S}^{VUS}) + \underline{S}^{VUS} \Leftrightarrow c_h^{(1)})$ under a VUS, while they get $(1 \Leftrightarrow \alpha) \sum_h q_h (c_h^{(2)} \Leftrightarrow c_h^{(1)})$ under a COLR auction. Note, however, that *if α is sufficiently close to one*, then both profits and consumer surplus are lower under a COLR auction. In this case, *an easily satisfied sufficient condition for the superiority of COLR auctions is that the shadow value of public funds be higher than the welfare weights of both consumers and firms in the area.*

Remark: When we consider the possibility of subcontracting, COLR auction can be optimal even if the firms' cost structures are very different from each other. *All that is needed for the optimality of COLR auction is that for most consumers the difference between the lowest and second-lowest cost to serve is not too big - or that alpha is large enough.*

Remark: Theoretically, this result has an obvious policy implication: the regulator should try to strengthen the bargaining power of the COLR as much as possible. In the context of the model presented in this section this is quite easy to do. It would in fact be enough to oblige the COLR to make only one take-it-or-leave-it offer to each of other firms. In practice, however, firms are not completely informed about each other's costs and it is not clear how the COLR's bargaining power can be efficiently increased.

4 Competition *for* the market vs. *in* the market

The previous section shows that competition for the market (or, to be precise, competition for the subsidies given to a market) can translate into significant savings for the regulator, especially when the regulator's information about the firms' costs is not very good. There may be, however, also another dimension of the Universal

Service problem about which “the market” knows more than the regulator, namely the quality of the service firms provide to consumers.

Quality of service is a multidimensional entity that can be quite difficult even to define with sufficient precision, let alone to enforce effectively. It is something, however, that consumers experience, know about and, when the price is right, are willing to pay for. It is also something that a sole COLR in a high-cost area may have no interest in providing.

Consider for example the case in which consumers prefer to buy low quality service from the COLR at the regulated price rather than buying high quality service at a price equal to the corresponding cost from some other carrier. The COLR would then face no competitive pressure and have no incentive to provide high quality service even if the marginal cost of quality is lower than its marginal benefit for consumers.⁴⁰

What can regulators do to solve this problem? Imposing a market penetration target as part of the COLR obligation or, more generally, paying the COLR as a function of the number of consumer served would not solve the problem in the above example.⁴¹ One possibility would be to make subsidy payments dependent on surveys of consumer satisfaction, but it is not clear how reliable these would be.⁴²

The problem of providing an efficient level of product quality is not particularly severe for a VUS scheme that pays a sufficiently high subsidy. Firms will have some surplus subsidy to dissipate in their competition for consumers (with the possible exception of the costliest ones) and, roughly speaking, they will compete in price or quality according to what consumers value the most and how costly it is to produce higher quality.⁴³

This suggests one potential solution for COLR auctions as well, namely the introduction of some competition “in the market” by appointing several COLRs per area and paying them on a per-subscriber basis.⁴⁴

⁴⁰Recall that the COLR would not be able to raise the price without losing the subsidy.

⁴¹It may help, however, if quality levels can be so low that (some) consumers would not buy the COLR’s service.

⁴²Consumers would have the incentive to complain about service quality even if the latter was as high as required by the COLR’s obligation, so that the regulator would force the COLR to increase it a notch further.

⁴³Two cautionary remarks are in order here. First, if consumers also differ in their taste for quality, then inefficient levels of quality may be provided (see Tirole, 1988, section 7.5.1.) Second, the private value of quality may be lower than the social value of quality for the same reasons that led to a Universal Service policy to begin with.

⁴⁴Doing so may have other benefits and costs than those discussed in this section (see Sorana,

Increasing the number of COLRs per area has an obvious cost, at least if sub-contracting is not feasible, since the level of subsidy would then also depend on the third-lowest (average) cost, instead of the second-lowest. But there could be much higher costs involved if the auction rules are not carefully crafted.

The next part of this section shows that COLR auctions for per-subscriber subsidies are more vulnerable to collusion than standard procurement auctions and COLR auctions for lump-sum subsidies.⁴⁵ Moreover, the problem is exacerbated if the auction appoints more than one COLR. *The source of the problem is precisely in the added scope for competition “in the market”*: Defectors from collusive agreements in COLR auctions for per-subscriber subsidies can be punished by charging low prices in the market immediately after the auction where a defection occurred, without having to wait till the next auction.

