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Five Principles for Spectrum Policy: A Primer for Policymakers

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Spectrum policy takes engineering and technical realities as inputs to a decision-making process that is driven by normative principles. While many competing principles have had their heyday, these five are enduring guides to making spectrum work in the public interest.

KEY TAKEAWAYS

- Spectrum's value comes from how people use it, so spectrum policy should maximize productivity rather than maximizing auction revenue or minimizing interference.
- Markets are the best way to drive spectrum to its most productive use, so spectrum policy should enable well-functioning markets for flexible licenses.
- There are important federal missions that require spectrum, but policymakers should account for its value in the appropriations process.
- Public and private research into new radio technologies is key to increasing the availability of spectrum through developments such as sharing systems and uses for higher frequencies.
- Unlicensed spectrum contributes to productivity when combined with proper technical rules and limited propagation, but calls for more unlicensed spectrum deserve close scrutiny.

OVERVIEW

Spectrum, the range of electromagnetic frequencies used by wireless devices, is a complex medium that requires highly technical engineering and design to be used effectively. The technical aspects of spectrum, however, are not synonymous with spectrum policy. Rather, spectrum policy takes engineering and technical capabilities as inputs to a decision-making process that is driven by a normative vision. While many competing principles have had their heyday throughout the history of spectrum policy, these five are enduring guides to making spectrum work in the public interest going forward.

1. THE GOAL OF SPECTRUM POLICY IS PRODUCTIVE USE

Spectrum policy must begin with a goal in mind. When presented with a spectrum policy issue, it can be easy to get lost in the details of technical disputes and forget what the ultimate objective the dispute resolution should achieve.

Simply put, the goal of spectrum policy is to maximize the productivity of spectrum. Productivity means that the use to which a radio frequency is put at a particular time and place creates more value for society than does the next best use. In other words, spectrum policy should aim to maximize the economic output spectrum enables.

Productivity must be judged in the long run. Alternative uses of spectrum vary widely and change frequently. Rather than micromanaging the "right" use of spectrum at a snapshot in time, maximizing productivity means setting the institutional framework that will tend toward more productive outcomes over time.

The goal of maximizing productivity may seem obvious, but it is notably different from other popular guides to spectrum policy.

First, maximizing productivity does not mean maximizing government revenue from the sale of spectrum licenses. Since 1994, spectrum auctions have generated immense sums of money for the federal treasury.[1] The need for revenue to fund other policy priorities makes these auctions popular, but it is important not to confuse the short-term benefit of cash in the federal treasury with the long-term benefits of a productive wireless economy. For example, even though spectrum auctioned for mobile wireless use has brought in billions of dollars, the value created by smartphones and other wireless devices is in the hundreds of billions of dollars every year.[2] This direct value to consumers—who use wireless services for everything from calling 911 to online gaming—is what productivity looks like. Furthermore, productive use does boost government revenue in the long run, since the income generated in and by this sector is subject to federal taxation. While lucrative auctions and productive use often go hand in hand, it is important not to confuse the two. A spectrum policy decision is not successful simply because it raises a lot of money, and it is not necessarily unsuccessful just because an auction fetches relatively little.

Second, maximizing productivity does not mean minimizing interference. Though interference between competing uses of the same or nearby frequencies is a reason spectrum policy is needed in the first place, that does not entail its minimization being the goal. To begin with, spectrum policy recognizes that not all interference is "harmful"; it's possible for a receiver to "hear" someone else's transmission but still be able to operate successfully. Moreover, spectrum

engineering always involves trade-offs, and it is often the case that being too averse to any risk of interference results in less successful communication than could occur if we accepted that it could occasionally result in some interference. Furthermore, interference depends on a variety of factors: Overpowered transmitters or poorly designed receivers could equally be at fault for harmful interference. Good spectrum policy, therefore, does not allow the presence of interference to be a trump card that blocks a potential allocation. While today's spectrum users are easier to see than potentially more productive new users, spectrum policy must look past short-term interests and instead define the rights and standards underneath which cooperative engineering and bargaining can reach productive outcomes in the long run.

The uses to which spectrum is put are the source of its value. Driving spectrum to the most productive uses should be the lodestar of spectrum policy.

