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IMPLEMENTING A MARKET-BASED SPECTRUM POLICY*

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ABSTRACT

The spectrum auctions were a step toward the Herzel-Coase vision of a flexible and efficient market for spectrum. This article examines what remains to be done. Spectrum must be unbundled from broadcast and transmission facilities. The ''commoditization'' of spectrum will facilitate standardization, price discovery, and open access to diverse users. A liquid secondary spectrum market will lower transactions and entry cost, making telecommunications markets contestable. Auctions should be used to elicit a supply of spectrum from licensees as well as to allocate it to new users. In closing the spectrum commons, Congress granted use to a privileged few. Unbundled spectrum property rights, commoditization, and open markets will give the public access to this public resource.

THE success of the recent spectrum auctions is a triumph of law-and-economics scholarship and auction theory.[1] Leo Herzel[2] proposed selling spectrum licenses, Ronald Coase[3] went a step further and proposed a market for spectrum based on property rights, and De Vany et al.[4] took the next step toward a market system by defining spectrum property rights that solved the technical problems of interference and provided the appropriate institutional basis for the exchange and enforcement of spectrum property rights.

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[1] A budget-hungry Congress may have been a more important cause than research or theory, but the foundation was there for the auctions to go forward when Congress was ready.

[2] Leo Herzel, Public Interest and the Market in Color Television Regulation, 18 U. Chi. L. Rev. 802 (1951).

[3] R. H. Coase, The Federal Communications Commission, 2 J. Law & Econ. 1 (1959).

[4] Arthur De Vany *et al.*, A Property System for Market Allocation of the Electromagnetic Spectrum: A Legal-Economic-Engineering Study, 21 Stan. L. Rev. 1499 (1969).

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Auction theorists[5] and analysts[6] at the Federal Communications Commission (FCC) designed and implemented the auction mechanism that achieved a high degree of allocational efficiency while revealing the enormous value of the spectrum.

The auctions have brought Herzel's and Coase's proposals closer to reality. But we are not quite there. Spectrum policy has only just caught up to federal policy in oil and gas drilling rights, where auctions have been used to allocate leases on federal lands for decades. The spectrum auctions signal new and more open criteria for allocating licenses as well as a new flexibility in the use of spectrum. Licenses are issued to the highest bidder in place of the complex hearings and political competition used in the past. But they are only a first step toward a market-based spectrum policy. If the medium of the information age is bandwidth, then how spectrum bandwidth is to be used and allocated are the most important issues to be solved in the information age. Much remains to be done to implement the vision that Herzel and Coase had of a flexible and efficient market for spectrum bandwidth.

We can see better where spectrum is in its progress toward a market system by comparing it to the capital market. The spectrum auctions are rather like an initial public offering of stock—licenses are ''new issues'' of spectrum offered to the highest bidder. There is a spectrum aftermarket in the sense that FCC licenses are implicitly traded whenever radio or TV stations are sold, but this aftermarket is encumbered by the illiquidity created by the bundling of spectrum with the assets that use it. We have none of the sophisticated trading instruments and low transactions cost that give the capital market its flexibility and liquidity. Only when we have unbundled spectrum and broadcasting assets to create deep and liquid markets in spectrum bandwidth and its derivatives will we capture the full promise of spectrum markets that Herzel and Coase contemplated.[7]

In this article I take stock of how far along the way to the Herzel-Coase vision of a spectrum market we are and try to see what tasks remain. I make some concrete proposals to move the process along. The discussion is focused on five key issues:

[5] See Preston McAfee & John McMillan, Analyzing the Airwaves Auction, 10 J. Econ. Persp. 159 (1996); and John McMillan, Selling Spectrum Rights, 8 J. Econ. Persp. 145 (1991), for a discussion of the contributions and contributors to the auction design.

[6] Notably, Evan Kwerel & John Williams, Changing Channels: Voluntary Reallocation of UHF Television Spectrum (OPP Working Paper Series, Federal Communications Commission 1992); and Evan R. Kwerel & John R. Williams, Moving toward a Market for Spectrum, 2 Reg.: CATO Rev. Bus. Gov't 53 (1993).

[7] The FCC has recognized the value of unbundling in permitting personal communications licenses to be used for other services, a valuable first step in unbundling that should extend over the whole spectrum.

1. creating an aftermarket,
2. refining the instruments of spectrum trading,
3. moving spectrum to market,
4. preventing interference under a market system, and
5. opening access to spectrum bandwidth.

I. Making a Market

The recent spectrum auctions might suggest that markets are beginning to operate to allocate the electromagnetic spectrum. That is only partly true, because auctioning licenses changes little about how spectrum is allocated *after* the auction. Though some licenses are granted more flexibility than in the past, there are only a few degrees of freedom for trades in the aftermarket to reallocate spectrum flexibly among different uses or users. In addition, the auctioned spectrum largely has been confined to unoccupied bands (or those occupied with relatively low-valued microwave broadcasting) and there is at this time no established mechanism for bringing occupied bands of spectrum to the auction block (there ought to be one and I close with a proposal to bring more spectrum to the auction block).

