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Greasing the Wheels of Federal Spectrum Deals

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Abstract

This paper reviews the numerous impediments to encouraging greater sharing or relinquishment of spectrum to commercial users. The paper offers five pragmatic policy proposals to make federal spectrum transactions easier, faster, and more attractive to agencies. First, nearly every proposal to promote more efficient federal spectrum use will work better if agencies have clear, technology-neutral rights to the spectrum they occupy. Second, federal agencies should track how commercially valuable their spectrum rights are by preparing regular balance sheets for their most commercially valuable spectrum rights. Third, the paper argues that agencies should be able to keep and spend most of the revenue from spectrum transactions. In this context, the numerous policies designed to prevent agency over-spending are actually hurting American consumers by impeding efficiency-enhancing spectrum transactions. Fourth, policymakers should task trusted intermediary institutions, such as federally funded research and development centers or contractors, to develop potentially mutually beneficial spectrum deals between federal agencies and the private sector. Finally, the paper argues that greater spectrum sharing would be feasible with more creative contingent contracts and supporting technology.

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"We must unlock the economic value and entrepreneurial potential of U.S. spectrum assets while ensuring that sufficient spectrum is available to support critical Government functions." -- President George W. Bush, June 30, 2003

"We must continue to make additional spectrum available as promptly as possible for the benefit of consumers and businesses. At the same time, we must ensure that Federal, State, local, tribal, and territorial governments are able to maintain mission critical capabilities that depend on spectrum today, as well as effectively and efficiently meet future requirements." --President Barack Obama, June 14, 2013

I. Introduction: The Challenge

Federal agencies have made significant efforts to relinquish commercially valuable spectrum, but pressure to do more is mounting with the growth in the value of spectrum for commercial uses. All sorts of challenges arise in promoting efforts to share and relinquish federally controlled spectrum, so it is not surprising that Republican and Democratic administrations face many of the same issues a decade apart.[1]

First, federal agencies have many legitimate and high-value uses for spectrum. Agencies rightfully argue that many benefits of government activity, such as those from a secure national defense, scientific advances, protected natural environments, and safe air traffic systems are difficult to quantify, much less monetize, but are nonetheless extraordinarily valuable to society. Thus, they would say, it is not obvious that putting their spectrum in commercial hands is moving it to a higher and better use.

In some cases, only mission experts with security clearances are in a position to assess alternatives to the current spectrum use in a given band. Further, agencies face conditions of rapidly changing technology and mission demands, creating a large option value to irreversibly clearing a band and relinquishing it to non-federal uses.

In many cases, multiple agencies with safety-of-life missions occupy a band, so any spectrum transacted to commercial users (including sales, leases, sharing, and barter arrangements) requires extensive technical and economic analysis, systems engineering, and a substantial bureaucratic process. Given the idiosyncratic nature of the missions, equipment, and uses involved, most transactions are unique and few economies of scale in doing them arise.

Another complication is that federal spectrum users do not own their spectrum, so they can't directly sell it even if they wanted to. And agencies are not compensated in a way that makes it worthwhile to study their options. While the Spectrum Relocation Fund (SRF) covers costs and a little more, it provides little net incentive.

[1] This paper draws in part on: Morris, Adele and Martin Cave. 2005. "Getting the Best Out of Public Sector Spectrum," September 8. 2005 TPRC, Research Conference of Communication, Information, and Internet Policy.

Given a history of disruptive ad hoc spectrum reallocations, some agencies may believe that they have "given at the office," and further reallocations from federal use are unfair when some commercial spectrum (say, broadcast television bands) are at least as inefficiently deployed as federal bands.

Moreover, even in the long run, special factors make some public sector spectrum demands highly inflexible:

- Physical laws determine certain frequencies that are vital to science, especially for passive bands used for radio-astronomy and remote sensing.
- International spectrum conventions and rules, such as those for air and marine communications, may reserve certain frequencies for specific uses.
- Certain frequencies may have special intelligence or security applications, for example for radar or satellite communications.
- Some frequencies are reserved for coordination with state and local first responders.

Critics might claim that oversight of federal agencies' spectrum use is lax, but given the extremely technical and often classified nature of agency systems, it is difficult to observe the genuine "needs" of the agencies. And "needs" is not really the right word when there are complicated tradeoffs across spectrum, other inputs, and mission performance. In any case, agencies have little incentive to cooperate with efforts to deprive them of resources. To make it even more difficult, the agency responsible for managing the federal spectrum inventory, the National Telecommunication and Information Administration (NTIA) at the Department of Commerce, is funded in significant part by charges to the agencies whose spectrum use they oversee. It is a challenge for any organization to balance serving clients and overseeing them at the same time.

