Using Markets to Solve Public Problems

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Abstract

Four public-sector uses of markets—for spectrum allocation, electricity supply, pollution control, and fishery management—are reviewed. Governments can successfully use markets for allocation. But the market must be well designed; and it cannot supersede the government's regulatory function.

Governments have begun using markets as a means to policy ends. Electricity markets have replaced production by state agencies or regulated monopolies. The right to use the electromagnetic spectrum for telecommunications has been auctioned off. In fisheries management, tradable quotas have started to be used instead of direct regulation. Part of the task of pollution control has been assigned to a market in emissions permits.

Controversy has dogged these exercises in market design. The high electricity prices that ruled in California after deregulation prompted calls to reregulate the industry. Some environmentalists say emissions trading is immoral, since it legitimates polluting. Critics of the spectrum auctions, such as the technology guru Nicholas Negroponte, say they amount to "an economically unsustainable tax" on the telecommunications industry, bringing high prices for consumers and stifling innovation.[1]

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[1] Negroponte is quoted in *Financial Times* June 8, 2000, p.5.

The case for using markets is a pragmatic one: they are justified only if they work better than the feasible alternatives. I extract some lessons in what follows from these experiences in the use of markets as policy tools.

Governments can successfully use markets. Information is the key. The market process—where it works well—generates information on which of the firms are able to put scarce resources to the best use: information that is unlikely to be revealed via a political or administrative procedure. Markets remove the need, in other words, for the government to pick winners.

Markets are a limited tool, however, for two reasons. First, they do not automatically work well. "Leave it to the market" is bad advice. For a market to deliver on its public-policy promise, the government must design it well. Second, a market can provide only part of the solution to a public problem. With electricity, spectrum rights, pollution rights, and fisheries, the market does its job only within the framework of continued government action.

1. Pollution Control

Acid rain causes lakes to die, as fish cannot survive in the acidified water. It blights forests and historic buildings. The grimy air harms people's health, causing respiratory and cardiac problems that can lead to premature death. To reduce sulfur dioxide emissions, the main cause of acid rain, the US government introduced, with the Clean Air Act of 1990, a new technique of pollution control. It eliminated the command-and-control method, under which each polluting firm had been directly regulated by officials from the Environmental Protection Agency (EPA), who decided how much pollution each individual firm would be permitted to emit. In its place, it created a market in the rights to pollute. The act brought in emissions allowances: licenses that allow the holder to emit in one year one ton of sulfur dioxide. The allowances were freely tradable. Anyone could buy or sell them, or bank them for future use.

Coal-burning electricity producers are the main emitters of sulfur dioxide. To reduce its emissions a plant must either install scrubbers (which clean the sulfur dioxide out of the flue gases) or switch to cleaner fuel (lower-sulfur coal or natural gas). The

costs of abatement differ widely among the different plants, depending on the plants' locations and the age and type of their equipment.

Reducing sulfur dioxide emissions by 10 million tons per year by 2010 was the government's announced intention. To achieve this by the old command and control methods might have required micromanagement by the EPA: investigating each individual polluting plant, deciding how much it should reduce its emissions, and ordering it to install specific pollution-control equipment. Alternatively, command and control might have set uniform standards for all firms, requiring them to take the same abatement steps regardless of costs or outcomes.

With tradable emissions allowances, flexibility is achieved without micromanagement or blunt rules. The government simply decides what total nationwide level of emissions is acceptable, and lets the market decide how much each plant cuts back. It creates a total number of licenses equal to the target level of emissions, and gives the licenses to the polluting companies, which then trade the licenses among themselves. Those firms that find it relatively easy to reduce their emissions sell some of their allowances and use the revenue to pay for their abatement activities (and have some profit left over). Those that find abatement relatively difficult buy extra allowances. As a result, the firms with low abatement costs clean up their operations more than the mandatory amount, and so the target reduction in total emissions is achieved at the lowest possible cost to the industry.

This theory is borne out in practice. Large numbers of allowances are bought and sold: in 1998 such trades corresponded to nearly ten million tons of emissions. Behavior varies across firms. Some sell allowances and emit less pollution than initially assigned, while others buy allowances and pollute more than their assignment. As the Environmental Defense Fund said, "Any utility that can find a way to exceed its reduction target is rewarded by being allowed to sell or trade its extra allowances to another utility that would have found it more expensive to meet its target by itself. This profit incentive has been spurring competition and innovation. For example, both energy efficiency and the use of cleaner fuels, such as natural gas, have increased, new cleanup chemicals have been developed to neutralize sulfur, and bioengineers are trying the create bacteria that will eat and metabolize sulfur in fossil fuels."

The emissions-allowances program has been, according to most who have studied it, a notable success, more effective than any earlier acid-rain program. The Environmental Defense Fund, one of the program's proponents, echoes this assessment: emissions trading "is cleaning up acid rain faster and far more cheaply than skeptics had predicted. The market system is unleashing inventiveness and showing that the cleanup need not put a heavy burden on the economy."[2] The amount of pollutants emitted actually fell 30 percent below the ceiling the government had set. This was achieved at a cost to industry of billions of dollars less than the alternatives. Air quality and sulfate concentrations in rain measurably improved nationwide.