Auctioning broadcast licenses is not equivalent to privatizing the spectrum. A broadcast license is not a property right in spectrum; it is a license to operate a transmitter of a given design, power, and frequency with an antenna configured and located in a particular way. Once licenses are set, there are few degrees of freedom left for reallocating spectrum or using it in different ways.[8] Moreover, because licenses can be revoked, all the first amendment objections to government content control and censorship of broadcasting remain.

For the situation in the United States, you have to imagine a securities market where there is a market for new issues but no aftermarket to price and reallocate the securities once they are sold. The spectrum auctions put the ''new issue'' broadcast licenses into private hands, but these allocations are relatively fixed thereafter. Trading licenses improves spectrum allocation by moving it to users who value it more, but it can do little to change the technology, the inputs, or the output mix produced. The auctions surely are a better way to issue licenses than the arbitrary ways of the past, but they have not given us the flexibility and incentives that are the prime advantages of a market over an administered system.

[8] Howard Shelanski & Peter Huber, Administrative Creation of Property Rights to Radio Spectrum, J. Law & Econ., in this issue, at 581, show how FCC licenses have, over the years, acquired many of the attributes of a property right.

Most modern markets in adapting to technological innovation or deregulation have evolved to a form of ''commoditization'' or ''securitization.'' A transition to a commoditized market is profound; it is a transition in market structure from a closed to an open system. Such changes have occurred in markets for foreign currency, financial derivatives, air travel, parts of telecommunications, personal computers, natural gas, petroleum, and power. In each of these industries, use expanded and prices declined after open markets developed. The next step in spectrum is to follow a path similar to these other industries, while remaining consistent with the technological attributes of spectrum use.

As markets are opened,

1. a commodity is unbundled from other products and services,
2. a process of price discovery and dissemination begins,
3. a form of product standardization facilitates price discovery,
4. price dissemination promotes arbitrage, which brings liquidity to the market, and
5. contracts and derivative markets develop to separate price risk from the physical asset.

A. Unbundling

A broadcast license bundles a service—the broadcast product—with another commodity—the spectrum band. The license grants an exclusive use of the band for delivery of a specific product; for example, a television license authorizes its holder to transmit television programming on a certain band in a specified location. The licensee cannot use the band to transmit another form of broadcasting. Moreover, each license is bundled with technology: the technical parameters of the transmitter location, power, antenna orientation, frequency band, and so on, are all specified in the license. We have reached a stage where unbundling the spectrum from the product or service it carries and the hardware is technically feasible and economically desirable.[9]

Partial unbundling has already occurred in television broadcasting where

[9] Usually, unbundling develops spontaneously, although sometimes it is prodded by forced unbundling in the process of deregulating the industry. In deregulating natural gas, the Federal Energy Regulatory Commission (FERC) ordered unbundling of transmission from gas; see Arthur De Vany & David Walls, The Emerging New Order in Natural Gas (1995). The FERC went further in its Order 636 to specify formal mechanisms for disseminating transmission pricing information and for short-term trading in gas pipeline transmission capacity. In telecommunications, long-distance and local telephone service were unbundled.

a given program may be transmitted via conventional means by broadcast on a licensed channel, via satellite, or via cable. The signal may be divorced from the medium. This separation allows markets to price the separate components and to let both the programming sources and the communications medium be delivered to the final consumer in the most cost-effective manner. In some cases, the consumer may wish to buy the bundled product that ties the communications medium to the program. The supplier can offer that choice by combining the unbundled commodities for the consumer.

Separating the market value of the spectrum from the price of related services and other products is difficult or impossible in a market where goods are bundled because there are no independent prices available. The ''price'' of spectrum in television broadcasting simply cannot be compared with its price in mobile telephone or microwave transmission. Because spectrum is bundled, through the licensing process, with the product it delivers, the market is closed to outsiders and new entrants. A nonconventional use of the spectrum cannot be accommodated.

An example of partial unbundling of spectrum is the use of frequency swaps. Two licensees have only to let one another use their channels under some form of barter arrangement. These kinds of swaps—barter transactions—are common in many industries. Oil and natural gas companies swap crude oil or gas with one another when they occupy different territories. The EuroBond market began with interest rate swaps among a few traders looking to avoid taxes. It now is one of the most important financial markets. Frequency swaps are a natural way to build integrated transmission networks.