The last part of this section shows that an auction that determines endogenously (i.e., on the basis of the firms’ bids) the number of COLRs can sometimes appoint several COLRs without falling prey to collusion. However, it may still be unable to generate enough incentives for high-quality service.

4.1 The Model

I will consider the simplest possible model of repeated COLR auctions for per-subscriber subsidies. There are N firms who have the same constant marginal cost of production equal to c and the same discount factor δ . Quality can be of two levels: $q \in \{0, 1\}$. The marginal cost of quality, also common to all firms, is γ and consumers’ marginal value for quality is $B > \gamma$. It is therefore efficient to provide high-quality service. There is a unit mass of consumers with unit demand and whose value for low-quality service is L . The regulator knows $(N, \delta, \gamma, B, L)$, but does not know the firms’ cost structure and (s)he wants high-quality service to be available at a price no higher than $p_r < L$. The timing of the models in this section is as follows:

1. The regulator chooses the auction rules. I will take the duration of the COLR franchise $T \geq 1$ and the reserve price $R \geq c + \gamma \Leftrightarrow p_r$ as exogenously given. I

1998a).

⁴⁵There is now a large literature on collusion in auctions. For the purpose of this section, Robinson (1985), Milgrom (1987), Graham and Marshall (1987), von Ungern-Sternberg (1988), and Wolfstetter (1996) provide useful introductions.

will also make the following assumptions.⁴⁶ First, *the regulator runs a single auction for the whole market*, so that the gains from breaking a bidders' ring are greatest. Second, *in case of ties, the regulator will appoint the firm with the lowest code number*,⁴⁷ so that a bidders' ring cannot use the auctioneer as the randomization device that decides the winner(s) in a given auction.

2. The firms submit their (sealed) bids and the outcome of the auction is announced.
3. Immediately after the auction, and at the beginning of every period until the next auction, firms simultaneously set their prices and quality levels for the period. Consumers divide themselves equally among the firm(s) that offer the best deal, i.e., the highest value of $Bq^f \Leftrightarrow p^f$. Production takes place and payments are made.
4. After T periods, go back to stage 2.

4.2 Auctions for two or more COLRs

The purpose of this subsection is to show that collusion among identical bidders is always enforceable when the auction appoints a fixed number $M > 1$ of COLRs and pays them on a per-subscriber basis.⁴⁸

Let us assume that the number of COLRs appointed in each auction is fixed exogenously (i.e., independently of the bids) at $M < N$. We can then show the following:

Proposition 4 *If $M > 1$, then maximal bid rigging (i.e., getting a subsidy equal to the reserve price) is sustainable in both uniform-price and discriminatory COLR auctions for per-subscriber subsidies. This result does not depend on the discount factor, the duration of the COLR franchise, or any of the other parameters.*

Proof:

⁴⁶In the context of this model, it is actually optimal for the regulator to behave according to these two assumptions.

⁴⁷Any other deterministic method (e.g., alphabetical order) would do.

⁴⁸Under the above assumptions, it would not make any sense to appoint several COLRs and pay them on a lump-sum basis. A COLR would then compete perversely in offering a worse deal than the other COLR(s) in order to avoid the losses from serving consumers.

*Case (a): uniform $(M + 1)^{th}$ price auction.*⁴⁹ Consider the following symmetric strategy profile. Before any auction, M firms are chosen at random as “designated winners”. They will bid $\underline{b} = c \Leftrightarrow p_r$, while the others will bid R . The winners’ subsidy will then be equal to R . If some “designated loser” bids \underline{b} or less, the subsidy would be exactly \underline{b} and everyone will bid \underline{b} forever after. No immediate gain from defection would then compensate the loss of the future gains from collusion.⁵⁰

After an auction in which no designated loser has defected from the agreement and become a COLR, and for all the T periods before the next auction, the winners will set a price equal to p_r and offer low quality service. The other firms will stay out of the market. If anyone sets a price lower than p_r , then all (other) COLRs will offer high quality service at a price equal to $c + \gamma \Leftrightarrow R$ ⁵¹ in the remaining periods before the next auction and everyone will bid \underline{b} forever after.

