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Economic Analysis at the Federal Communications Commission

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Abstract. This article reviews some of the major economic issues faced by the FCC in the last year. It focuses on the application of new analytic techniques at the FCC, and identifies several areas in which further academic research would be valuable to the FCC.

Key words: Auctions, diversity measure, experimental economics, Federal Communications Commission, media ownership, merger simulation, regulation, spectrum policy.

I. Introduction

The Federal Communications Commission (FCC) has responsibility for ensuring that the telecommunications, broadcast and cable television, radio, and direct broadcast satellite (DBS) service markets perform in a manner that is consistent with statutory objectives. Economic efficiency is often a key component of these statutory objectives. Thus, economics has a central role to play in the development of public policies related to these markets. FCC economists have the responsibility to identify important economic issues, provide methodologies for evaluating these issues, and apply such methodologies in an effort to inform final decisions on important policy matters.

The purpose of this article is to describe some of the economic analyses conducted by the FCC in 2002–2003 and to identify areas of future research that would be valuable to the FCC. The emphasis is on policy issues that involve the adoption of new economic tools and techniques by the FCC. A comprehensive overview of the role of economic analysis at the FCC, and the broader policy agenda of the FCC's current Chairman, Michael Powell, is provided in Kwerel et al. (2002). This article will focus the specific implementation of some of the issues raised in Kwerel et al. (2002).

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II. Media Ownership and Measuring Diversity

Section 202(h) of the Telecommunications Act of 1996 (1996 Act) requires that the FCC reassess every two years its broadcast television and radio ownership rules to determine if they remain in the public interest.[1] The FCC has recently completed and released its most recent "biennial review" of broadcast ownership regulations.[2] The "Biennial Review Order" begins by articulating the policy goals of FCC media ownership regulations – diversity, competition, and localism.[3] As part of the review process, and to help build a sound public record for its decisions, the FCC commissioned a series of economic studies designed to examine these policy goals and the impact of market structure on achieving them.[4]

The Biennial Review Order identifies two types of diversity as policy goals viewpoint diversity and program diversity. Viewpoint diversity refers to availability to the public of a wide range of perspectives on political issues and other topics of interest. As discussed below, the FCC developed a "diversity index" that it used to inform its decision regarding cross-ownership limits on common ownership of television stations, radio stations, and daily newspapers in certain geographic markets. The FCC's policy to promote viewpoint diversity is based on the premise that maintenance of a reasonable number of independently owned media outlets in each geographic market limits the likelihood that a political perspective will be blocked from transmission to the public.

Program diversity refers to the availability to consumers of a wide range of programming formats and content. The FCC determined that its rules to ensure economic competition among rival media outlets would be sufficient to realize its goal of promoting program diversity. The FCC further concluded that radio and television are two separate economic product markets. This determination led the FCC to retain (but modify) separate local market limits on ownership of television stations and radio stations.[5] The FCC's objective in adopting these rules is to encourage the availability of a wide range of programming to consumers and to promote service innovation, notwithstanding that viewers do not pay directly for broadcast television service.[6] Even though directed at economic competition,

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1 Telecommunications Act of 1996, Pub. L. No. 104-104, 110 Stat. 56 (1996).

2 *Report and Order* in MB Docket 02-277 (Biennial Review Order) adopted June 2, 2003, released July 2, 2003. Some of the rules examined herein were remanded to the FCC by the courts for additional analysis and support. See Biennial Review Order at note 8 for references to relevant court decisions.

3 Id., at paras. 17–79.

4 The studies are available at http://www.fcc.gov/ownership/studies.html.

5 See Biennial Review Order at paras. 132–234 for television and paras. 235–326 for radio. The television analysis takes into account cable networks, but the local limit varies only with the number of television stations in the market. See Id. at paras. 145, 191.

6 See Id., at paras. 60–68 for a discussion of this point and an explanation of why the FCC is shifting from its former focus on competition in advertising markets as a proxy for consumer welfare in media markets.

these rules also promote viewpoint diversity by ensuring the presence of multiple independent outlets within the television and radio sectors in each market.

Localism refers to the degree to which television arid radio stations tailor their programming to the needs and interests of their local communities. Stations can do this by producing local programming – news in particular – and by selecting programming from national sources that is responsive to local needs. One important way in which the FCC achieves this goal is by following its statutory mandate to "make such distribution of licenses, frequencies, hours of operation, and of power among the several States and communities as to provide a fair, efficient, and equitable distribution of radio service to each of the same".[7] In the context of the Biennial Review Order, the FCC found that maintaining a national television station ownership limit also fosters localism.[8]

In the past, the FCC's diversity goal has sometimes been described as promoting "competition in the marketplace of ideas". In the Biennial Review Order, the FCC borrowed some concepts and techniques from antitrust analysis to study the impact of media outlet ownership structure on viewpoint diversity. As mentioned above, the concern is to limit the likelihood that news or a political viewpoint would be foreclosed in the marketplace of ideas (i.e., blocked from transmission to the public). The policy tool involves regulating media ownership to ensure the availability of a reasonable number of independently owned outlets in each geographic market.

In contrast to its findings on economic competition, the FCC concluded that the "diversity market" encompasses multiple media markets. This conclusion is based, *inter alia*, on two of the studies commissioned for the biennial review proceeding. Nielsen (2002) is a survey of how consumers use media to obtain news and current affairs information. The study reveals that the average consumer obtains this information from three different media.[9] Waldfogel (2002) also supports the proposition that consumers use multiple media sources for news and information.