In an elegant twist, environmental groups sometimes buy emissions allowances and hold them inactive. The Clean Air Conservancy in Cleveland, Ohio bids for allowances and then offers them for sale to the public, with the promise that each one bought and retired prevents the discharge of a ton of sulfur dioxide into the air. Sixth-graders at the Glens Falls Middle School in Cleveland, among others, raised money to buy allowances. "It's been a real launching point for us, to allow individual citizens to get involved and feel like they've actually done something for the environment," said Kevin Snape of the conservancy. They reduced pollutants in the air, over a three-year period, by 6,000 to 8,000 tons.[3] The allowances are especially in demand, he remarks, for giving as Christmas presents. Similar activities occur around the nation, with ordinary people making a small but perceptible contribution to cleaning the air. (Their scale is small but not unimportant: they could be driving pollution, at a rough guess, around one percent below the level the government mandated.) The firms that sell allowances to environmental groups make a profit, it is safe to assume; the price more than covers their abatement costs. The environmentalists, spending their own money, get a purer environment.

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[2] This section draws facts from Ellerman, Joskow, Schmalensee, Montero, and Bailey (2000), Bohi and Burtraw (1997), and EPA (1999). The quotes from the Environmental Defense Fund are from its March 1995 newsletter, at www.edf.org. See also www.epa.gov/acidrain, the EPA site.

[3] *Columbus Dispatch*, Dec. 1, 1999, p. 4D; *Buffalo News*, Aug. 27, 1997, p. 16C.

Environmental programs that make use of market incentives have sprung up elsewhere: to phase out the use of leaded gasoline, to improve air quality in Los Angeles, and to limit the worldwide emissions of carbon dioxide, the source of global warming.[4]

2. Spectrum

Auctions have been successfully used to allocate licenses to use the electromagnetic spectrum for telecommunications: starting in New Zealand and then the United States, and followed by countries such as Australia, Mexico, and Canada. Hong Kong and Singapore are committed to using spectrum auctions and Japan is considering it. They have become what the *Financial Times* called "the world's largest concerted transfer of money from the corporate sector to state coffers."[5] As of early 2001 the US auctions had fetched a total of $42 billion. In 2000, an auction of spectrum licenses in the United Kingdom yielded $34 billion, and one in Germany went to $46 billion.

A new market was created with the spectrum auctions. Previously, the US government had given the spectrum rights to telephone and broadcasting companies. Initially, licenses were assigned by administrative decision. Prospective license-holders filed applications, and the FCC held comparative hearings to decide which applicant was the most worthy. This cumbersome method broke down under a backlog of unassigned licenses. Congress replaced it with lotteries, giving licenses to some lucky applicants. The lotteries succeeded in assigning licenses quickly, but the prospect of windfall gain attracted applicants in droves. There were nearly 400,000 applications for cellular licenses. In one not atypical case, some dentists won the right to run cellular-telephone service on Cape Cod; they immediately sold their license to a real telephone company, Southwestern Bell, for $41 million. The value of the licenses the government gave away during the 1980s, according to a Commerce Department estimate, was $46 billion.

Congress could not shrug off such figures, and in 1993 it passed legislation giving the FCC the authority to auction licenses. The FCC was to "design and test multiple alternative methodologies" for competitive bidding. The act specified a range of aims for the auction: achieving an "efficient and intensive use of the electromagnetic spectrum,"

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[4] See Goldberg (2001).

[5] *Financial Times* Nov. 2 2000.

promoting rapid deployment of new technologies, preventing monopolization of licenses, and ensuring that some licenses go to minority-owned and women-owned companies, small businesses, and rural telephone companies.

The spectrum auctions were large and complex. No one knew at the outset what the licenses were worth. Thousands of licenses were offered, varying in both geographic coverage and the amount of spectrum covered. The bidders included most U.S. telecommunications firms: long-distance, local, and cellular telephone companies and cable-television companies.

The $42 billion raised over a series of auctions far exceeded any published predictions of the spectrum's value. The Office of Management and Budget had estimated before auctioning began that $10 billion would be raised. The industry responded skeptically to this estimate. BellSouth chairman John Clendenin said, "There is no rational methodology on which that $10 billion was calculated." The government estimate, he asserted, "was sort of pulled out of thin air." MCI chairman Bert Roberts said, "The government is smoking something to think they are going to get $10 billion for these licenses." To a cynic these responses might have looked disingenuous; it was after all in the industry's interest to talk down the spectrum's value. As it turned out, the government's estimate was actually too low. In terms of the money it raised and the information it revealed about the spectrum's true value, the auction was a success.

What is the government's role in spectrum allocation now that auctioning is used? It still has its regulatory function, parceling up the spectrum and coordinating its usage. Without a clear definition of property rights, the spectrum, like anything else, would not be used efficiently. What was turned over to the market was the decision—hard for a government official to make well—of who gets the right to use each piece of spectrum.

The main beneficiaries of the spectrum auctions were consumers, who got a speedy introduction of new telecommunications services at competitive prices, and taxpayers, through the revenue generated. "When government auctioneers need worldly advice, where can they turn?" the *Economist* asked, and answered, "To mathematical economists, of course." William Safire in the *New York Times* called it the "greatest auction in history."

One complaint about auctions is that they favor large bidders with a deep pockets. New entrants find it hard to compete. There are two responses to this. One is that the 1990s, the period in which market forces came into the telecommunications industry, in fact saw a large amount of entry. The other is that the alternative to auctions, administrative processes, are not notably open to outsiders. It may be easier for a new firm to raise money to bid in an auction than to be a player in the political process. Governments that use so-called beauty contests to assign spectrum often favor the incumbents. When the South Korea awarded two mobile licenses in 2000, for example, fixing the price at $1.1 billion and using promises of performance as the criteria for awarding them, it selected SK Telecom, Korea's biggest mobile provider, and Korea Telecom, which is state run.