Despite all these challenges, some federal-to-commercial spectrum transactions have succeeded, and potential remains to do more. Proposals for how achieve this potential abound.[2] This paper grapples with how to lower the costs of federal spectrum transactions. A lot can be done to make them faster, easier, and more satisfactory for agencies without blowing up the whole system. The recommendations here are more prosaic, perhaps, than dramatic revisions to the statutory authority of existing institutions, but probably more doable.

Experience suggests that making changes in the interest of the agencies is critical. As implied in the Presidential quotes above, NTIA and federal interagency teams have been working for over a decade on plans-to-make-plans-for-further-planning to implement "market-based economic mechanisms" and other incentives for spectrum management.[3] I participated in those

[2] A review of policy proposals appears in IDA Science & Technology Policy Institute, *A Review of Approaches to Sharing or Relinquishing Agency-Assigned Spectrum*, IDA Paper P-5102 (Jan. 2014), *available at* https://www.ida.org/upload/stpi/pdfs/p5102final.pdf.

[3] See for example, NTIA, 2008. *Spectrum Management for the 21st Century: Plan to Identify and Implement Incentives that*

processes in the mid-2000's when I was the Department of the Treasury's staff representative to the Federal Government Spectrum Task Force, and I know how difficult progress is.[4]

Even with strong White House leadership and Congressional pressure, changes that work against agency interests, such as imposing spectrum fees, are nearly impossible to implement. Energetic and spectrum-savvy political appointees come and go, so those in the bureaucracy that oppose change can usually wait out the initiative du jour. Moreover, it is hard to keep spectrum policy in the spotlight long enough to accomplish much. The administration is busy fighting wars, enforcing laws, managing wildfires, and accomplishing other critical missions that at any particular point in time are arguably far more important than promoting efficient spectrum management. This motivates my focus here on practical, actionable policies that agencies, at least at the higher levels of management, could accept or even embrace.

Section II argues that defining and devolving clear rights to agencies for the spectrum they occupy is an important enabling condition for successful reforms. Section III makes the case for keeping a transparent record of spectrum asset values -- a balance sheet of a sort. In Section IV, I argue that Congress and OMB should allow agencies to keep much of the revenue from their spectrum transactions. I explain why policies designed to prevent unauthorized federal spending are lowering net social benefits by impeding an improved allocation of resources. Section V recommends engaging trusted third parties to do the heavy analytical lifting in constructing promising spectrum transactions, and Section VI calls for creative thinking about the structure of such transactions and development of technology that supports those arrangements. Section VII concludes.

II. Clarify Agency Spectrum Rights

U.S. law divides authority over spectrum between the independent Federal Communications Commission (FCC) and the President, who delegates executive branch powers to NTIA. Agencies describe and defend their spectrum requests to NTIA, and NTIA gives them spectrum "assignments." NTIA maintains the inventory of federal spectrum resources, and agencies are expected to return any unused frequencies to NTIA for potential reassignment to other agencies.

An assignment includes parameters such as frequency, bandwidth, geographical location, power of transmission, and where relevant, the

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Promote More Efficient and Effective Use of the Radio Spectrum. (See Task II-C in Appendix 1) http://www.ntia.doc.gov/files/ntia/publications/incentives_plan.pdf. Also, NTIA, 2006. *Spectrum Management for the 21st Century: Plan to Implement Recommendations of the President's Spectrum Policy Initiative,* (See Project G), *http://www.ntia.doc.gov/files/ntia/publications/implementationplan2006.pdf And Spectrum Management for the 21st Century Report 1: Recommendations of the Federal Government Spectrum Task Force,* (see Recommendation 8 in Appendix B), 2004. *http://www.ntia.doc.gov/files/ntia/publications/spct_pol_part_1_rl.pdf*

[4] A Presidential Memorandum issued June 5, 2003, established this task force. http://www.ntia.doc.gov/files/ntia/publications/presmemoonspectrumpolicy.pdf

direction of propagation. In some cases, however, assignments detail the authorized equipment rather than the physical parameters of the allowable radio signals. That can tie agency spectrum rights to legacy systems and complicate shifts to new technologies, particularly if such a shift simply frees up spectrum for use by another agency.