As another example of unbundling, suppose that spectrum licensees were required to become contract carriers. Right now they are either common carriers, like the phone company, or private carriers, like a radio station, who carry only their own signal (there are some hybrids who are neither in the mobile bands). Keep all the other aspects of the license intact but change who has access to the channel by permitting producers to contract for broadcast time, location, and bandwidth for their programs. This sort of change would parallel what happened in natural gas, when pipelines were transformed under the so-called open-access rulings of the Federal Energy Regulatory Commission from private to contract carriers. In gas, this was a revolutionary change.[10] So would it be in telecommunications and spectrum allocation.

Suppose a radio show producer could contract with a station for bandwidth and time to broadcast her show. The station, as contract carrier,

[10] See *id.* on the transformation of natural gas under open access.

would sell time and frequency slots within its territory to any comer as spots or as long-term contracts. Access to broadcasting would be open to anyone. Unused slots would be offered in a secondary spot market. All this parallels the situation in natural gas transmission trading. Such a system makes public access to spectrum real, not the fiction it is now. It becomes very simple to build a network of stations; one contracts for the bandwidth and time slots with the individual stations and then puts on whatever it is that one wants to broadcast.

A system of contracting for bandwidth and time slots could reproduce the financial syndication that we have now in broadcasting. Programs could be packaged with broadcasting, in the way now typical in the industry, by bundling the bandwidth and time slots with the programs. Importantly, the acquisition by the producer of broadcast bandwidth would free her of the content regulation that stations now exercise. As long as I buy the bandwidth and you are a common carrier, you do not get to decide what I ship with my electrons. Since the station is no longer responsible for program content, the FCC can no longer hold its license hostage to content. With access to bandwidth open to the whole public, content regulation becomes a direct limitation on someone's free speech and is no longer clouded by a public trust claim to the spectrum that holds the broadcaster's license hostage. The free speech that we exercise when we use audible bandwidth at a public corner will then extend to broadcast bandwidth.

B. Price Discovery

Efficient markets require accurate price information to guide trade and investment decisions. When bundled frequencies and broadcast licenses are traded,[11] traders and investors must disentangle the implicit spectrum price from the cost of the bundled object traded, in this case the license and the transmission assets that go with it. In natural gas and electricity, mismatches in supply and demand brought a small ''spot'' market into existence as a balancing and covering mechanism. Similarly, in spectrum, unused or oversubscribed frequencies would result in a short-term spot market where these imbalances could be reconciled.

The prices made in these spot markets then become a source of information to the contract market in addition to fulfilling their function of guiding the utilization of frequencies. A market for frequencies makes the discovery and dissemination of price information open and reliable. Such an unbundled market for the commodity is unencumbered by the illiquidity of the specialized assets now bundled with spectrum.

[11] Shelanski & Huber, *supra* note 8.

C. Standardization

Accurate price discovery requires a known and standardized product. Subtle differences among frequencies, territories, and other attributes of spectrum impede price discovery in spectrum. The auction design addressed these issues by fixing frequency bands and territories, and thus a first step toward standardization has been achieved in the PCS bands. For example, the A and B block licenses sold for PCS service were 30 MHz and were defined for 51 specific geographic service areas (the MTAs). The licenses specify a telecommunication service that may not be changed. In the later Wireless Communications Services auction, the licenses fully unbundled spectrum from product: the WCS license permits the holder to offer any service within the licensed frequency band and territory so long as it does not interfere with other licensees.

The efficiency of pricing achieved in these auctions was high. Peter Crampton[12] remarks that in the first broadband auction, where two licenses were sold in each territory, ''the prices differed by less than one minimum bid increment in 42 of 48 markets.'' Other auctions generated correspondingly accurate prices, and there is evidence that bidders used the information efficiently. This is evidence that spectrum can be standardized sufficiently for accurate pricing.

D. Liquidity

Liquidity is the ease and speed with which an asset may be bought or sold. A lack of liquidity forms a transactions cost barrier to reallocating a commodity. When spectrum is bundled with an asset dedicated solely to producing a specific product, its liquidity is impaired. Unbundling spectrum from the assets and product will open the market to new and diverse traders. The increase in the numbers of traders and their heterogeneity will reduce buyer concentration and add adaptability and flexibility to the market. Unbundling also puts more of the spectrum commodity into play so that it can respond to price information.

The cost of entry and exit will fall for many kinds of telecommunications services and network configurations with an unbundled and liquid market in spectrum. Unbundled spectrum interests traded in a liquid market will support hit-and-run entry, making the markets for many telecommunications services contestable. An active and liquid aftermarket will support many forms of short-term spectrum leasing and trades as well as longer-term arrangements. The cost of a ''round trip'' transaction in spectrum

[12] Peter Cramton, The FCC Spectrum Auctions: An Early Assessment, 6 J. Econ. & Mgmt. Strategy 431 (1995).

would fall far below the present level, leaving investors more free to investigate other uses of the spectrum and to contest services now protected by bundled licenses. Fixed cost is a consequence of high transactions cost, which is to say of specialized assets traded in illiquid markets. Unbundle spectrum from these illiquid assets and its market will become more liquid. Communications assets will likewise become less specialized and more liquid, and new entry will be encouraged.