It is clear that the only deviation that the colluders need to worry about is that of a designated COLR setting a price below p_r and/or offering high-quality service. For completeness and future reference, I characterize below the condition for this to be unprofitable, but I wish to emphasize that this condition does not affect the result claimed in the proposition: *bid rigging is an equilibrium in the auction even if collusion in the post-auction market is not sustainable!*

The value of collusion for a designated winner (V^W) and a designated loser (V^L) are obtained as the solution of the following system of two equations

$$V^W = \frac{1}{M}(p_r + R \Leftrightarrow c) \frac{1 \Leftrightarrow \delta^T}{1 \Leftrightarrow \delta} + \delta^T \left(\frac{M}{N} V^W + \frac{N \Leftrightarrow M}{N} V^L \right) \quad (8)$$

$$V^L = \delta^T \left(\frac{M}{N} V^W + \frac{N \Leftrightarrow M}{N} V^L \right) \quad (9)$$

The solution is

$$V^W = (p_r + R \Leftrightarrow c) \frac{(1 \Leftrightarrow \delta^T)N + \delta^T M}{MN(1 \Leftrightarrow \delta)} \quad (10)$$

⁴⁹In this case, the restriction to $M > 1$ is not important.

⁵⁰Note that it is a subgame perfect equilibrium to bid \underline{b} forever.

⁵¹For notational simplicity I will allow prices to be negative. The analysis would be essentially unchanged if I imposed the non negativity constraint, allowed the quality of service to vary continuously in $[0,1]$, and assumed that γ and B are sufficiently large.

$$V^L = (p_r + R \Leftrightarrow c) \frac{\delta^T}{N(1 \Leftrightarrow \delta)} \quad (11)$$

The expected profits of a firm in the collusive equilibrium are then

$$V = \frac{M}{N} V^W + \frac{N \Leftrightarrow M}{N} V^L = (p_r + R \Leftrightarrow c) \frac{1}{N(1 \Leftrightarrow \delta)} \quad (12)$$

A COLR's deviation from collusion in the market (i.e., setting a price of $p_r \Leftrightarrow \varepsilon$ ($\varepsilon \in (0, \gamma)$) and getting the whole market for the period) at the beginning of the t^{th} period after an auction will be unprofitable if

$$(p_r \Leftrightarrow \varepsilon + R \Leftrightarrow c) < (p_r + R \Leftrightarrow c) \frac{1}{M} \frac{(1 \Leftrightarrow \delta^{T-t})}{(1 \Leftrightarrow \delta)} + \delta^{T-t} V \quad (13)$$

If we take ε to be arbitrarily small, "hence" zero, and substitute the value for V , the gains from deviation become

$$(p_r + R \Leftrightarrow c) \left(1 \Leftrightarrow \frac{(1 \Leftrightarrow \delta^{T-t} N + \delta^{T-t} M)}{MN(1 \Leftrightarrow \delta)} \right) \quad (14)$$

These gains are maximal in the period just before a new auction - the defecting COLR can get its booty only once, so it had better get the "normal" COLR profits in the first $T-2$ periods. Collusion in the market will be sustainable if

$$(p_r + R \Leftrightarrow c) \left(1 \Leftrightarrow \frac{(1 \Leftrightarrow \delta N + \delta M)}{MN(1 \Leftrightarrow \delta)} \right) < 0 \quad (15)$$

or

$$M < \frac{N(1 \Leftrightarrow \delta)}{N(1 \Leftrightarrow \delta) \Leftrightarrow \delta} \quad (16)$$

This shows that increasing the number of COLRs per area can indeed provide sufficient incentives for competition "in the market". Note that this condition does not depend on the reserve price, i.e., on the level of collusion. Therefore a bidding

ring cannot increase its cohesiveness by being less greedy and getting a subsidy lower than R .

Case (b): uniform M^{th} price auction, i.e., subsidy equal to the worst accepted bid. The analysis is similar to the case of discriminatory auctions below and is thus omitted.

*Case (c): discriminatory "get-your-bid" auction.*⁵² The collusive outcome in the auction is now achieved by having the designated winners bid R and the designated loser not participate at all.⁵³ A designated loser who defects from the agreement and bids $R \leftrightarrow \varepsilon$ would immediately be punished by the other COLR(s) who would all switch to the non-collusive equilibrium and offer high quality service at a price equal to $c + \gamma \leftrightarrow R$ thus depriving the defector of any profit.⁵⁴ Note that this kind of punishment strategy would not be possible in a standard procurement auction, nor in a COLR auction for lump-sum subsidies. The rest of the analysis is analogous to the one of case (a).

QED.

In the case of discriminatory auctions, the above proof uses the fact that $M > 1$ (and that competition is Bertrand-like) since it relies on the fact that the punishment of defectors does not entail negative payoffs for the punishers. The continuation strategies after the punishment phase, in fact, give zero payoff to everyone, so losses would not be recovered.