Based on data on the availability of certain media (e.g., television, radio, newspapers, and the Internet), the FCC developed a "diversity index" to measure and analyze the size and structure of the marketplace of ideas in local markets.[10] The FCC has measured the size of this marketplace in the past using what is termed a "voice test". This test simply involved a count of the number of independently owned media outlets in the local marketplace.[11] One weakness of this approach is

[7] Communications Act of 1934 as amended, 47 USC §307(b).

[8] Biennial Review Order, at paras. 578–584.

[9] Five media categories were mentioned by respondents-newspaper, television, radio, Internet, and magazines, although hardly anyone listed magazines as a primary source.

[10] Details of the analysis and the rules adopted are available in Biennial Review Order, at paras. 327–481.

[11] The Biennial Review Order, at paras. 1–2, describes the pre-existing rules, including the limit on television station ownership within a market, the limit on television-radio combinations within a market, and the prohibition on common ownership of a daily newspaper and a broadcast station within a market. The first two of these rules rely on (different) voice tests, while there is no voice test for the third rule.

that it assumes that consumers obtain the same amount of local news and public affairs information from each medium. The newly devised diversity index relaxes this restriction. Specifically, the diversity index uses the Nielsen survey results to weight different media according to reported consumer usage of each medium to acquire local news and information. Different outlets within the same medium are given equal weights, reflecting the FCC's determination that for viewpoint diversity the key issue is availability of independent alternative media outlets, not actual consumer usage of them.[12] The diversity index is created by analogy with the Herfindahl–Hirschmann Index employed in antitrust analysis. In particular, it is defined as the sum of the squared "market shares" for each media owner. The share attributed to each media outlet equals the share of the total consumer usage of local news (as reported in the Nielsen survey) accounted for by the individual medium, multiplied by one over the number of outlets of that medium in that market.[13] The index is calculated by adding together the shares of commonly owned outlets of all media to obtain market shares for each media owner, and then squaring those shares and summing them across all owners.

Using the national weights obtained from Nielsen (2002), the FCC calculated the level of diversity in several test markets and, based upon this analysis, crafted its refined cross-media ownership limits. This new approach has led to a more accurate measure of the size and structure of the marketplace of ideas and has moved the discussion of diversity away from pure ideology and into a framework in which economists can more fully contribute.

III. Media Ownership – Experimental Economics as a Policy Making Tool

The primary role of economists in the FCC is to provide a framework based on sound economic reasoning that can be used to inform policy decisions. In many cases such a framework can be supplied through the application of generally accepted economic theories to the specific policy issue in question. In some cases this framework may require extending or modifying existing theories. In other cases, the framework may require a summary and analysis of the existing empirical literature of relevance to the subject at hand.

It is possible, however, that because of the highly specialized nature of the economic issue(s) before the FCC, neither theory nor empirical analyses may be able to establish an appropriate framework. Indeed, most theories employ simplifying assumptions that, though necessary for the development of a prediction, may be inconsistent with the environment to which the policy decision applies. At the same time, traditional empirical analysis may itself be inadequate, since in many instances the "what if" question embedded in the policy issue may involve an economic outcome that has never been observed in the naturally occurring world.

[12] Biennial Review Order, at paras. 420–431.

[13] Each outlet of a particular medium in a market gets equal weight.

Further complicating the policy-making process is the fact that the FCC's policy decisions are made in an adversarial environment. In such an environment, an interested party has an incentive to submit analyses that increase the likelihood that the FCC will adopt a decision that, while favorable to that party, may be inconsistent with society's interests.

While the courts grant substantial deference to the FCC on matters of regulatory policy by virtue of its status as an expert agency, they nonetheless demand that the FCC's policy decisions not be arbitrary or capricious. In those situations where theory sheds insufficient light and traditional empirical analysis cannot be usefully employed, this standard is particularly difficult to meet. The cost of making the wrong policy decision, however, may be very high, both in terms of reduced efficiency in the allocation of resources and reduced incentives for investment by firms due to regulatory uncertainty.

To address these problems, the FCC in 2002 turned to experimental economics for some assistance.[14] The policy issue involved determining whether and to what extent cable television operators should be limited in the number of subscribers they can serve nationally. This issue stems from Section 613(f) of the Communications Act of 1934, enacted in 1992, which directs the FCC to establish such a limit so that cable operators do not use their dominant position in the multichannel video programming distribution market to unfairly impede the flow of video programming to consumers.[15] Specifically, experiments were conducted to shed light on whether, and at what point, an increase in concentration would reduce the bargaining power of programming networks (e.g., MTV, Food Network, Golf Channel), as well as lower the efficiency of the trades between buyers and sellers.[16]

Experimental studies in the economics literature have shown that the rules that govern economic transactions can have an important effect on the terms of those transactions.[17] These results suggest that the market mechanism in which cable operators and programming networks strike bargains is an important institutional detail that the experimental design must take into account. Hence, the economic experiments used by the FCC were constrained by an important institutional feature – the actual market mechanism used by cable operators and programming networks in the naturally occurring world to arrive at mutually acceptable affiliate fee payments.[18]

[14] Experimental economics first appeared in an FCC proceeding when the National Telecommunications and Information Administration ("NTIA") submitted an experimental study analyzing the comparative performance properties of combinatorial and non-combinatorial auctions. See Bykowsky and Cull (1993).