In the United States, the auctions' success did not do away with the government's penchant for giving away what the public owns, as Congress voted to give spectrum for high-definition broadcasting to the television networks. The television industry holds far more sway over the politicians than the telecommunications industry, evidently, for the telephone companies pay billions for spectrum while the broadcasters get it for free. This is not unrelated—might we speculate?—to the networks' control over the news coverage of election campaigns. Senator John McCain called the spectrum giveaway "one of the great rip-offs in American history." The FCC estimated the spectrum the broadcasters received for free was worth $70 billion. The broadcasters complained, meanwhile, about bureaucracy. "They cut the red tape lengthwise here in Washington," said Edward O. Fritts, president of the National Association of Broadcasters. "We have an FCC that is attempting to layer more regulation. We are proud of what we have accomplished, and would like to continue to do it unencumbered by red tape."[6] And, one might add, unencumbered by having to pay for their main input.

3. Electricity

Electricity deregulation in California was supposed to create, according to the State Assembly bill that initiated it, "a market structure that provides competitive, low cost, and reliable electric service." It didn't.

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[6] *New York Times* Oct. 16 2000; *Washington Post* Dec. 17, 2000, p. H1.

The attempt to build a market in electricity went badly awry. The price of wholesale electricity soared to ten times what it had been. Blackouts ensued, interfering with everyday life. Governor Gray Davis labeled the experiment with electricity markets "a colossal and dangerous failure."

The primary reason for California's electricity catastrophe predated deregulation. You can't defeat supply and demand. In the years leading up to deregulation and immediately following it, California's robust economic growth had brought increases in electricity usage. Meanwhile, no significant new generating plants were built; generation capacity actually declined by two percent between 1990 and 1999. With or without deregulation, California would have suffered electricity shortages. California had bad luck, being hit shortly after deregulation by two unpredictable events, either of which alone might have been manageable but together were damaging. Less rainfall and snowfall than normal meant low water levels for hydro generation and increased the need to use natural gas to generate electricity. At the same time there was a big increase in the price of natural gas. This is not all, though. The manner of the deregulation led to its breakdown. The design of the new electricity market was inadequate.

The electric utilities once produced most of the power themselves. Production costs were high because, as regulated monopolies, the utilities could pass any cost increases on to their customers in higher rates and so had little incentive to hold their costs down. A competitive market, it was hoped, would bring more efficient production and cheaper electricity. To create a wholesale-electricity marketplace, the regulators asked the utilities to sell off their generating plants. In the new deregulated system, the utilities were purely retailers of electricity, buying wholesale electricity from the independent generators. Signing the bill enacting deregulation in 1996, Governor Pete Wilson said, "We've pulled the plug on another outdated monopoly, and replaced it with the promise of a new era of competition."

It was "the most complex transition of an industry done anywhere in the world," according to Steve Peace, the chair of the Senate energy committee and an architect of the new market. The special features of electricity as a commodity make the performance

of the market unusually sensitive to its design.[7] Since electricity is costly to store, it must be produced as needed. Demand fluctuates widely from hour to hour and from season to season. At peak demand times, all but a handful of generators are operating at their maximum capacity, and at such times those few marginal producers are able to bid the price high. In most markets, high prices bring about their own demise, as they attract new producers into the industry, who then push the prices down. With electricity, however, even in the long run and even with the pull of high prices, supply can only slowly expand to meet demand. Building a new generating plant takes years, in part because of the engineering required, in part because of not-in-my-backyard objections.

An online auction was implemented to set the prices. Each day, companies wanting to buy electricity submit bids stating the amount of electricity they want the next day and the price they are willing to pay. Companies wanting to sell submit offers of quantity and price. A bank of computers array the bids and offers and, hour by hour, calculate the price at which supply meets demand. (Such an auction would not have been feasible a few years earlier, by the way, for powerful computers are needed in order to instantly compare the bids, compute the market-clearing price, and allocate the quantity orders to the buyers and sellers.)

The auction prices rose higher and higher. "We are so far into the realm of extraordinary gouging we are orders of magnitude off the chart," California Assembly Speaker Fred Keeley told the Federal Energy Regulatory Commission in 2001. Why did deregulation raise prices, rather than lowering them as it was supposed to?

The high prices were in part an ordinary market response to high demand. What determines the competitive market price is the marginal cost (that is, the cost of generating one additional megawatt of power). When a large supply is needed it is the high-cost gas-fired plants, and not the low-cost hydro plants, that are the pivotal suppliers. When demand hits a peak, therefore, marginal cost is high and so price is high. Moreover, the price of natural gas rose dramatically in 2000. The price of electricity rose with the cost of generation.

This is not the whole of the story, though, for at times prices rose far above the generation costs. Some of the generating companies after deregulation had the power

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[7] The authoritative account of the principles of electricity deregulation is Wilson (1999).

unilaterally to set the price. Gray Davis, saying the generators were earning "unconscionable profits," slammed them as pirates and price-gougers.

"There is evidence that some generators may be withholding electricity," the governor said, "to create artificial scarcity and drive up the price astronomically."[8] Such manipulation of the market is illegal. It is for the courts to decide whether it actually occurred. Making such a judgment requires a detailed examination of the firms' accounting records, which calls for the power to subpoena. But whether or not the generators illicitly colluded to cause artificial scarcity, part of the explanation for the high prices is merely the natural scarcity arising from limited supplies. It was easy for the generators to game the system. At peak demand, most generators cannot expand their output because they are already producing at their full capacity. The remaining generators, only a handful, determine how much power gets produced. Each of those pivotal generators is aware that the quantity the system purchases won't vary with the price. Charging what the market will bear therefore means bidding very high.