This may suggest that the auction vulnerability to bid rigging may not be as bad as it looks. Although collusion in the auction is a Nash equilibrium, it is not necessarily a strong equilibrium, i.e., it can be vulnerable to defection from a coalition of players. In fact, if $N \geq 2M$, it may be profitable for M designated losers to jointly defect from the collusive agreement and clinch all the COLR positions. The defeated would-be COLRs would then lose the subsidy and would no longer be able to wipe out the defectors' profits without incurring in immediate losses themselves.⁵⁵

This does not change the fact, however, that COLR auctions for per-subscriber subsidies are more vulnerable to collusion than COLR auctions for lump-sum sub-

⁵²In this case, the restriction to $M > 1$ and the assumption of Bertrand competition have bite.

⁵³Nothing essential would change if participation were mandatory. The designated winners would bid $R - \varepsilon$ and the designated losers would bid R

⁵⁴Recall that we are assuming Bertrand competition.

⁵⁵If firms' costs differ, it would also be impossible to wipe out the profits of a single defector when that defector is the lowest-cost firm.

sidies (and standard procurement auctions). The following subsection shows that this is true even if $M = 1$.

4.3 Single COLR Auctions for per-subscriber subsidies

We have already shown that second-price single-COLR auction admit collusive equilibria. Now consider a first-price COLR auction that appoints a single COLR (i.e., $M = 1$).

The payoffs from sticking to the collusive agreement are now given by

$$V^W = (p_r + b_c \Leftrightarrow c) \frac{N(1 \Leftrightarrow \delta^T) + \delta^T}{N(1 \Leftrightarrow \delta)} \quad (17)$$

$$V^L = (p_r + b_c \Leftrightarrow c) \frac{\delta^T}{N(1 \Leftrightarrow \delta)} \quad (18)$$

$$V = (p_r + b_c \Leftrightarrow c) \frac{1}{N(1 \Leftrightarrow \delta)} \quad (19)$$

where $b_c \leq R$ is the designated winner's bid (of course, $b_c \geq c \Leftrightarrow p_r$).

Consider the deviation from a designated loser bidding $b_d < b_c$ and becoming the sole COLR. It will be clear that a defector would bid right below b_c so we will simplify matters by assuming that the defector can become a sole COLR by bidding exactly b_c . In a standard procurement auction or in a COLR auction for lump-sum subsidies, the worst punishment that can be inflicted to such defector is to bid \underline{b} at any future auction. This punishment is still possible here, of course, and it will suffice if

$$(p_r + b_c \Leftrightarrow c) \frac{1 \Leftrightarrow \delta^T}{1 \Leftrightarrow \delta} \leq V^L \quad (20)$$

which is equivalent to

$$N \leq \frac{\delta^T}{1 \Leftrightarrow \delta^T} \quad (21)$$

In this case, as expected, collusion is more likely if the number of firms is small, the COLR franchise is short, and the firms patient. Note also that, with the punishment strategy outlined above, if collusion is sustainable at all, then it is sustainable in the maximal degree, i.e., with $b_c = R$.

The following shows that, in COLR auctions for per-subscriber subsidies, some degree of bid rigging can be sustainable even if condition (21) is violated.

Consider the following punishment strategy.⁵⁶ If a designated loser actually wins, then the other $N-1$ firms will all offer high-quality service at price $\hat{p} \equiv (c + \gamma \Leftrightarrow b_c)$ for all the periods before the next auction. They will then revert to the collusive strategy.⁵⁷ If anyone fails to punish a defector, then the punishment phase will end immediately and everyone will bid \underline{b} forever after.

This is clearly enough to dissuade any would-be defector: it would get no immediate payoff and possibly lose some future gains from cooperation. It remains to check whether punishment is individually rational.

The payoff of a “punisher” is now

$$\frac{(\hat{p} \Leftrightarrow c \Leftrightarrow \gamma)}{N \Leftrightarrow 1} \frac{(1 \Leftrightarrow \delta^T)}{(1 \Leftrightarrow \delta)} + \delta^T \frac{(p_r \Leftrightarrow b_c \Leftrightarrow c)}{N} \frac{1}{(1 \Leftrightarrow \delta)} \quad (22)$$

and it is positive whenever

$$\frac{N}{N \Leftrightarrow 1} \leq \frac{\delta^T}{(1 \Leftrightarrow \delta^T)} \frac{(p_r + b_c \Leftrightarrow c)}{b_c} \quad (23)$$

Remark: It is interesting to note that *collusion is more likely to be sustainable if it is done at a higher level* (i.e., with $b_c = R$). The intuition is clear: the more profitable collusion is, the easier it is to get back the cost of punishing defectors. Similarly, and perhaps more surprisingly, *the bidding ring is sometimes more likely to work if there are more firms*, because this allows to share the cost of punishments more evenly.