[15] Section 613(f) of the Communications Act of 1934; 47 U.S.C. §533(f).

[16] See Bykowsky et al. (2002).

[17] See Smith (1964).

[18] An "affiliate fee" is simply the payment, normally expressed on an amount per subscriber basis, that distributors (e.g., cable operators) pay programming networks for the right to show their assembled package of programs.

The need to model this bargaining mechanism carefully was reinforced by "parallelism" concerns raised by many parties who commented on the experiments.[19] However, just as no proper theory can incorporate every aspect of the real world (otherwise the theory would lack predictive power and would at best describe a specific instance of reality), no economic experiment can mimic every institutional feature present in the real world. Nor should the experiment include every feature of the real world, given the increased difficulty that the experimenter would experience in assessing cause and effect. Thus, while experiments used for public policy-making must capture the most important features present in the "real" market, they must not become so complex as to make the objective of the experiments much more difficult to achieve.

The experiments began with the creation of a market that paralleled the market in which these cable operators and programmers negotiate affiliate fees. Participants were given a set of incentives that mirrored the incentives that participants have in the naturally occurring market. The experimental market consisted of four sellers, representing programming networks, and from three to five buyers, representing cable or satellite operators. In order to capture the limited channel capacity relative to the number of programming options available, each buyer was restricted in the number of trades that it could complete in each trading period. Both buyers and sellers were assigned values representing local and national advertising revenues that each party might expect to earn if a trade is completed (i.e., if a programming network is carried by a particular operator). Both buyers and sellers were also assigned fixed costs, so that positive profits were earned at the end of each experiment only if a sufficient number of profitable trades were completed.

A set of treatment variables representing differing levels of market concentration among buyers was constructed. Another treatment variable included the assignment to the largest buyer (i.e., cable operator) of a "most favored nation" (MFN) provision. Under an MFN, each programming network guarantees that the largest buyer will not pay an affiliate fee that is higher than the affiliate fee (expressed on a per subscriber basis) paid by any smaller buyer. Following the completion of the experiments using different treatments, a broad set of statistical analyses were used to identify whether increasing levels of concentration reduced the bargaining power of programmers and, if so, whether this reduction is likely to reduce the flow of programming to consumers. Given the common use of an MFN provision in the market, the most interesting statistical results are those that apply when the largest buyers have an MFN.[20]

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[19] Parallelism refers to the possibility that the results of an economic experiment may not be easily extended to the naturally occurring market if there exist substantial differences between the experimental market and the naturally occurring market.

[20] The results of these experiments differed in many respects from experiments where large buyers did not impose an MFN provision on programming networks. For example, the existence of an MFN provision increased the bargaining power possessed by the MFN-endowed buyers and reduced the affiliate fees (per subscriber) that such buyers paid relative to smaller buyers.

Statistical analysis revealed that cable operators differed in the amount of bargaining power that they displayed when negotiating with programming networks. In particular, the largest cable operator possessed significantly more bargaining power than nearly all of the smaller buyers. Because of this greater bargaining power, the largest cable operators negotiated lower affiliate fees (expressed on a per subscriber basis) than did the smallest cable operators. In addition, buyers pay lower affiliate fees (per subscriber) in a market that includes a single large cable operator (i.e., market share of 51%) and several smaller cable operators than in a market that includes either two "moderately-sized" cable operators (i.e., market shares of 27% and 24%) and several smaller cable operators, or a market that includes two major cable operators (i.e., market shares of 44% and 39%).[21] The experiments also showed that the small and moderate sized programming networks incur the greatest losses and earn the least profits, respectively, in a market that includes a single large cable operator (i.e., market share of 51%). Finally, the experiments revealed that for the treatments considered, trading efficiency is not adversely affected by changes in concentration among buyers.

Much additional research could be done, however, on the role of the MFN in sequential multi-lateral bargaining situations. For example, the experiments to date have not explored the consequences of a "tiered" MFN, in which multiple MFN provisions are applied to buyers, with each buyer being guaranteed a price that is no higher than that paid by any smaller buyer. Also, the MFN provision was exogenously imposed in the existing treatments, rather than being allowed to arise endogenously in the course of the experiment. While such extensions would substantially complicate the experimental design, they might shed additional light on the nature of bargaining in the markets of concern. Another issue of substantial interest that was not covered in the experimental design is the role of vertical integration on the bargaining outcomes. In the real world market, large cable operators are often vertically integrated with programming networks.

The results of the "experiment" of introducing experimental economics into a rulemaking proceeding are promising. For example, the experimental analysis caused commenters to focus attention on the core economic questions that lie beneath the policy issue. The result stems directly from the methodology itself. A good experiment forces one to think clearly and carefully about the core economic issues and the range of treatment variables that must be constructed to explore those issues. The use of economic experiments would have been useful even if there were a formal economic theory to guide the policy making process. In such an instance, experimental economics would have contributed to the policy-making process by testing the theory's predictions. Viewed more broadly, experimental economics may, in many instances, allow policy makers to test a new policy proposal in the laboratory before instituting it in the naturally occurring world. It is a perspective

[21] Each of the treatments contained a buyer representing a satellite operator with a market share of 17%.

long adhered to by airplane manufacturers and other entities that are substantially worried by the great cost associated with designing a craft that does not fly.