Proving that prices were excessive is hard, because the marginal cost of generation varies widely from hour to hour, depending on what fraction of the generation capacity is being used at each point in time. To establish whether prices have been marked up over costs, and by how much, entails gathering very detailed data on generation costs and examining many thousands of individual transactions. According to Severin Borenstein, James Bushnell, and Frank Wollak, wholesale prices in 1998-99 were an average of 16 percent above marginal cost. Then in 2000 prices soared a further 500 percent. In just ten months in 2000-2001, according to an estimate by the Independent System Operator, which runs the state's power grid, the prices the generators charged the utilities exceeded competitive prices by $6.2 billion.[9]

It was the design of the new market that caused it to malfunction. Before deregulation, the system was centrally controlled. Decisions all the way from generating the power to delivering it to homes and businesses were made inside each utility, under regulatory supervision. The old system worked; power was reliably supplied. But it did not work efficiently: the costs of generation were high. Given the limitations of central

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[8] Quotes from *Los Angeles Times*, Jan. 11, 2001; Jan. 14, 2001; *Economist*, Aug 24, 2000; *San Jose Mercury News* April 11, 2001, p. 1A.

control, it worked about as well as could be expected. It is difficult if not impossible to efficiently run a system as complex as a large state's power supply from the center.

Deregulation eliminated the central control, by interposing a market between the generation and distribution stages. There was a catch, though. No alternative set of controls was installed in its place. The control mechanism in a normal market is the price system. It is the movement of prices that makes a market work. When supply is short, the price rises. Consumers have an incentive to use less. Demand falls and the shortage is averted. Price movements make the system self-correcting. In the deregulated electricity market, this simple mechanism was thwarted. Prices were not allowed to do their job.

Although the wholesale price at which the utilities bought power was market-set, the regulators fixed the retail price the utilities could charge their customers. When wholesale prices shot up, retail prices stayed put. The utilities were squeezed, paying far more to buy electricity than what they were permitted to sell it for. Pacific Gas and Electric, the company supplying Northern California's power, filed for bankruptcy in 2001, claiming it had amassed debts of $9 billion because of this gap between its costs and the price it could charge.

If the retail price had varied month by month to reflect wholesale prices, not only could the utility have avoided indebtedness, but consumers would have been motivated to conserve electricity. They might have installed energy-saving light bulbs, acquired the habit of switching appliances off when they are not being used, or turned the air-conditioning down a little.

A thoroughgoing deregulation would have allowed retail prices to fluctuate not just month to month but hour to hour. For business customers, especially, sophisticated meters allowing real-time pricing could have been installed. If the retail price had followed the wholesale price in its roller-coaster fluctuations, then power users would have had an incentive to reduce their consumption in high-demand hours and increase it in low-demand hours. Businesses could shut down when prices were high, and run extra shifts when they were low. Peak-time power would thus be saved for other uses such as in homes.

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[9] Borenstein, Bushnell, and Wolak (2000); *New York Times* March 23, 2001, p. A14.

The Californian electricity market tripped up, then, on the most elementary requisite of market design: prices should reflect production costs. With the retail price fixed, the system had no way of responding to shortages—of which there turned out to be plenty.

Normal market mechanisms were prevented from doing their job also in a further sense. The regulators required the utilities to buy all power when needed. Long-term supply contracts with generators were prohibited; power could be bought only in the spot market. The ability to buy ahead would have helped ease the day-to-day volatility of the wholesale prices and diminish the generators' peak-time market power. This regulatory mistake served to exaggerate the day-to-day price fluctuations.

California deregulated by half measures. The mix of controls and market-set prices was incompatible: it made no sense to free up wholesale prices while keeping retail prices fixed. This is not to say, however, that California should have deregulated completely. Ongoing government regulation of the electricity market is needed.

Prices could have been far above generation costs even under a more thoroughgoing reform At times of peak demand, when a handful of generators are able to hold the system for ransom, the price is bid very high. Competition by itself cannot always be relied on to hold the price down close to generation costs. Overpricing is an ever-present possibility in an electricity market. Some regulatory oversights on pricing are in order to keep in check egregious price-gouging.

The transmission grid—the high-voltage lines that carry the power—is by its nature a monopoly, so cannot be left to an unregulated market. Because of the physics of electricity, the operator of the grid must constantly monitor it to ensure its reliability. The amount of power being pumped into the grid by the generators must always equal the amount being tapped by electricity users. The transmission system would be destabilized, bringing blackouts around the state, if there were a sudden uncompensated surge in the amount of electricity either being put in or drawn out. No matter how smoothly the retail and wholesale electricity markets operate, therefore, the grid needs continuing regulation.

Some critics say California's deregulation didn't go far enough; it should have moved to fully free markets. Others say there should have been no deregulation, for markets for electricity can't work. Both sides have some truth; but both are oversimple.

The deregulation fell short in retaining retail-price controls and preventing prices from signaling scarcity; it went too far in eliminating restraints on overpricing by the generating companies. The problem was not too much or too little use of markets, but poor market design.

The main lesson from Californian electricity is that, no matter how badly deregulation is needed, the details of how it is done matter. Elsewhere, such as in New Zealand and Australia, electricity markets have successfully been introduced. In those markets, most of the power is traded in long-term contracts, not in the day-ahead market, and retail prices are move with generation costs. Moreover, their market designs were not put through the same kind of trials as California's, for electricity was in plentiful supply.

5. Fisheries

Fisheries today are in a state of crisis. Seventy percent of the world's fisheries are being overfished or are on the verge of it, according to the World Wildlife Fund. In the United States alone, species such as red snapper, New England cod, Chesapeake Bay blue crab, swordfish, Atlantic billfish, winter flounder, shrimp, tuna, and shark suffer from overfishing. Jim Leape, a vice-president of the wildlife fund, says, "The oceans can no longer absorb the abuses we have piled on them."[10]

The chronic overfishing results from the common-property nature of the fishery. Overfishing occurs primarily because the fishers respond to the incentives they face. Biology sets a maximum extraction rate. If too many fish are caught, too few are left in the ocean to reproduce at a rate that maintains their population at a sustainable level.