E. Separating Financial and Physical Risk

Forward and futures markets typically develop along with the commodity market. As spot trading expands, commodities become more standardized and unbundled and reliable price information develops. Open participation in the market gives it depth and liquidity. These provide the basis for forward and futures contracts that separate financial risk from the physical commodity. In turn, the forward market adds to price discovery and gives the market additional depth and liquidity.

Futures trading contributes to the commoditization of financial and energy markets, where organized futures markets allow producers and consumers to manage supply and price separately. If spectrum is unbundled, as it must be to open access to this ''invisible resource'' as Harvey Levin[13] called it, a futures market would play an important role in price discovery. It would also level the playing field to let countless small spectrum users now shut out of the licensing process compete for spectrum. Unbundling and ''open access'' have been the competitive forces in telecommunications, natural gas, and power markets, and they will have comparable force in spectrum.[14]

II. Refining the Instruments of Trade

From the beginning, the important questions concerning spectrum access and use revolved around property rights. The FCC system of spectrum management had its origins in the conditions of 1925–27. When the courts denied the authority of the secretary of commerce to limit the frequencies on which licensees could broadcast or to limit the number of licenses issued, broadcasters were freed from the restrictions of their licenses and left to decide on the power of their stations and the frequency band they used. As

[13] Harvey Levin, The Invisible Resource (1971).

[14] A deep and open, commoditized spectrum market is surely the best hope for achieving the open access to spectrum that Eli Noam, Spectrum Auctions: Yesterday's Heresy, Today's Orthodoxy, Tomorrow's Anachronism, J. Law & Econ., in this issue, at 765, eloquently argues for.

Tom Hazlett shows,[15] the spectrum became a commons, and interference rose to a level that threatened radio broadcasting.

In 1926, while Congress was discussing this situation, a court decision established the legal priority to an established wave length. Discussions in Congress[16] cited *Oak Leaves* as laying a foundation for property rights: ''The claim to 'Property Right' may be either in the use of the physical apparatus or in the right to freedom from interference . . . unless one adopts the suggestion of 'the government ownership of the ether,' an admission of property rights seems inevitable.''

Prodded by the impending privatization of the spectrum, Congress passed a stopgap measure designed to prevent licenses from becoming property rights by limiting license terms to 90 days for a broadcasting station and 2 years for any other type of station. Later that year, the House and Senate quickly passed the law making the spectrum ''the inalienable possession of the people of the United States'' and established the Federal Radio Commission to assign wavelengths, determine the power and location of transmitters, regulate the transmitters used, and prevent interference. Those powers are now held by the Federal Communications Commission.

The concept of property in the electromagnetic spectrum faces formidable technical obstacles. A signal occupies a place in a multidimensional space whose dimensions are time, geophysical space, frequency, and power. Broadcast technologies—like radio, television, cellular telephone, microwave, or air traffic control—transmit information on signals that propagate freely in space. These signals are encoded in the amplitude and modulation of waves of electromagnetic radiation. These waves occupy an infinite frequency domain. When the signals are received and decoded, their information content can be recovered. The electromagnetic spectrum is the term given to the range of frequencies over which electromagnetic signals can be transmitted. How does one define property rights to this resource? Can one own something that does not really exist?

The original definition of a spectrum property right laid down by De Vany et al.[17] remains valid. Spectrum property must be exclusive in order to solve the common pool problem. Unless the owner can exclude others, broadcasting on the frequency and area will become a commons. It was the nonexclusivity of spectrum-use rights that led to the chaos of the 1920s. Exclusivity also means that no one can use your spectrum without your permission. An externality, like interference, is a use without consent. So ex-

[15] Thomas W. Hazlett, The Rationality of U.S. Regulation of the Broadcast Spectrum, 38 J. Law & Econ. 133 (1990).

[16] Tribune Co. v. Oak Leaves Broadcasting Station, Cong. Rec. Senate 215 (1926).

[17] De Vany *et al.*, *supra* note 4.

clusivity carries a double burden: we must have an unambiguous assignment of the property and a secure means for the owner to stop interference. Externalities occur in the absence of legal rules to prevent their occurrence or where enforcement costs are high even where legal rules do exist. Contracting between spectrum owners with respect to externalities must be a practical possibility. In addition, because exchange can alter the pattern of externalities, we must specify the parties who must consent to a transaction.

A property system is based on the dimensions of the physical space occupied by broadcast frequencies. These dimensions are time, area, and spectrum frequency and bandwidth. In this respect, a property right is like one of the licenses sold in the spectrum auctions; these specified time, territory, and frequency band. But a property right is for pure spectrum, which is not tied to a specific service or a transmitter with fixed characteristics.