IV. Combinatorial Auction for Spectrum Licenses

The FCC currently assigns spectrum licenses to competing users using a simultaneous, multiple round ("SMR") auction. In this auction, buyers have the opportunity to submit a set of sealed bids for individual licenses only. In an early assessment of auction design, Bykowsky and Cull (1993), Chakravorti et al. (1995), and Harris and Katz (1993) recommended that the FCC employ a "combinatorial auction" to assign spectrum licenses. This type of auction enables buyers to place a sealed bid for a combination of licenses as well as for a single license. This approach avoids several inefficiencies often associated with SMR auctions but introduces complexities into the auction process that, heretofore, the FCC considered too difficult to resolve.

1. Current Spectrum Auction Process

In an SMR auction all spectrum licenses are available for bidding simultaneously. In addition, the auction consists of discrete, successive rounds in which buyers have the opportunity to place sealed bids on their desired licenses. At the end of each round, the bidding data are processed, and the identity of all bidders and the level of their bids are made public.[22] A minimum acceptable bid on each license for the next round is then calculated based upon the highest bid on each license in the previous round. This multiple round process serves as a learning period for buyers, providing them with information about the value of the licenses to other buyers. In the current context, the use of multiple rounds therefore increases the likelihood that licenses will be assigned to the buyers who value them the most.[23] The period between auction rounds also allows bidders to take stock of, and perhaps adjust, their bidding strategies. Bidding continues, round after round, until a round occurs in which all bidder activity ceases. That round becomes the closing round of the auction. Licenses are then assigned to the winning bidders at prices equal to their bids.

2. Advantages and Uses of a Combinatorial Auction

A combinatorial auction may have substantial benefits in certain instances. These benefits arise from the buyers' ability to bid on combinations of licenses on an

[22] The sealed-bid nature of the auction ensures that the submitted bids, and the identity of the submitting bidders, are not disclosed until the round has ended.

[23] To induce buyers to bid and to move the auction along, the SMR auction also includes "activity", "minimum acceptable bid", and "eligibility" rules. The SMR auction also includes a rule that permits bidders to withdraw their bids under certain conditions.

all-or-nothing basis, an action not permitted in an SMR auction.[24] Due to this restriction, the SMR auction may result in an inefficient assignment of licenses. As Bykowsky et al. (2000) show, when synergies (benefits from combining complementary licenses) exist, buyers may have to bid above their stand-alone value for a single license in order to have any hope of acquiring complete packages. These buyers incur the risk of suffering a net loss because, in subsequent bidding rounds, they may fail to acquire the entire package. In some instances, such risk reduces the aggressiveness with which buyers bid and, in so doing, leads to a mis-assignment of items. In other instances, buyers bid too aggressively and, in so doing, obtain items at prices exceeding the value they place on those items. Banks et al. (2003) provide experimental evidence that this latter effect, referred to as the "financial exposure" problem, may be a serious concern in existing SMR auctions.

In general, package bidding is most appropriate when there are strong complementaries among licenses for some bidders and the pattern of those complementaries varies among bidders. The risk that bidders will only win a part of their desired set of licenses in an SMR auction is greatest in this environment.

The public may benefit from the use of a combinatorial auction in another important area. Under the current method by which the FCC assigns spectrum to specific service uses, radio communication engineers first estimate the most valuable use of spectrum and then identify a spectrum "band plan" that is consistent with the spectrum-efficient provision of that service.[25] This process typically involves choosing a single service among a set of services, each of which has a different but competing band plan.[26] This largely administrative process is hampered by the incentive of prospective service providers to exaggerate both the value that they place on spectrum (i.e., a proxy for how much value society places on that service) and the amount of spectrum that they need to provide their service efficiently. The incentive to misrepresent information substantially complicates the process of assigning spectrum to particular services and will likely lead to a misallocation of spectrum across services.

However, one solution to this problem is a combinatorial auction that allows prospective service providers with different but competing spectrum needs, due to differences in the services that they wish to provide, to submit such needs to a centralized mechanism, along with the price that they would willing to pay to have those needs satisfied. Following the submission of such information, a specialized algorithm can be used to identify the most desirable use of the spectrum, given the bids submitted by the prospective service providers.

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[24] Milgrom and Ausabel (2001) state that a fully expressive bidding language would make it feasible for bidders to bid "straightforwardly" and, thus, would lead to an efficient assignment of licenses. In response, some computer scientists have begun to evaluate the expressiveness of different bidding "languages" (i.e., the formal syntax in which a bid is expressed). See Nisan (2000).

[25] Spectrum efficiency is maximized when the largest amount of information can be transmitted over the least amount of bandwidth. Federal Communications Commission (2002, p. 21).

[26] The competing nature of the band plans occurs because a given piece of spectrum may be used to provide different services.

3. Combinatorial Auction Implementation Issues

While providing the above benefits, a combinatorial auction may introduce new inefficiencies if important auction design and development issues are not addressed successfully. One issue pertains to a "coordination" problem and another to a "scalability" problem.