"Right now, my only incentive is to go out and kill as many fish as I can," said John Sorlien, a Rhode Island lobsterman. "I have no incentive to conserve the fishery, because any fish I leave is just going to be picked by the next guy."[11] His logic is watertight. The fish will be caught and will not reproduce, even if he behaves responsibly and refrains from catching them. He cannot by himself ensure the fish stocks are maintained. His choice is to catch either a large number today and few tomorrow, or a smaller number today but no extra tomorrow. Responsible behavior goes punished. There

[10] For an excellent account of the fisheries crisis, see Grafton, Squires, and Kirkley (1996). The World Wildlife Fund report is summarized in *Monterey County Herald*, Aug 19, 1998.

is a race to fish. The logic of the situation traps each fisher into taking as many fish as he can. The externality is that the other fishers bear the costs of one's own overfishing.

The fishing industry takes 80 to 84 million tons of fish each year from the world's oceans. According to the World Wildlife Fund, fishing at a rate that would allow the fish to regenerate would mean catching just 60 million tons per year. How can overfishing be prevented? The various solutions that have been tried cover the full range of externality remedies.

Communities of fishers sometimes devise informal solutions: collective mechanisms to counter overfishing. In the Bahia region of northern Brazil, fishers work within an intricate code of conduct governing both the total amount of fish that can be taken and how much each of them may take. The members of the community sanction those who violate the code, refusing to speak with them in social situations or sabotaging their boats and nets. In Tonga, fishers obey social norms requiring them to share their fish. Anyone who catches more than his family can eat must give it away according to rules that favor the needy and the elderly. The local fishing communities of Japan also manage their resources in a sustainable way. Because they have specific geographic boundaries and the same families engage in fishing from generation to generation, all understand the code of conduct and social sanctions effectively support it. In The US state of Maine, some communities regulate the lobster fishing in local waters, determining who may fish when and where. They back their conservation measures with force. Anyone who flouts the community's rules risks having his traps cut free or even having his boat sunk.[12]

Informal solutions work only within tight-knit fishing communities. With large, anonymous groups of fishers that outsiders can enter, social sanctions hold little sway and so government intervention is usually needed to prevent overfishing.

Regulating fisheries, governments have imposed controls on the number or size of boats. They have specified that fishing can take place only within a certain season. Each of these is a blunt form of control, and each leads to predictable distortions. Regulatory controls on inputs induce the fishers to compensate by overusing whatever inputs are

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[11] *New York Times Magazine*, Aug. 27, 2000, p. 38.

unregulated.[13] Restrictions on the number of boats have brought bigger boats with extra equipment and crew. Restrictions on the length of the vessels have induced companies to build wider, heavier boats. Restrictions on the number of crew have resulted in investment in high-tech fishing gear; adding electronic devices for locating fish increases a vessel's catch dramatically. Restrictions on equipment, on the other hand, have meant extra crew being hired. A short fishing season induces firms to invest in high-capacity boats, so they can catch as much as possible in the time allowed; the investments sit idle for the rest of the year. A short season also means that for much of the year the fish must be delivered frozen to the customer, providing less value than if it was fresh.

Recognizing these distortions from regulation, some governments have switched to a new, more market-based method of conservation. Rather than controlling inputs, the regulators assign to each fishing vessel a quota, defining how much it is allowed to catch. Quotas directly address the basic issue—that overfishing is a consequence of the fact that no one owns the fish—by establishing property rights. By eliminating the externality each fisher's decision imposes on the others, quotas eliminate the race to fish.

The New Zealand government introduced tradable quotas in themid-1980s. The aim was to reduce catches to sustainable levels. Quotas were allocated to individual fishers based on their prior investments in equipment.

Quotas to be bought and sold like any private property. A new entrant or an incumbent wanting to expand needs to buy quotas. This means the quotas end up with the most efficient producers. Unlike under regulation, the fishers have reason to invest in productivity-improving skills and equipment. The quota term is unlimited. When the government wanted to reduce the total catch because of what it judged to be overfishing, it used a market process. It called for tenders from the fishers. A bid stated how much money the fisher would accept to reduce their allowed catch by a specified amount. The government accepted the lowest bids up to its target catch reduction, and paid each successful bidder the market-clearing price per tonne of quota reduction.[14]

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[12] Bender, Kagi, and Mohr (1998), Sethi and Somanathan (1996), *New York Times Magazine*, Aug. 27, 2000, p. 40.

[13] Grafton, Squires, and Kirkley (1996), Grafton, Squires, and Fox (2000).

[14] Sharp (1996, p. 442).

Quota-holders have a stake in preserving the fishery in order to maintain the value of their quotas. In New Zealand, the fishers have formed associations to fund research aimed at conserving the stocks of scallops, snapper, and orange roughy.

Overfishing occurs because no one owns the fish before they are caught. Creating property rights, by means of quotas, removes the incentive to overfish. But it is an imperfect solution, for the monitoring of the property rights is expensive and leaky.

The fishery, in summary, is impervious to perfect management. In a fixed and stable community of fishers, codes of behavior backed by social sanctions can confine fishing to a sustainable rate. But in most fisheries new fishers can enter, so there is no such stable community, and there an absence of government oversight brings disastrous overfishing. Government regulation of fishing, on the other hand, causes distortions and in any case usually fails to avert the overfishing. The best feasible solution is catch quotas. By creating property rights, quotas directly tackle the externality of the fishers' decisions on how many fish to take. While this is the most market-oriented of the solutions, it can be implemented only with extensive government monitoring.