The above condition can then be rewritten as

$$N \leq \frac{\delta^T}{(1 \Leftrightarrow \delta^T)} \left(1 \Leftrightarrow \frac{c \Leftrightarrow p_r}{R}\right) (N \Leftrightarrow 1) \quad (24)$$

⁵⁶This punishment is not necessarily the most effective, but it suffices for the purposes of this section.

⁵⁷This makes defection irrelevant with respect to the defector’s payoff. If one wants punishment to be strict, then there may be competitive bidding for one or more auctions before reverting to the collusive equilibrium. It would also be possible to revert to a collusive equilibrium in which the defector has a lower probability of winning.

Condition (24) will be more easily satisfied than (21) if and only if

$$\frac{N \Leftrightarrow 2}{N \Leftrightarrow 1} > \frac{c \Leftrightarrow p_r}{R} \tag{25}$$

which is satisfied if, for example, $p_r = 20, c = 40, R > 30, N > 4$. Since the punishment strategy that generates (21) is always available, we have shown

Proposition 5 *Bid rigging is more likely to be sustainable if subsidies are paid on a per-subscriber basis.*

4.4 Endogenous number of COLRs

The model presented above is an extremely simple idealization, but the result seems transferable to a much broader (and realistic) range of settings: if subsidies are paid on a per-subscriber basis, collusion in Carrier Of Last Resort auctions becomes easier. This effect is strengthened by the appointment of more than one COLR per service area because the punishment of defectors is thus made easier for the non-defecting COLRs.

The regulator, however, has a few options that may mitigate this problem. In theory, the regulator could impose a price floor equal to p_r . This would limit the immediate punishment of a defector to γ . In practice, this may be quite problematic. If the area may contain also (or only!) low-cost consumers, the regulator risks becoming not only the protector, but the necessary cause of collusion in the market. Moreover, it is not clear whether the Telecommunications Act gives the regulator the power to impose price floors. A (certainly legal) alternative would be to adjust the reserve price downward whenever the price charged to consumers drops below p_r and thus limit the possibility of recovering the losses incurred in the punishment of defectors.⁵⁸

The rest of this section shows that making the number of COLRs a suitable endogenous function of the bids received may be another way to alleviate the problem of collusion. In some cases, it may even allow the regulator to get the best of both worlds: appoint several COLRs who will compete “in the market” while guaranteeing competition “for the market” under the same conditions needed for the case of single-COLR auctions.

⁵⁸Of course, this would also increase the likelihood of collusion in the market.

The idea of making the number of COLRs dependent on the firms' bids already appears in Milgrom (1996)⁵⁹ and, in different contexts, in the literature on regulation with endogenous market structure mentioned in the introduction.⁶⁰

The intuitive appeal of this idea is that it trades off the value of added competition “in the market” among two (or more) firms against the cost of accepting the second-best (or worse) bid.⁶¹

Let Δ be maximal difference between the two best bids that makes both acceptable. Without immediate punishment, a designated loser would gain from defecting and becoming a sole COLR if for some $t \leq T$

$$\begin{aligned} (p_r + b_c \Leftrightarrow \Delta \Leftrightarrow c) \frac{1 \Leftrightarrow \delta^t}{1 \Leftrightarrow \delta} > V^L \Leftrightarrow \\ \Leftrightarrow \Delta < (p_r + b_c \Leftrightarrow c) \frac{(N(1 \Leftrightarrow \delta^t) \Leftrightarrow \delta^T)}{N(1 \Leftrightarrow \delta^t)} \end{aligned} \quad (26)$$

Remark: Note that a (naive) choice of Δ that reflects the trade-off between competition and subsidy may be too high to make defection interesting.⁶²

The usual calculations show that immediate punishing of this defection would not occur if

⁵⁹It is also part of the main COLR auction design proposed (by GTE) in the regulatory proceedings at the FCC and at the California Public Utility Commission. In fact, Paul Milgrom was the leader of the team of consultants that advised GTE in these occasions and that included David Salant, Padmanabhan Srinagesh, Debra Aron and, for the Summer of 1997, myself. A brief description of GTE's auction proposal to the California Public Utility Commission (Universal Service Proceeding R. 95-01-020/021) can be found in Sorana (1998).