A. Coordination Problem

To arrive at the efficient assignment of licenses, multiple buyers may have to coordinate their bids in order to "defeat" the buyer with the highest package or combinatorial bid. Such coordination may be difficult because of the "public good" nature of a unilateral bid increase. Specifically, because the full cost from unilaterally increasing one's bid falls entirely on the cooperating buyer, while the benefits extend to all non-cooperating buyers, each buyer may elect not to raise its bid unilaterally. Bykowsky et al. (2000) have termed this strategic problem the "threshold problem". Depending on the distribution of license valuations across buyers, it is possible that no single buyer may be able unilaterally to increase its own bid(s) enough to defeat the highest package buyer. In that instance, coordination among multiple buyers is a necessary condition for the efficient assignment of licenses. Ledyard (1995) provides evidence that suggests that such coordination is more likely if buyers are able to communicate with each other.

In one of the first combinatorial auction designs, Banks et al. (1989) provide bidders with the opportunity to coordinate their bids by publicly announcing, via a bulletin board, their willingness to pay for specific licenses or combinations of such licenses. DeMartini et al. (1999) provide a design in which the auctioneer calculates, following the submission of all bids in one round, a set of minimum bids for next round in the auction. These minimum bids are calculated in a manner that assigns, broadly speaking, a portion of the shortfall between the highest package bid and the sum of the highest bids for the licenses contained in the package to each of the single-item (i.e., non-package) bids. Their design is effective in overcoming the threshold problem in several instances and is superior to the design offered by Banks et al. (1989).

B. The "Scalability" Problem

In a combinatorial auction, identifying the efficient assignment of licenses based upon the single-item and package bids submitted in the auction requires solving the following integer programming (IP) problem:

$$\max \sum_{j \in B} b_j x_j$$

$$\text{s.t.} \sum_{j \in B} a_{ij} x_j = 1, \quad \text{for all } i \in L \tag{1}$$

$$x_j \in \{0, 1\}, \quad \text{for all } j \in B,$$

where:

$$B = \text{set of considered bids},$$

$$b_j = \text{bid amount of bid } j,$$

$$L = \text{set of licenses being auctioned},$$

$$a_{ij} = \begin{Bmatrix} 1 & \text{if license } i \text{ is in bid } j \\ 0 & \text{otherwise} \end{Bmatrix}$$

and,

$$x_j = \begin{Bmatrix} 1 & \text{if bid } j \text{ is the winning set} \\ 0 & \text{otherwise} \end{Bmatrix}$$

The optimization problem involves identifying the set of buyers whose bids maximize auction revenue subject to the conditions that each license is awarded only once and that the licenses are not divisible. As noted by Rothkopfet al. (1998), the above optimization problem is one of a set of optimization problems for which there is no guarantee that a "solution" can be identified within a "reasonable" amount of time as the scale of the problem increases.[27] In some instances, solving for the optimal solution may involve searching over all possible combinations of licenses and their associated prices.[28] Moreover, a multiple-round auction may be needed to overcome the threshold problem. The multi-round requirement means that the IP problem must be solved multiple times during the course of the auction.

Conducting a combinatorial auction also involves identifying a set of prices that is consistent with the license assignment identified by the solution to the IP problem. Rassenti et al. (1982) resolve this problem by solving a modified linear programming problem that is the "dual" to the assignment problem.[29] The solution to this modified linear programming problem generates a set of "pseudo" competitive equilibrium prices for each of the licenses up for auction. While the solution generates a set of prices for each license and for packages of licenses simultaneously, it nonetheless involves solving another mathematical programming problem.[30]

[27] The solution of such a problem involves identifying a particular solution and proving that no better solution exists.

[28] There are over 10^{15} license combinations when only 50 licenses are up for auction.

[29] One approach to solving integer programming problems is to convert the problem into a linear programming problem by relaxing the integer value constraint. The "dual" solved by Rassenti et al. (1982) is based on the linear version of the assignment problem.

[30] There are other factors that may complicate the computation problem. For example, the possibility exists that multiple sets of bids generate the same optimal solution (i.e., maximum revenue) to the assignment problem. This possibility requires that a method be devised for selecting a particular set of bids.

The auction design process is further complicated by the fact that, because of imperfections in the capital market, buyers may be incapable of bidding their valuations on the entire set of licenses that they desire. While the presence of "budget-constrained" buyers is not unique to combinatorial auctions, the recognition of their presence is important given the mathematical properties of a combinatorial auction. In a combinatorial auction, different collections of bids may lead to substantially different license assignments from round to round. Indeed, as a result of an increase in the high bid for a single license, bids for a single license or a small package of licenses that were previously non-winning may become winning bids later in the auction. This possibility means that buyers may win more licenses than they desire if they miscalculate the likelihood that a previous losing bid may end up being a winning bid. Alternatively, such a miscalculation may result in bidders acquiring more licenses than their budget allows.

There are several possible solutions to this problem. One is to solve the optimization problem using bid data from only the most recent bidding rounds. This approach may lead to an inefficient assignment of licenses, however, because it restricts the number of bids upon which the solution is based. Another possible solution is to require that the assignment problem be solved subject to the constraint that a buyer's winning bids must have been placed in the same round.[31] This restriction eliminates the possibility that a buyer would unexpectedly be declared a winner of a license because of a bid placed in a different round in the auction. However, the solution comes at the expense of computation speed. Existing optimization procedures rely heavily on identifying and discarding "dominated" bids (i.e., bids that are lower than the existing high bid) to enhance computation speed. The effectiveness of this technique is reduced dramatically, however, since the object of comparison is no longer an individual bid but rather the set of bids submitted by the buyer in a particular round. Under the proposed solution, the only way in which a set of bids submitted by a particular buyer could be discarded is if the buyer placed a set of bids on the identical licenses in a subsequent round.