6. Markets as Policy Tools

Some lessons can be drawn from these exercises in using markets in the public sector. Markets are useful policy tools; but they do not solve all problems.

(i) Markets reveal information

What the emissions-allowance market does, like any other competitive market, is to generate information.[15] It reveals how to reduce pollution in the lowest-cost way, as well as what the costs of reducing pollution actually are.

Why can't the government achieve whatever the emissions-allowance market achieves? Smart bureaucrats could, in principle, control pollution as cost-effectively as the market by requiring extra reduction from those plants that have lower abatement costs—except that the bureaucrats do not know where abatement costs are high and where they are low. The key information is held locally. Each firm is different. It is the firms themselves that best understand their own circumstances, and in particular how

[15] On markets as information providers, see McAfee and McMillan (1987) and McMillan (2002).

much it would cost them to cut their own pollution. The EPA can know a firm's abatement costs only if the firm itself volunteers the information. The incentives under command and control worked against this. Managers, negotiating with the EPA, might exaggerate their firms' abatement costs in order to be assigned easier cleanup targets. The managers may even not have known how low their abatement costs could be driven, for under command and control they had little incentive to find out. Bureaucracy-run pollution controls were hindered by a lack of information.[16]

Under the market, by contrast, decisions are made by the people who are the best informed. Actions speak louder than words: what firms do in the marketplace provides more reliable information than anything they might say to the bureaucrats. Firms with low cleanup costs have a profit-based incentive to reveal this fact, by selling their allowances.

The prices of the allowances surprised most observers, being far lower than expected. The surprise came because command and control had left everyone (except perhaps for the polluters themselves) with a distorted impression of those costs. Before emissions trading began, the EPA estimated it would cost $750 to clean up a ton of sulfur dioxide. The electric-power firms claimed it would cost them up to $1,500. The average price at which the allowances actually traded over 1994-99 was about $150.[17] Actions speak louder than words. By selling an allowance for $150, a firm was in effect saying that cutting its emissions would cost it no more than $150 per ton. The EPA had believed the abatement cost to be an astonishing five times higher, and the industry had claimed it to be an even more astonishing ten times higher, than the market revealed it to be.

The emissions-allowances market has turned out to be the environmentalists' ally. Under direct regulation the EPA, greatly overestimating the cost of cleanup, may have

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[16] A technical sidepoint: it is theoretically possible to devise a mechanism that induces firms to reveal their private information, along the lines of Baron and Myerson (1982). This would involve subsidizing the plants that reveal themselves to be low-cost (and so are asked do the most cleanup) and taxing the others. Such a mechanism is, however, difficult if not impossible to implement in practice.

[17] The $1,500 figure was stated in the 1990 Clean Air Act as the price of direct sales of allowances by the EPA, and the $750 figure was cited by the EPA in 1990 as its best guess of the price at which allowances would trade (Bohi and Burtraw, 1997, p. 8). The allowances prices ranged between $70 and $220 over 1994-99 (see www.epa.gov/acidrain/ats/prices). The price of low-sulfur coal fell in a way that could not have been anticipated, and this explains part of the five- to tenfold difference between actual and predicted prices (Bohi and Burtraw 1997, Ellerman et al. 2000). Much of it, though, is due to information generation.

pushed for less pollution reduction than it should have. By showing how inexpensive the cleanup really is, the market has actually bolstered the case for aggressive clean-air targets.

The multibillion-dollar prices reached in the spectrum auction seem ludicrous to some. In the frenzy of the bidding, the critics say, the telecommunications executives bid far above real value. If that were true, we should question their competence (as should their shareholders). But it isn't likely to be the correct interpretation. Rather, these prices show the rest of us what the executives already knew—mobile telecommunications is enormously lucrative. Before there was competition, that knowledge stayed with the firms—who were content, no doubt, to keep it to themselves. The arrival of competition forced the insiders to reveal the value of the spectrum rights, and to pass much of that value on to the government.

The competitive process reveals information. After the auction, the seller knows which of the bidders values the item the most, and the price gives an estimate of value. There is a twist, however. The bidders are in part all trying to estimate the same thing, the future profitability of running mobile telecommunications services. This common-value feature means the bidders risk falling into the trap of the "winner's curse:" that is, learning, too late, that the price has gone higher than the item is worth. If they are all knowledgeable, then the best estimate is something like the average of their valuations. The winning bid, of course, is higher than the average bid. The winner is likely to be the bidder whose estimate is the most optimistic, probably overoptimistic.

In any auction, unwary bidders risk overestimating the value of winning. Bidders sometimes get caught up in the excitement of an auction and pay too much. But they need not be fooled. Experienced bidders avoid the winner's curse by bidding cautiously: they recognize they will win only if they have relatively high value estimates and bid accordingly lower. Laboratory experiments corroborate this: the subjects bid too high initially, but as they become more practiced they tend to adjust and avoid overbidding. Alert winners are not cursed.[18]

(Although pricing rules of the EPA auction tend to induce low prices, as I will discuss, this is not the explanation, for most of the transactions occur in the private market.)

[18] On bidding to avoid the winner's curse, see Wilson (1969) and Milgrom and Weber (1982). For the experiments, see Garvin and Kagel (1994).

It is not difficult to avoid being subject to the winner's curse. All you have to do is understand why there is a risk of bidding too high. The phrase "winner's curse" has in fact become common parlance in the telecommunications industry. There is little reason to believe the winning bidders routinely overbid. (The wisdom of hindsight is a different matter. Changes in the telecommunications industry subsequent to the auctions may in some cases, such as the German and UK auctions, have caused a rethinking of the value of the spectrum; but that is an ordinary business risk.)