⁶⁰In particular, Dana and Spier (1994) have shown in a one-stage, two-firm model of auction for licenses that a “modified second-price auction” may be optimal. Their auction rule awards two production licenses if the two firms' bids are both above a threshold that depends on the opponent's bid. Otherwise only the highest bidder would be awarded a production license.

⁶¹There may be no such trade-off, though. If there are significant costs to enter the auction, a larger number of winners may increase participation and hence lower the equilibrium level of subsidy (Seshadri *et al.*, 1991).

⁶²The “naive” choice could be computed as follows. Assuming that the winners of the auction will split the market equally without colluding and that the subsidy is set at the level of the worst-accepted bid, appointing two COLRs instead of one would cost $(\frac{1}{2}b^{(2)} + \frac{1}{2}b^{(2)}) - b^{(1)} = b^{(2)} - b^{(1)}$ to the auctioneer, it would cost an extra $(\frac{1}{2}\gamma + \frac{1}{2}\gamma) = \gamma$ to the firms, and would bring a benefit of B to the consumers. Therefore, the two lowest bidders should be appointed as COLR if $(b^{(2)} - b^{(1)}) < \frac{\lambda_C B - \lambda_F \gamma}{\lambda}$ where $(\lambda_C, \lambda_F, \lambda)$ are, respectively, the welfare weights of consumers and firms, and the shadow cost of subsidies. In a one period model, this would actually achieve the regulators goal.

$$(p_r + R \Leftrightarrow c) < \frac{N(1 \Leftrightarrow \delta^t)}{(N \Leftrightarrow 1)\delta^t} (R \Leftrightarrow \Delta) \quad (27)$$

Therefore the regulator could be able to appoint several COLRs without risk of collusion if

$$\frac{\Delta N(1 \Leftrightarrow \delta^t)}{(N(1 \Leftrightarrow \delta^t) \Leftrightarrow \delta^T)} < (p_r + R \Leftrightarrow c) < \frac{N(1 \Leftrightarrow \delta^t)}{(N \Leftrightarrow 1)\delta^t} (R \Leftrightarrow \Delta) \quad (28)$$

There are two reasons why one should not look at this result with too much optimism. The first reason is that the regulator is unlikely to have enough information to set a value of Δ that is compatible with (28), even if such a value existed. The second is that (28) may be satisfied only for values of Δ so low that the appointment of more than one COLR would be useless. To see why this may be the case, assume that (28) is satisfied and there is no collusion in the auction at any level of bidding higher than $c \Leftrightarrow p_r + \Delta$. But then, if $\Delta < \gamma$, no firm will have any incentive to provide high-quality service. Competition “for the market” could completely cannibalize competition “in the market.”

5 Conclusions

This paper has highlighted both opportunities and dangers that auctions for Universal Service subsidies offer the regulator. The opportunities arise from the possibility of using the information that firms have at a much finer level of aggregation than that attainable by the regulator. The dangers arise from the temptation of asking too much of auctions. Auctions can muster competition “for the market” effectively and reduce the cost of subsidization, but attempts to achieve strong competition also “in the market” may backfire and result in the loss of competition altogether. A clever auction design may reduce these dangers, but not always eliminate them. On the other hand, one should not exaggerate the effect of potential collusion on the choice of the subsidization mechanism. If the reserve price is set at the same level that would be used for the subsidy in a VUS scheme, then auctions will generally be (weakly) cheaper even in the case of collusion.

There is little need to emphasize that much research on auctions for subsidies remains to be done. Leaving aside more general issues about the analysis of (procurement) auctions, I mention here only a few topics that arise naturally from

the models presented in this paper. First, the analysis of COLR auctions for per-subscriber subsidies should be extended to consider the case of service areas that contain both profitable and unprofitable consumers, possibly with different tastes for quality. Second, one should consider explicitly the timing of the production process. The incumbent firm is often the only firm that can provide service immediately. Some other firms may have to rely on buying access (possibly at regulated prices) from the incumbent, at least before their own network is fully operational. This aspect of the problem, among other things, is crucial for the regulator's choice of franchise periods and default penalties.⁶³ Finally, one should consider more general technological structures. Entrants are likely to use different technologies from the incumbent's⁶⁴ and the design of the auction should be flexible enough to accommodate this diversity.

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⁶³These design choices may also allow the regulator to increase the winner's bargaining power in the post-auction bargaining phase and thus reduce the level of subsidies.

⁶⁴For example, wireless providers have more costs that are fixed with respect to the number of users and variable with respect to the level of usage.

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