4. *Important Areas for Future Research*

Designing a scalable combinatorial auction raises several important research issues. For example, the issue of scalability rests on the concern that there is no guarantee that the solution to the assignment problem can be identified within a "reasonable" amount of time as the scale of the problem increases. This, in turn, assumes that final auction results are sensitive to the "quality" of the identified solution. The validity of this assumption is unknown in the context of a multiple round auction where buyers have repeated opportunities to raise their bids in response to observed prices calculated across a series of bidding rounds. In a related area, another important area for further research lies in the area of pricing individual licenses and packages of such licenses following the solution of the assignment

[31] The FCC used this approach in its first combinatorial auction in September 2003.

problem. Given that multiple prices may be consistent with the efficient assignment of the licenses, a variety of different pricing rules exist. One important question is whether the choice of the pricing rule affects the final assignment in a multiple round auction.

Another important research area involves determining the effectiveness of some of the proposed solutions to the bidder budget constraint problem. One such solution involves imposing the restriction that a buyer can only have one of its bids win. This solution would be imposed by requiring bidders to employ an XOR bidding language.[32] Thus, in order to win more than one license, the buyer must submit at least one package bid. While this solution eliminates the possibility that the buyer may win too many licenses or win at prices that exceeds its budget, the solution requires that the buyer submit numerous bids for single licenses and for packages of licenses. In addition, very little is known about whether such a language generates new strategic opportunities for bidders.

Finally, while newer and faster ways of solving large integer programming problems are being discovered, advances in the design of the combinatorial auction itself may lead to a superior solution to the scalability problem. For example, Porter et al. (2003) have introduced a promising new approach that is "optimizer-light". Under their approach, a simple pricing rule would guide buyers in their attempt to acquire preferred licenses. This new "price-guided" approach uses prices on individual "items", together with a simple procedure for adjusting those prices in response to calculated excess demand, to find the efficient assignment of items and the prices for those items. The analysis of this new approach is in its early stages. However, at least one important question needs to be addressed: Does this price-guided mechanism lead to an efficient assignment of items in economic environments in which bidders have very complex preferences?

V. Merger Simulations: The Echostar–Hughes Case

In October of 2001, Echostar Communications agreed to purchase Hughes Electronics from General Motors in a deal valued at $25.8 billion. Since Hughes and Echostar hold numerous spectrum licenses, regulatory approval from the FCC was necessary to consummate the sale. On October 10, 2002, the FCC declined to approve the license transfers and, in accordance with the Communications Act, sent the transfer application to an administrative law judge for a full evidentiary hearing. On December 10, 2002, prior to the hearing, Echostar and General Motors terminated their agreement. The analysis of the proposed transaction represents the first time that the FCC has relied on merger simulations, and as discussed below, led to several questions about the application of the techniques.

32 An XOR (exclusive OR) is a bidding language that permits a bidder to express that she wishes to have only one of her bids, but not both, accepted. For example, bids of the form "AB XOR C" would be interpreted as a bid to acquire A and B or C, but not the bundle A, B, and C.

The FCC's analysis focused on the combination of Echostar and Hughes' subsidiary, DirecTV. Both firms provide direct broadcast satellite (DBS) service to U.S. consumers. In return for a monthly fee, video programming such as ESPN, USA Network, and the History Channel is transmitted via satellite and received at consumers' residences using a small 18-inch dish. The DBS providers also offer numerous pay-per-view and premium channels delivering sports, movies, and foreign language programming.

License transfers decided by the FCC proceed much like a trial. The parties requesting permission to transfer the licenses submit an application setting out the reasons that the application should be approved. Parties opposed to the license transfer also submit arguments. The FCC then analyzes the pleadings, conducts an independent analysis, and renders a decision. In the present case, the merging firms submitted a merger simulation in the spirit of Froeb and Werden (1996) to estimate the likely price effects associated with increased market power and reduced costs. In addition, the firms projected large increases in consumer surplus from the expanded availability of local television broadcasts on the satellite system.

The delineation of the product market was one of the issues that the FCC instructed the administrative law judge to examine in the full evidentiary hearing. For the purposes of the initial analysis, the Commission chose to consider the relevant product market as the multichannel video program distribution (MVPD) market. The products in this market include DBS services as well as traditional cable television services, wireless cable services (known as multichannel multipoint distribution services or MMDS), home satellite dishes (this product differs from the DBS product in that the dishes are generally about 6 feet in diameter), and satellite master antennae systems (these systems are similar to home satellite dishes but serve aggregations of consumers such as those living in an apartment complex). While this list appears to indicate that there are a number of products in the market, DBS and traditional cable services have a combined market share in excess of 96%. Consequently, the analysis concentrated on the ability of competition from cable operators to constrain the prices of the merged firm.

It is also important to note that the products are differentiated. The most significant differences are the channel offerings. The channel capacities of cable companies range from 30 to over 200 channels. The channels offered for sale by the merging firms are quite similar: 90% of the channels in the popular programming packages are the same. The main differences between the two DBS products are in the area of premium services. DirecTV offers premium programming concentrating on professional and collegiate sports, while Echostar offers foreign language programming. These premium services are purchased by a relatively small fraction of customers.