A further criticism of spectrum auctions is that they raise the prices that consumers ultimately pay for services. Janice Hughes of Spectrum Consultancy Services, an advisor to the Hong Kong government, said, "A auction would push the price of a single license to at least US$1 billion per operator and, there is no question about it, those costs would be passed on to consumers in the form of substantially higher prices."[19] To argue this, however, is to confuse fixed and variable costs. A firm that cares about profits bases its price on its marginal cost: that is, the cost of supplying an additional customer with the service. The auction price is paid before any service is provided—it is a fixed cost—so is not part of the marginal cost of supplying the service and does not affect the price charged to customers. There is a caveat to this fixed-cost argument. If capital-market frictions mean that the more the firm borrows, the higher the interest rate it must pay, then the extra debt added by the auction price could result in the firm's investing less and having a higher marginal cost. This caveat aside, the auction revenue is a pure transfer from the firm's profits to the government. The price to users would be the same whether the government sold the spectrum or gave it away.

(ii) Markets must be well designed

As the California electricity market illustrates, the design of a market must be watertight, especially when large sums of money are at stake. Any oversight in market design can have harmful repercussions, as smart people can be counted on to seek ways to outfox the mechanism. A newly instituted market achieves what it is supposed to only if it is well designed. The rules of the market matter.

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19 *South China Morning Post* Aug. 21, 2000, p. 3.

The US spectrum auctions used a novel form of auction, the *simultaneous ascending auction*. Multiple licenses are open for bidding at the same time and remain open as long as there is bidding on any of the licenses. Bidding occurs over rounds, with the results of each round announced before the start of the next. Given the complexity of the sale, it was decided, the simultaneous ascending auction would induce more competitive bidding and a better match of licenses to firms than the time-tested alternatives. Despite initial hesitation—"I don't want the FCC to become a beta test site," said FCC official Robert Pepper—the FCC implemented the innovative auction.

Many detailed rules are needed to support the broad principles of the simultaneous ascending auction. Months of work by FCC officials and economic theorists went into ensuring the auction rules had no gaps that could be exploited by shrewd bidders: the rules cover more than 130 pages.[20]

Why use a simultaneous ascending auction? Why not use the time-tested method, a sequential auction, in which the licenses are simply offered one after the other? Or why not use the quickest method, offering all the licenses simultaneously in a single round of sealed bids? The main reason is that the licenses are interdependent. For most of the licenses there is a close substitute: a twin license that covers the same region and the same amount of spectrum. Licenses are also complementary: a license may be more valuable if the holder also has the license for a contiguous region.

Some bidders needed to win multiple licenses. In defining the licenses, the FCC divided the United States geographically and the spectrum by waveband, making thousands of licenses. The FCC expected that some bidders would want to aggregate licenses, either geographically (a bidder might want, for example, not northern or southern California alone but both together in a package) or by waveband (putting together two or more licenses to make a larger piece of spectrum). The FCC did not know before the sale how the licenses should be packaged. Different firms wanted different packages. The auction mechanism had to be flexible enough to enable the bidders to construct their own license packages.

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[20] For more on the process of designing the FCC auctions, see McAfee and McMillan (1996) and Milgrom (2000), and the website of Market Design Inc., www.market-design.com. For up-to-date information, see the FCC's auction site, www.fcc.gov/wtb/auctions. Many of the ideas used in designing the auction trace their origins to Robert Wilson; see his Econometric Society presidential address, Wilson (1999).

Both features of the auction—the *simultaneous* bids and the *ascending* bids—helped ensure that licenses went to the firms best able to use them. The ascending bids, with the bid levels rising as the bidders repeatedly countering their rivals' bids, let bidders see how highly their rivals value each license and which packages they seek. As closing approaches, each bidder knows whether will likely put together its preferred package, and roughly how much it will cost. With all licenses open for bidding simultaneously, a bidder has flexibility to seek whatever license package it wants, and to switch to a back-up if its first-choice package becomes too expensive.

As well as aiding license packaging, the ascending auction allows bidders to respond to each others' bids, diminishing the winner's curse. Seeing the level of the others' bids reduced their fear of the winner's curse and pushed up their bids.

The success of the spectrum auctions justified the choice of auction form. With the tradable pollution licenses, by contrast, the market-design issue was not fully faced. The government put in place an auction for the allowances that was flawed. The flaw is interesting, for it shows the importance of apparently innocuous features of the rules of the market game.[21] The issue illustrates the chess-like reasoning that markets of all kinds often induce in their participants, and the need for market rules to anticipate the participants' decision-making.

The EPA implemented a double auction: that is, both potential buyers submit bids and potential sellers submit price offers. Bids and offers are sealed. Prices are set as follows. The EPA arrays the bids from highest to lowest, and the offers from lowest to highest. It then matches the highest bidder with the lowest offerer, the second-highest bidder with the second-lowest offerer, and so on, until the last buyer-seller pair for whom bid exceeds offer is reached. The prices paid are equal to the buyers' bids, so each transaction occurs at a different price. The firm bidding the highest pays the price it bid to the seller offering the lowest price; the second-highest bidder pays its bid to the second-lowest offerer, and so on. This pricing rule might perhaps look reasonable at first glance. But it induces perverse incentives. By lowering its offer a seller gets to be matched with a higher bidder and so increases the price it receives. Sellers therefore do best by offering low prices. Buyers, paying their own bids, do best by bidding low, just above the (low)

[21] Cason and Plott (1996) pointed out this flaw in the EPA auction.

level they foresee for the sellers' offers. The sellers and the buyers quickly understand this logic, and all offers and bids are low.