A property right is defined as the right to use exclusively a spectrum density over a defined time and area. An owner of a spectrum property right can lay down a spectral power density over a geographic territory. If you could see the invisible power density, it would look like a ''bubble'' or ''tent'' occupying a frequency domain over an area. The height of the tent would be the signal strength contours falling within a specific bandwidth over this territory. The physical attributes of the property are succinctly stated in the definition of property rights as TAS rights, for time, area, and spectrum.

This is the physical space that any signal transmitted from broadcaster to receiver occupies. It is the area within which the owner has exclusive rights to transmit. And it is the space into which no others may lay down signal field strengths beyond a well-defined limit. The frequency ''fence'' at the boundaries of the bandwidth and geographical area is defined as some critical threshold that cannot be exceeded. Any broadcast from another area or frequency that results in a signal field strength within the boundaries of this fence that exceeds the limit is a trespass. The owner has the right and duty to enforce the right.

This simple definition meets all the desiderata of a property definition. The exclusive assignment of rights to all three TAS dimensions to specific individuals or firms eliminates potential common-resource problems. The definition takes external effects into account by clearly limiting the extent to which any spectrum owner can spill radiation into a neighbor's TAS package. No legal prohibition is placed on the transferability of spectrum-use rights or on the uses to which they may be put.

Finally, it should be noted that the rights are defined with respect to transmitters rather than receivers. Transmitters are the natural place to put responsibility for spectrum control and operation. It is in the interests of broadcasters as communicators of information to insure that their signals

are received. And they have the means to do so at their disposal in their property rights and the flexibility that they bring. The property rights definition does not cut off the public's access to signals. Anyone can receive signals, but they do not have the right to obtain the information they contain without the owner's permission.[18] Under a property system, a TAS package becomes a portfolio of interests to be divided or combined with others in whatever ways offer more revenue or lower costs. As soon as we have an aftermarket in spectrum interests, it will be possible to configure and dissolve communications networks by buying and selling off the spectrum interests.

III. Solving the Interference Problem

The real stumbling block to a market system of spectrum allocation is the interference problem. The spectrum is a multidimensional space; signals propagate indefinitely in the frequency, spatial, and time domain. When signals collide in a piece of that space, some of the information that they carry is destroyed. If signals cannot be fenced in or kept from colliding in segments of the spectrum space, how can information-destroying interference externalities be avoided? Pervasive interference externalities destroy the ability of markets to work efficiently and may prevent them from working at all if the spectrum becomes a commons.

Consider first how the FCC deals with the signal collision problem. In essence, they do it by controlling the inputs and the production process so as to indirectly control the outputs. Broadcast licenses fix the technological parameters of the broadcasting equipment. They control the power, antenna locations and configurations, and time of operation of the equipment. They set the frequency bandwidth of every broadcaster, from large bandwidth users like television, satellites, and cellular telephone to microwave and even humble garage door openers.

The foundation of the traditional administered spectrum management systems is the block allocation system.[19] A block is a contiguous band of frequencies dedicated to a particular service governed by unique technical standards. Virtually all of the currently usable spectrum is allocated. The blocks facilitate frequency-use coordination by carving segments of spectrum into territories shared by services whose technical standards are similar. But these fixed allocations lock spectrum into uses whose values vary

[18] Shelanski & Huber, *supra* note 8, point out how a license or property right to transmit a signal over a frequency does not provide protection against unauthorized capture of the signal. The content of the signal must be protected by other means.

[19] Arthur De Vany, Property Rights in the Electromagnetic Spectrum, in The New Palgrave Dictionary of Economics and the Law (Peter Newman ed. 1998).

greatly over the country. For example, the UHF-TV band comprises 336 MHz of bandwidth everywhere in the United States, yet few cities have more than a handful of UHF-TV stations (each using just 6 MHz).

The block allocation method achieves a workable degree of coordination, but at a large cost.[20] Great portions of the spectrum go unused. Blocks freeze spectrum into fixed categories of use. They deny spectrum to new uses. Block allocations must fix technical standards for each block. So they freeze technology as well.

Solving the interference problem via this traditional FCC method is a complicated fixed-point problem. One must find a mapping of spectrum allocations, technical standards, power limits, and transmitter locations such that the signals broadcast by every licensee are compatible and noninterfering. Interference is what one party does to another, which depends on what they both are doing and what others are doing. Solving the interference problem involves finding a fixed-point equilibrium in which the actions of many agents interlocked in complicated ways are made compatible.