2. WELL-FUNCTIONING MARKETS ARE THE BEST TOOL TO ACHIEVE SPECTRUM-ENABLED PRODUCTIVITY

Given the goal of maximizing productivity, the next question is how to achieve it. It is both impractical and unwise to micromanage every megahertz of spectrum. Policymakers are unable to determine what use is most productive at every time and place, and, even if they could, their determinations would rapidly become obsolete. Though such a "command-and-control" approach was tried for most of the 20th century, the shift toward market-based allocation began in 1994 and has proved successful.[3]

The market process allows economic actors to compete alternative plans for spectrum use against each other to reveal which plan is likely to be most productive compared with its next-best competitor. This information is automatically packaged in a market price that both signals which spectrum bands are most valuable and incentivizes spectrum users to make the most of the frequencies they are allowed to use. Someone who pays for a spectrum license better be able to generate more value than they paid for it, otherwise they'll lose money. Anticompetitive trade practices are possible in spectrum as much as in any other industry, but fair competition law applies to it as well; there is not cause for extra-stringent regulations on the spectrum market.

Although the move from command-and-control to market-based allocation of spectrum began with government auctions, it is important not to conflate spectrum *auctions* with spectrum *markets*. Spectrum auctions have been a great success for the United States, but the reason for their success is that these auctions get spectrum into the market, where incentives to use it productively take hold. The auction mechanism itself is not an indispensable ingredient.

Just as the government might auction a piece of land but then let the market run its course for future sales and leases of that land, spectrum markets can use auctions to get previously unallocated bands into the marketplace and then allow spectrum to change hands rapidly without a cumbersome administrative process. The continued development of this kind of thriving secondary market would be an important indicator of successful spectrum policy.

The nature of the rights available in markets is also important to the markets' function. In the past, spectrum licenses strictly limited the uses to which a particular band could be put. But if bands are legally restricted to specific uses, they cannot flow to more-productive uses without a change in the law. Therefore, "flexible-use" licenses, which allow any use that complies with

basic technical standards, are now the norm and should be expanded to bands where they do not yet exist.

3. GOVERNMENT SPECTRUM USE NEEDS INCENTIVES AND GUARDRAILS

From the earliest days of radiocommunication, the federal government and private companies have both used spectrum. Federal spectrum use, however, generally lacks the same incentives for efficient use that exist in commercial markets. When a private company wants spectrum, it has to pay for it, and the company can only stay profitable by buying just what it needs and using it efficiently. Since government agencies don't have the same profit motive, there is little incentive for them to shrink their spectrum footprint even if they could achieve their mission with more efficient use. This interplay has resulted in federal agencies controlling large swaths of spectrum the government does not account for but could be quite valuable to consumers and the overall economy.

Congress established the Spectrum Relocation Fund (SRF) to create better incentives for agencies to relinquish spectrum they don't need, but the SRF is limited in reimbursing the costs of equipment with "comparable capabilities" to their existing use. This requirement hinders an agency's ability to economize and modernize its spectrum use and instead entrenches older, lower-quality systems. A more holistic SRF that accounts for the costs of planning for reallocation and encourages efficient upgrades would provide an incentive for agencies to develop creative solutions that improve the overall productivity of spectrum while still achieving important federal missions.

Still, reimbursement alone will likely not be sufficient to overcome risk aversion and institutional inertia that has resulted in the inefficient status quo. There will likely remain a need for Congress to designate particular bands for reallocation in order to force the hand of complacent agencies. In the long run, however, a spectrum strategy that relies on Congressional action for each new reallocation is not sustainable. A system that generates the right incentives from within the executive branch itself is a preferrable solution.

This system should begin with agencies having an accurate inventory and valuation of their spectrum. When gaining new capacity, spectrum rights should be treated like anything else agencies buy; just as federal agencies buy everything from pencils to office buildings on the private market, they should have the approximate market price of their spectrum charged to their appropriation. In practice, federal spectrum could be held by the National Telecommunications and Information Administration (NTIA) and other agencies could lease the access they need.

While this system would result in higher budget requests from agencies, it would really only recognize the costs the current system does not account for. Political scrutiny as to whether an agency is using its spectrum efficiently is a good thing for enhancing its productivity. At the same time, Congress should recognize that providing adequate funding for critical government services that rely on spectrum is a productive use and provide the funding needed for those missions.

Government spectrum also needs cooperative management. While there is an established interagency process, led by NTIA, to resolve spectrum disputes within the federal government, this process has broken down on several occasions (most recently with the dustup between 5G deployment and radio altimeters).[4] Effective federal spectrum management must start from a

spirit of cooperation and adherence to the NTIA process while ensuring that the process is driven by timely and evidence-based engineering analysis.