The FCC concluded that the proper geographic market is local. At first glance it may appear odd that while the FCC was unable definitively to define the product market, no such problem existed in defining the geographic market. However, regardless of the competitor, the product must be delivered to consumers' homes.

Consumers are reluctant to travel to consume the video entertainment provided by DBS providers, but instead choose among firms that can deliver the product to their residences. It would have been analytically intractable to consider each residence in the U.S. as a separate geographic market. Therefore the FCC considered the relevant geographic market to be a cable service area, since all consumers served by the service provider were likely to face the same product choices. In the U.S. most consumers can choose from three competitors: Echostar, DirecTV, and an incumbent cable operator. A few markets have seen entry by a second company offering traditional cable television service. In addition, parts of the U.S. where cable service is unavailable were considered to be a separate market where the only products available were those of the merging parties. The number of households in these areas was an issue of contention. Estimates of this number ranged from 4 million to 18 million, though most sources put this number near the bottom of the range.

The merging parties prepared an analysis of the likely net benefits of the merger to support their application to transfer control of the spectrum licenses. The heart of the analysis was a merger simulation based upon a system of demand equations estimated using a nested logit model. The estimation followed in the tradition of Berry (1994), basing the estimation on market shares in nearly 5,000 geographic markets.

However, difficulties arose in the estimation. Consistent estimation of the inclusive value, or nest strength, parameter requires the use of instrumental variables. The merging firms were unable to find suitable instruments for this parameter. Commission staff also encountered this problem while estimating demand. Accurate estimation of this parameter was paramount, since it represented the correlation between the unobserved utilities of the two DBS products and, therefore was a critical element of the cross-price elasticities of demand between the MVPD products. Unable to estimate the parameter, the firms utilized the relationship between the diversion ratio and nest strength to calculate the parameter.

As with any horizontal merger, the unilateral price effects hinge upon the degree of substitution between the merging products. In this case, the merging parties presented diversion ratios that indicated that cable service was a closer substitute to DBS service than either of the DBS services were to each other. These diversion ratios were obtained through surveys of former customers. As previously mentioned, 90% of the entertainment channels available through Echostar are also available through DirecTV, and the prices of the firms' packages are within a few dollars of each other. The FCC staff concluded that the exit surveys conducted by the firms were not measuring consumer behavior on the relevant axis. These firms' subscriber bases have been growing at 15–20% a year. In addition, churn has been relatively minor, at 1.6% per month for both firms. Consequently, most of the competition between these firms takes place in competing for current cable customers, not in competing to attract each other's customers.

In a growing market such as this, diversion ratios based upon the behavior of current customers can paint a distorted picture of the substitutability between the products. One possible explanation for the observed behavior in the exit survey is that DBS is a new service to most consumers. When they purchase the service they may not be entirely familiar with its characteristics. Upon experiencing the service for a time, they may decide that it does not fit their needs. Because the programming, delivery mechanisms, and prices of the DBS firms are very similar, a rejection of one firm's service may well indicate a rejection of the characteristics of the DBS services. If this scenario were to hold, diversion ratios are unlikely to provide reliable information on the closeness of the services. In the end, the FCC's analysis examined the sensitivity of the simulation results to changes in the diversion ratio. The FCC found that the results were sensitive enough that it had concern over this issue and should examine it further at a hearing.

The statute governing the FCC's license transfer process requires that a license transfer be found to be in the public interest. The price effects discussed previously are one element of the public interest test. Firms also have an opportunity to argue that a proposed merger, while possessing some harmful effects, promotes other goals of federal communications policy. The merger partners alleged that the combination would allow them to deploy a state-of-the-art satellite-delivered high-speed Internet access service to replace their existing technologies. The firms argued that the volume of customers required to break-even was sufficiently large that it could only be reached by pooling the assets of both firms. The FCC, however, was unconvinced by the claims that these benefits could only be realized under the merger, instead believing that, in this instance, the policy goal of encouraging the deployment of broadband services could be achieved through a joint venture, if necessary.

The firms also indicated that the merger would allow them to expand the number of markets where they retransmit local broadcast television signals over their satellite systems to local viewers. As the applicants demonstrated, this feature is popular among consumers, providing sufficient incentive to expand the coverage. However, if the merger were to occur, the FCC was concerned that the elimination of competition between the DBS firms would reduce this incentive, and consequently the FCC could not find it to be a mitigating factor in the public interest test.

One of the early concerns of parties opposed to the merger was that the merged firm could discriminate and charge substantially higher prices in locations lacking cable service. To alleviate this problem, the merging firms offered to charge a uniform national monthly price for their product. The FCC rejected the proposed remedy as ineffective and impractical. Competition between the merging firms for new customers takes place in promotions offering free or reduced prices for equipment and installation. The proposed remedy did not address this avenue of competition, nor did it address other service quality issues, leaving the door open for discrimination in other forms. The proposed remedy was unlikely to protect consumers adequately, but likely to create expansive monitoring and enforcement duties. The FCC's goal is to promote competition, not replace competition with regulation, and consequently the Commission in a unanimous decision declined to approve the merger.

VI. Conclusion

This paper describes four prominent policy issues that were addressed by the FCC during the past year. It indicates the variety of economic techniques that the Commission uses to shed light on those issues, and indicates areas of future research that will aid it in its decision-making.