Freezing technologies, operations, and bandwidths creates a fixed-point equilibrium solution by brute force, but it results in all the inefficiencies that plague the present system. There is little room for new technologies. Changes in frequency assignments are difficult and complicated. Existing uses must be moved or have bandwidth taken from them without compensation if room is to be made for new uses. Moves are restricted by the block allocation system. There is little room for small incremental changes because the system works only by maintaining complex mutual constraints among all spectrum users. Relaxing or changing one constraint affects the equilibrium of the system in complicated and unpredictable ways.

A property right in spectrum solves the fixed-point problem by shifting the problem from the central planner to the field, from inputs to outputs. Every spectrum user is assigned a definite time, place, and bandwidth to use as they see fit. Compatible use of the spectrum is guaranteed by defining specific rights in time, area, and bandwidth that exhaust the spectrum landscape. Spectrum is not fenced off into blocks, and the technical parameters of broadcasting are not set.

The FCC could move in the direction of a property right by restating the present broadcast standard content of licenses in terms of the spectrum dimensions they use, as they did in the WCS licenses. Broadcast standards should be set by specifying the frequency band, the area, and the time dimensions in which the licensee's signal strength is permitted to reach speci-

[20] The FCC has moved away from the traditional, block allocation, solution to the interference problem in PCS. This innovation could be extended to other frequencies.

fied levels. Licensees use the spectrum to deliver any service as long as they remain within these limits and do not interfere with other users. A system of interference protection that is based on outputs rather than inputs could achieve all that the present system does and would be free of many of the inefficiencies of licenses that freeze technology, transmitter locations, and operations.

IV. Moving Spectrum to Market

One of the problems in moving spectrum to the market is clearing incumbents from the band. The FCC defined a complex procedure for clearing spectrum incumbents, putting the obligation on the winning bidder. The relocation policy creates what is essentially a bilateral or multilateral monopoly negotiation between the PCS auction winning bidder and the incumbent microwave licensee(s) who is (are) to be relocated. The ultimatum of the game is that the new licensee may request mandatory relocation of the incumbent but must pay the cost. Some sort of limit on the upper bound of these costs is contemplated, and a year limit on the bargaining is proposed.[21] (Using an auction to clear the frequencies voluntarily would eliminate this problem.)

Abandonment of frequencies by an incumbent—a move that eliminates relocation cost entirely and one that may be the cheapest alternative in many cases—is rational only if the licensee receives compensation. However, compensation is authorized only for relocation, and, hence, an incumbent will always choose to be relocated even if he would abandon for a payment that is less than his relocation cost.

The game is not incentive compatible. The incumbent has few incentives to truthfully reveal the relocation cost and many to overstate it. The PCS licensee has few incentives to identify the extent to which its operations would interfere with the incumbent's operations.

The overhang of the uncertain and cumbersome relocation procedures mandated by the FCC suggests that a rational bidder has to shave the bid by enough to be compensated for the cost of extracting the spectrum from an incumbent given a strong position from which to negotiate the terms of her relocation. That can be fixed through the sort of careful auction design work that went into the earlier auctions, which is what I discuss in the next section.

[21] Peter Cramton, Evan Kwerel, & John Williams, Efficient Relocation of Spectrum Incumbents, J. Law & Econ., in this issue, at 647, analyze the relocation game.

V. Using an Auction to Free Up and Reallocate Spectrum

The government wants to reap the very considerable revenue that is available from reallocating spectrum from lower- to higher-valued uses.[22] The bidders have to pay a relocation cost that is not truthfully revealed by the incumbent. The government cannot just take the spectrum, and, thus, we have this relocation problem. The real solution is to hold an auction on both sides, one to clear spectrum voluntarily from incumbents and the other to reallocate it to new users.

By design, the supply-side auction would reveal the opportunity costs of the incumbent rather than the inflated costs that are evident in the claims some incumbents have made. If permitted to bid in the next round for other spectrum, an incumbent could voluntarily be relocated to another band. When a licensee can sell a spectrum band high and buy a different one low, relocation is painless and maybe even profitable. The spread between the bid and offer prices is the gain in efficiency from spectrum reallocation. The problem is that unless the government gets the spread on each transaction, there will be no revenue for the treasury, and the motives for the auctions will vanish.

This is an easy problem to fix as there are many auction mechanisms that will yield revenue for the treasury while eliciting a voluntary supply of spectrum. If we did not have to capture any value for the government, we could just hold a double-sided simultaneous auction and let it converge to a clearing price. This may leave little spread in the bid and offer prices and little revenue for the government, which is, after all, its main incentive.

We need an auction that induces each bidder and incumbent to reveal their true values, meaning the auction must discriminate according to their reservation values and in the prices they pay and receive. Then the government takes the difference for each transaction that is made. If the auction is in a fixed area and frequency band, where there is relative homogeneity among the pieces, then the bands are interchangeable, no matter who sells or buys them. The government can take bids and offers, match transactions to maximize the value added, and take all of the difference.