This approach to federal spectrum will set the stage for more positive-sum spectrum management that preserves the integrity of federal missions while also not overprotecting government frequencies.

4. TECHNOLOGICAL ADVANCEMENTS SOLVE MANY POLICY STALEMATES

Much of today's spectrum policy is a reckoning with the reality that the most valuable spectrum has already been allocated, so it is not possible to add new uses easily without impacting existing ones. This sometimes results in protracted battles in which incumbents resist reallocations anywhere near their existing transmissions, while newcomers insist their access to a band is feasible and necessary.

While careful engineering can often reach a reasonable resolution of such conflicts as they arise, technological advancements can increase the available options to resolve these disputes, particularly by allowing different uses to share the same frequency band.

A sharing policy implemented through real-time frequency-management systems has already been implemented in some bands; however, while these regimes have their merits, the underlying technology has yet to reach its full potential.[5] Private and public research and development of sharing systems is well worth the investment and could enhance the overall capacity of radio frequencies to the benefit of all wireless applications and their users.

While the physics of electromagnetic radiation remains constant, clever engineering can "make more spectrum" by finding ways to use allocated bands more efficiently or even frequencies previously thought too high to be useful. Effective spectrum policy seeks to push the frontier of what is technically possible by enabling private experimentation and putting direct government investments in basic research.

5. UNLICENSED SPECTRUM IS PRODUCTIVE WHEN MANAGED CAREFULLY

Unlicensed spectrum bands are ranges of frequencies anyone can use without having to get a license from the Federal Communications Commission (FCC). The most prominent uses of unlicensed spectrum today are Wi-Fi and Bluetooth.

It is obviously attractive to not have to pay for radio frequencies, but there is a trade-off. Rather than having a legal right to protection from interference, unlicensed users must accept interference from other unlicensed devices. As a common-pool resource, unlicensed spectrum is vulnerable to a "tragedy of the commons" in which a commonly held resource is overused since no individual user has an incentive to conserve it.

While property rights (e.g., spectrum licenses) are the classic solution to this problem, a lack thereof does not make a tragedy of the commons a foregone conclusion.[6] For unlicensed spectrum, technical protocols and the physics of unlicensed bands can often substitute for the more property-like rights embodied in a license.[7]

For example, many unlicensed devices follow a "listen-before-talk" protocol in which they wait for an unused channel before sending their own transmission, which keeps different signals from

getting into a radio "shouting match." Frequencies allocated to unlicensed use usually propagate relatively short distances and do not easily penetrate walls, so multiple networks can operate nearby without picking up each other's signals. These characteristics of unlicensed bands have likely led to their productive use, especially for relatively short-range applications.

The success of existing unlicensed bands, however, does not mean more unlicensed spectrum is always beneficial. For instance, calls for more unlicensed spectrum based on "congestion" in existing bands do not justify more of the same.[8] Congestion is an example of the overuse described by the tragedy of the commons. It is, therefore, not a sign of productivity but a sign that the technical and regulatory limits have broken down and may become an insufficient substitute for property rights.

Each band allocated to unlicensed use comes at the expense of the productivity that could be gained from licensed use and, as in federal spectrum, there is no market price to indicate whether existing unlicensed uses are the most productive use of a given band. While it is beneficial to avoid transaction costs inherent to markets, losing the information the market process generates about the relative productivity of alternative uses is a significant cost. Balancing these costs and benefits is the central dilemma of unlicensed spectrum.

Unlicensed spectrum has a symbiotic relationship with wireline and licensed wireless connections, since a great deal of Internet traffic traverses a Wi-Fi connection to get to end users. Still, interference protection is a necessity for reliable, wide-area networks that are the backbone of many services consumers rely on. Moreover, recent allocations have resulted in immense new swaths of unlicensed spectrum.[9] In the near term, therefore, new unlicensed allocations should be the exception rather than the norm.

CONCLUSION

By internalizing these five principles, policymakers will be able to better envision the most beneficial end of a spectrum policy decision and choose the right means to get there. As wireless devices and applications become an ever-greater part of our national, economic, and personal priorities, it is essential that policymakers focus on long-run productivity and the institutions and incentives most likely to produce it.

About the Author

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ENDNOTES

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