Each policy issue presented a unique set of challenges. First, the review of the broadcast media ownership rules demanded a fresh look at an important FCC goal – the enhancement of program and viewpoint diversity. This involved, among other things, an attempt to measure the amount of viewpoint diversity in a given geographic market.

Second, due in part to the absence of a formal model that predicts the effects of changes in cable concentration on the flow of programming to viewers, the FCC commissioned an experimental study to shed light on this important issue. The study shed light on several issues related to the economic performance of the cable television industry. More importantly, however, the study demonstrated the feasibility of using experimental methods for evaluating and designing public policies.

Third, in response to theory and the expressed desire of bidders to express the valuation they place on packages of licenses, the FCC has begun to examine the use of a combinatorial auction to assign a "large" number of licenses to competing users.

Finally, the FCC also examined the sensitivity of the results of a merger simulation based upon small changes in one or more parameter values. This analysis was the first application of a merger simulation framework by the FCC to a license transfer proceeding. The results revealed that, in the case of the proposed EchoStar–DirectTV merger, the welfare effects of that merger were highly sensitive to small changes in one or more parameter values, and as a result the merger was not approved.

References

Banks, J., J. Ledyard, and D. Porter (1989) 'Allocating Uncertain and Unresponsive Resources: An Experimental Approach', *The Rand Journal of Economics*, **20**, 1–25.

Banks, J., M. Olson, D. Porter, S. Rassenti, and V. Smith (2003) 'Theory, Experiment, and the Federal Communications Commission Spectrum Auctions', *Journal of Economic Behavior & Organization*, **51**, 303–350.

Berry, Steven T. (1994) 'Estimating Discrete Choice Models of Product Differentiation', *The Rand Journal of Economics*, **25**, 242–262.

Bykowsky, M., and R. Cull (1993) 'Issues in Implementing a Personal Communications Services Auction', Attached to Comments of the National Telecommunications and Information Administration in PP docket No. 93-253.

Bykowsky, M., R. Cull, and J. Ledyard (2000) 'Mutually Destructive Bidding: The FCC Auction Design Problem', *Journal of Regulatory Economics*, **17**, 205–228.

Bykowsky, M., A. Kwasnica, and W. Sharkey (2002) 'Horizontal Concentration in the Cable Television Industry: An Experimental Analysis', Federal Communications Commission, Office of Plans and Policy, Working Paper No. 35r.

Chakravorti, B., W. Sharkey, Y. Spiegel, and S. Wilkie (1995) 'Auctioning the Airwaves: The Contest for Radio Spectrum', *Journal of Economics and Management Strategy*, **4**, 345–373.

DeMartini, C., A. Kwasnica, J. Ledyard, and D. Porter (1999) 'A New and Improved Design for Multi-object Iterative Auctions', Division of the Humanities and Social Sciences, Social Science Working Paper 1054.

Federal Communications Commission (2002) 'Spectrum Policy Task Force Report', ET Docket No. 02-135.

Federal Communications Commission 'Report and Order and Notice of Proposed Rule Making' (The Biennial Review) MB Docket 02-277, June 2003.

Froeb, L. M., and G. J. Werden (1996) 'Simulating the Effects of Mergers Among Noncooperative Oligopolists', in Hal R. Varian ed., *Computational Economics and Finance: Modeling and Analysis with Mathematica.* Santa Clara: TELOS, pp. 177–195.

Harris, R., and M. Katz (1993) 'A Public Interest Assessment of Spectrum Auctions for wireless Telecommunications Services', Attached to comments of NYNEX Corporation in PP docket No. 93-253.

Kwerel, E., J. Levy, R. Pepper, D. Sappington, D. Stockdale, and J. Williams (2002) 'Economic Issues at the Federal Communications Commission', *Review of Industrial Organization*, **21**, 337–356.

Ledyard, J. (1995) 'Public Goods: A Survey of Experimental Research', in J. Kagel and A. Roth, eds., *Handbook of Experimental Economics.* Princeton, New Jersey: Princeton University Press, pp. 111–194.

Milgrom and Ausabel (2001) 'Ascending Auctions with Package Bidding', At http://wireless.fcc.gov/auctions/conferences/combin2001/papers.htrnl.

Nielsen Media Research (2002) 'Consumer Survey of Media Usage', FCC Media Ownership Study #8, September 2002. At http://www.fcc.gov/ownership/studies.html.

Nisan, N. (2000) 'Bidding and Allocation in Combinatorial Auctions', Unpublished Working Paper, Institute of Computer Science, Hebrew University. Porter, D., S. Rassenti, A. Roopnarine, and V. Smith (2003) 'Combinatorial Auction Design', Unpublished Working Paper, George Mason University, Inter-disciplinary Center for Economic Science.

Rassenti, S., V. Smith, and R. Bulfin (1982) 'A Combinatorial Auction Mechanism for Airport Slot Allocation', *Bell Journal of Economics*, **13**, 402–417.

Rothkopf, M. H., A. Pekec, and R. M. Harstad (1998) 'Computationally Manageable Combinatorial Auctions', *Management Science*, **44**, 1131–1147.

Smith, V. (1964) 'The Effect of Market Organization on Competitive Equilibrium', *Quarterly Journal of Economics*, **78**, 181–201.

Waldfogel, J. (2002) 'Consumer Substitution Among Media', FCC Media Ownership Study #3, September 2002. At http://www.fcc.gov/ownership/studies.html.