If the auction is incentive compatible and true values are revealed, then the prices received and paid will differ among the parties according to their private values and costs. Thus, the auction is a discriminating one, and all the area between the demand and supply curves can be captured by the government auctioneer. The auctioneer only matches bids and offers and need take no position in any transaction and, thus, bears no risk. I have not for-

[22] Kwerel & Williams, Changing Channels, *supra* note 6, estimate that one UHF TV channel in Los Angeles might create $1 billion in new value if it were reallocated to cellular service.

mally analyzed this procurement and disposal mechanism and leave the task to auction theorists. We seem to require a two-sided simultaneous auction with package bidding for interdependent licenses that differ in frequency and geographic scope.[23] We want no budget balance constraint. The government is not constrained to break even, which would destroy incentive compatibility, which we need in order to assure positive government revenue, so both these requirements go in the same direction.

VI. Opening Access to the Spectrum

The great irony in Congress's declaration that the electromagnetic spectrum is the possession of the people is that access to the spectrum is almost completely closed to the public. The spectrum is locked away in blocks of bandwidth licensed to a privileged few through methods that are too complex and expensive for all but major corporations or the politically connected to bear (an extraordinary number of broadcast licenses are held by former members of Congress). Another irony is that, with the gateway to spectrum access closed, innovations that expanded the public's access to broadcasting were stalled until cable could be used to bypass spectrum.

Government control of the spectrum originally was asserted on the grounds that it was the best way to maintain public access to this resource. Yet, the public has no meaningful access to the spectrum. Meaningful public access to spectrum will come only when bandwidth becomes cheap, and a private property system can best accomplish that. It may seem ironic that the way to increase public access to the spectrum is to make it a private resource. But an open, commoditized, unbundled spectrum market system will dramatically lower the cost of bandwidth and give the public meaningful access to spectrum.[24]

VII. The Final Barrier: The Regulatory Game

Political support for regulating spectrum use is based on the benefits that inure to various coalitions; regulation was not necessary to solve the interference problem.[25] Moreover, in the absence of fixing technology, broadcast locations, and other inputs, interference protection is not well defined (who is interfering with you depends on what you are doing now, which can only be defined with reference to your broadcast and receiver technologies, locations, power, and so on). Because the FCC defines its task as interference

[23] A thoughtful referee suggested this auction form.

[24] Noam, *supra* note 14.

[25] Thomas W. Hazlett, The Political Economy of Radio Spectrum Auctions (Institute of Governmental Affairs 1993).

protection rather than specifying spectrum rights, it faces an intractable problem of calculating a compatible specification of technologies and operations that are noninterfering in an era when technology is rapidly advancing. Consequently, there is no fixed-point equilibrium that solves the interference game unless the FCC blocks technological advances. This is just how interference protection operated in the past, but that policy is becoming untenable.

Balancing mutual constraints keeps the system together and maintains a regulatory equilibrium. In order to gain interference protections, licensees are severely constrained in how they operate. Radio and television broadcasters gain if licensing limits competitors, but they face constraints themselves in how they may operate and what they may broadcast. Their licenses can be withdrawn on fairly arbitrary grounds. Had the FCC granted licensees blocks of spectrum areas that covered their intended range of operations and protected them from invasion, they would not have had to freeze technology and frequency allocations to solve the interference problem. But, then, I think the FCC would have been much less powerful with this system as they could not so readily leverage interference protection into the ability to grant monopoly broadcasting franchises.

Interference protection and protection from competition are tied together, but they depend on a set of increasingly unstable constraints. The spectrum auctions, the demands for new flexibility in frequency allocations, the rapid pace of technological change, and the increasing demand for spectrum that lies warehoused in unused allocations are placing many new demands on the FCC. It will not be able to maintain a consistent set of interference and competition protections in this new environment. As soon as exemptions and new degrees of freedom are extended to this coalition or that group of spectrum licensees, the constraints are relaxed selectively in a way that changes competitive conditions for other coalitions.

A regulatory equilibrium is a collection of coalitions that are relatively stable with respect to one another (the relevant concept is of a coalition-proof, Nash equilibrium coalition structure). Granting a relaxation for a coalition affects the stability of all the coalitions in the structure. Given the complexity of these interdependent constraints, changes can have large and unforeseen consequences. A change of one or a few constraints can cascade through the system and render other coalitions unstable. Because everyone's benefits depend on the constraints on someone else, a small liberalization for one diminishes the gains others get from adhering to the constraints they are under. They push for liberalizations too. The equilibrium of this Prisoner's Dilemma game can be sustained only through the rigid block allocation system and restrictive licensing.