The EPA's auction design gets things the wrong way around: a seller does better by offering a lower price. Fortunately, the poor design of the auction turned out to have no ill effects. Bottom-up market creation compensated for the flaws in the top-down market design. The emissions-allowances program was rescued by the emergence of a private market alongside the EPA auction. (In fact the EPA envisaged its auction as a way of jump-starting the private market, and in this it succeeded.) Intermediaries took on the role of market makers, buying and selling allowances on behalf of clients and sometimes speculating on their own account. Although sellers may be deterred by the prospect of low prices from offering their allowances in the EPA auction, they have the alternative of the private market. The private market handles most of the transactions.

The secondary market in emissions allowances is easy to operate. One allowance is identical to another: it is simply the right to emit one ton of sulfur dioxide in a year. Because of the simplicity of what is being traded, it was not difficult to create a smoothly operating secondary market in emissions allowances. For this reason, in the case of emissions allowances, getting the market design wrong turned out to be inconsequential.

With pollution allowances, it was just a matter of leaving it to the market. With electricity, by contrast, the inadequate market design was not so easily rescued. Because demand is insensitive to price and the consequences of a supply shortfall are severe, a few producers are sometimes in the position, as we have seen, of being able to bid prices far above production costs. These high prices do not immediately call forth new sources of supply, since new generation facilities take years to come on line. Unlike the case of the pollution allowances, private-sector intermediaries cannot step in to correct the official market's failings by starting their own marketplaces, for all the power must travel though the grid. Because of electricity's particular properties, the market's performance is highly sensitive to its design.

In understanding the breakdown of the California electricity market, the blame need not be placed on the fact that the market designers were in the public sector. The private sector is equally prone to market-design mishaps. Trial and error is the usual way for most markets to develop: learning from errors is the chief way of correcting any

design flaws. Of the companies offering novel methods for online buying and selling that were floated in the late 1990s, for example, a few prospered but most perished. The internet-industry shakeout of 2000-2001 winnowed out the less promising online marketers. The difference between public-sector and private-sector market design is that the government's exercises can be on a very large scale and are carried out in the glare of news media, so when things go wrong we hear about it.[22]

(iii) Markets do not supersede regulation

Emissions allowances were introduced not to take the government out of pollution control, but to help it control pollution more efficiently. Emissions trading does not mean the market replaces the government; rather, the government is using the market to help it attain its policy goal. The government hands over to the market a part of its role: deciding how the emissions cutbacks are to be shared among the firms. But it retains its primary roles: assessing how much pollution in total is to be allowed, checking compliance, and fining any firms that break the rules.

The success of emissions trading does not mean, of course, that we can leave all pollution problems to the market. Even where markets work, as with the control of sulfur-dioxide pollution, the government must continue to take the lead, setting the overall ceiling on emissions and monitoring compliance. Further, command and control is still needed in some areas where markets are not workable. Acid rain is easier to address than some other forms of pollution. A market can be set up as readily as the sulfur-dioxide emissions market only if the total amount of pollution matters more than where it originates. For pollution that is strictly local, with a single firm damaging a specific region, there is no way of creating a market in emissions licenses, for there would be no one to trade them with; direct regulation is still required. Markets cannot be applied to every kind of pollution.

With spectrum auctions, similarly, a role for the government remains. It continues to coordinate the usage of the spectrum by defining the what purposes each wavelength band can be put to—broadcasting or various specific telecommunications applications. Some of this coordination role can in principle be passed on to the market: New Zealand

[22] For more on market design in general, see McMillan (2002).

is going the farthest in considering passing some of the spectrum management to the private sector. But the ultimate decision on how the publicly owned spectrum is to be used remains with the government: it still does the waveband equivalent of land-use zoning. There are externalities: users of adjacent wavebands might cause interference with each other. Reassigning spectrum as new technologies arise might require central coordination.

With fisheries, also, creating and enforcing workable property rights requires ongoing government action. Quotas do not eliminate the need for regulatory supervision. The regulator must decide what level of total catch is sustainable. It must devise rules on who initially receives the quotas; dividing up the rights to the catch is inevitably a source of contention among the fishers. Extensive government monitoring is needed to check that the catches do not exceed the quotas. This is intrusive and costly, for activities at sea are harder to monitor than most land-based activities. Official inspectors check catches upon landing, and there are stiff fines for exceeding quotas. Military aircraft to patrol the waters, checking for boats that should not be there. Property rights in ocean fishing come only if the government expends sizeable bureaucratic, investigative, and enforcement resources.

No system of monitoring, moreover, is infallible. New Zealand goes to greater lengths than most countries to prevent out-of-quota fishing. It insists on full documentation, with paperwork recording each step of the fishes' journey from point of landing to final consumption or export. Fishers may not sell fish to anyone other than a licensed fish receiver. Catch reports, licensed-fish-receiver receipts, cold-storage records, and export invoices are all collated and checked for discrepancies. Overfishing and misreporting are criminal offenses. Even so, the poaching persists. An estimated 450 tons of crayfish are sold on the black market each year.[23] This is one-seventh the size of the legal catch. Enforcing property rights in fish requires government action.

With the fisheries, as with the other public-sector applications, resorting to markets does not remove the need for government action.

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[23] On monitoring, see Batkin (1996) and Squires, Kirkley, and Tisdell (1995). The illicit-crayfish number is from *New Zealand Herald*, Feb. 17, 2000.

7. Conclusion

In picking winners, governments have a poor track record. Picking winners is exactly what the government is called upon to do when it makes allocation decisions such as which firm gets the right to use a publicly owned resource. A market-based allocation leaves the government to do what only it can do, while turning over to the market the job of picking winners. Competitive markets, if well designed, can reveal the information that is needed for allocating the resources.

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