The need for flexible new spectrum uses will be lethal to the present sys-

tem of administrative spectrum allocations that require substantial discrimination among parties and overrestrictive limits on access by the broader public to what will become the most important and abundant communication medium of all. The hole is already in the dike, and how it will turn out is hard to say. But there is no turning back to the old way of doing things, and the frequency allocation tables will increasingly become flexible. The FCC will not be able to keep up with the processing and political demands on it, and support for the system will erode.

VIII. Conclusions

My somewhat optimistic conclusion is that much of the groundwork has already been put in place for spectrum policy naturally to evolve to a market-based system. Shelanski and Huber[26] argue convincingly that FCC licenses have, over the years and in response to market conditions, evolved property-like attributes. Without anyone intending a market-based spectrum policy as the outcome, the basis for an evolution to that outcome already exists, and we will probably get there, not by design, but through a natural evolution of the present system.[27] Markets will come to spectrum the way they always develop: by fumbling through minor and major crises and by bootstrapping tradeable instruments and coordinating institutions from what we have now.

Rather than attempt to design a policy for implementing a market-based spectrum policy, we should just help it happen. Explicit attempts to implement markets will coalesce interests against them and, worse still, may result in the interests designing the markets to their advantage. But if we let each of the diverse interests play their own strategies in the Prisoner's Dilemma, the system will unravel by itself. The basis for a bottom-up evolution of such a policy already exists or is close to being put in place, and an evolution of spectrum allocation to a market system will happen more rapidly than trying to plan it and make it happen. The idea that markets are implemented or designed is the same old mentality that gave us planning and regulation in the first place. My ''plan'' for a market system is no plan. It is the *Field of Dreams* plan: auction the spectrum and the market will come.

All we need is a little luck in how the aftermarket operates and a crisis that raises perceptions of the vastly different privileges and restrictions on access to spectrum and spectrum-using services that the FCC has created and enforces. The auctions and the aftergames they bring forth will raise

[26] Shelanski & Huber, *supra* note 8.

[27] Kwerel & Williams, Moving toward a Market for Spectrum, *supra* note 6.

those perceptions. The fragile coalitions of spectrum licensees and political interests that the FCC is trying to manage and hold together are sustainable only by practicing pervasive discrimination concerning who has access to the spectrum and the services it provides. Once suppliers and customers taste open access to spectrum, there will be no turning back.[28]

In terms of concrete policy proposals that have a chance of gaining acceptance and of moving us along the path to a market-based policy, I propose that spectrum auctions be extended beyond their present scope. Though much design effort has gone into the auctions, too little has gone into worrying about how to acquire and clear the spectrum.

A major concern is that spectrum auctions will induce the FCC to make spectrum use more restrictive in order to create scarcity rents for the bidders and capture this induced value in higher bids. The line of thinking I have employed here suggests that, while possible, this is unlikely. And the supply auction that I propose neutralizes this possibility.

The most important and readily implemented step toward a market system would be to redefine how interference protection is accomplished. Rather than seek to protect licensees from interference by fixing their broadcast and receiving technology and all its related inputs, the FCC should restate licenses in terms of the output dimensions—the frequency band, the area, and the time dimensions in which the licensee's signal strength is permitted to reach specified levels. This step has already been taken in the WCS licenses and should be expanded to eventually encompass all licenses. Once this is done, interference protection no longer requires technology, transmitter locations, and all the related inputs and operations to be frozen. Interference protection shifts to the field where measurable signal strengths are recorded and verified, and interference issues become very much like issues of trespass. Licensees should then be permitted to subdivide their bandwidth and territories, offering what is essentially an undivided interest in the licensed bandwidth to others. Even within a framework of licensing, such a system would bring new flexibility to spectrum use and gracefully accommodate new technology.

Only the task of building institutions for the aftermarket remains, and we shall have a start on them when the clearinghouse begins to routinize the operations—recording title and clearing relocation costs and reimbursement rights—the FCC plans to give them. An important and easily implemented step toward a spectrum aftermarket would be for the FCC to liberalize and expand the scope of clearinghouse functions.

[28] George Gilder, Auctioning the Airwaves, Forbes ASAP, April 11, 1994, at 1, provides a glimpse of the kind of access to personal communications broadband radio, minicells, and the microchip could make possible.

The most important forces destabilizing the regulated equilibrium will come when sectors in the public perceive that they do not have access to a service that some other group does. Then the rallying point becomes ''access,'' and the arbitrary limits that presently are maintained in the name of interference protection or in the purported cause of keeping the spectrum as a public asset will lose their legitimacy. ''Access'' was the rallying cry that broke apart the old system of regulation in natural gas, power, and railroads, and it will eventually come to telecommunications.

The information revolution will be driven by the falling cost of bandwidth. But the price of bandwidth cannot fall under the current system of spectrum management; too much spectrum is warehoused for politically powerful interests, too much is grandfathered to uses that no longer have value, and too much innovation is stifled by the way the present system works. Commoditization and open markets will open access to the spectrum for all of us.

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