I would argue that **nearly every proposal to promote more efficient federal spectrum use will work better if agencies have clear, technology-neutral rights to the spectrum they occupy**. That is because virtually any kind of spectrum contract or transaction is easier to construct if a clear exchange of rights is involved.[5]

Others demur. IDA (2014) concludes that the potential for spectrum property rights to "incentivize Federal agencies to improve spectrum efficiency and to share or relinquish excess spectrum is unclear." One concern about spectrum property rights appears in a report by President's Council of Advisors on Science and Technology (PCAST): "[S]pectrum should be managed not by fragmenting it into ever more finely divided exclusive frequency assignments, but by specifying large frequency bands that can accommodate a wide variety of compatible uses and new technologies that are more efficient with larger blocks of spectrum."[6]

To these concerns I would say that by themselves, spectrum rights probably won't do much to incentivize federal agencies to share or relinquish spectrum. Rather, having clear rights is a necessary condition for other incentives to work. **Agencies will "own" their spectrum choices more if they have property-like rights to their spectrum. Those rights should be articulated like the flexible use, technologically neutral, FCC licenses.** Only when agencies bear the costs and benefits of different options will they be invested in new management approaches. In addition, an agency may be more willing to consider giving up some of the rights in an assignment (such as certain geographic areas) if there is no question whether the agency can keep the remainder.

I say "property-like" rights because my recommendation centers on the articulation and broad control of the spectrum. This does not necessarily mean that agencies should be able to conduct any and all spectrum transactions without oversight or guidance and keep all the revenue and spend it however they want. That degree of true property rights is generally inconsistent with how the federal government works.

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[5] See: Matheson, R. and A. Morris, "The Technical Basis for Spectrum Rights: Policies to Enhance Market Efficiency," *Telecommunications Policy* 36 (2012), pp. 783-792. Working paper: http://www.brookings.edu/~/media/research/files/papers/2011/3/03%20spectrum%20rights%20matheson%20morris/0303_spectrum_rights_matheson_morris.pdf

[6] President's Council of Advisors on Science and Technology (PCAST). 2012. "*Report to the President: Realizing the Full Potential of Government-Held Spectrum to Spur Economic Growth*. Executive Office of the President (July). http://www.whitehouse.gov/sites/default/files/microsites/ostp/pcast_spectrum_report_final_july_20_2012.pdf

For example, one can imagine different criteria in different bands that spectrum transactions should meet, and undoubtedly some limits on the retention and use of spectrum revenues will apply. But like in any market, striking deals will be easier if buyers and sellers are clear about what goods are available.

III. Keep Spectrum Balance Sheets

Federal agencies should know the market value of their spectrum rights. Quantifying and monetizing federal spectrum assets, particularly by agency, is not straightforward, but it is worth the effort. It is far more likely that policy officials will under-manage an asset if they have no idea how much it is worth. The new rules from the Office of Management and Budget (OMB) around procuring spectrum-using equipment go part way to asking agencies to monetize the spectrum they use, but the guidance only applies to spectrum used by new systems and the analysis is not regularly updated.[7]

OMB should ask agencies to prepare regular spectrum balance sheets, particularly for their assignments in the most commercially valuable bands.[8] The balance sheets should be updated at least every few years as assignments and market conditions evolve.

Of course, spectrum is different than typical federal capital assets such as "land (including parklands), structures, equipment (including motor and aircraft fleets), and intellectual property (including software) which … have an estimated useful life of two years or more."[9] Nonetheless, spectrum is a durable asset, in some cases with profound market value, and it behooves the federal government to treat it as such. Preparing a balance sheet doesn't have to be as formal as ordinary federal accounting, but some kind of standardized asset calculation is warranted.

OMB and/or NTIA should develop guidelines for preparing these balance sheets to address certain analytical challenges. For example, government and non-government entities share large swaths of spectrum in some bands. Maritime communications and air traffic control communicate across the two sectors in the same bands. Federal electrical power systems interconnect with both domestic and international non-federal power systems, and Civil Air Patrol stations communicate with the military. In other cases, such as some satellite applications, both government and non-government users access the same bands, but it is not clear who "uses" how much. One approach would be for agencies to estimate of the share of available transmission capacity occupied by their emissions and apply that to the overall band asset value.

[7] OMB Circular No. A-11 (2014), Section 31.12. http://www.whitehouse.gov/sites/default/files/omb/assets/a11_current_year/s31.pdf.
[8] The "balance sheet" framing comes from a conversation with John Leibovitz.
[9] Capital Programming Guide v 3.0, Supplement to OMB Circular A–11: Planning, Budgeting, and Acquisition of Capital Assets. http://www.whitehouse.gov/sites/default/files/omb/assets/a11_current_year/capital_programming_guide.pdf

IV. Allow Agencies to Benefit from Spectrum Transactions

As IDA (2014) relates, a number of existing policies prevent federal agencies from retaining and spending revenues from spectrum transactions. The Governmental Accountability Office (GAO) explains that, as a general proposition, an agency may not augment its appropriations from outside sources without specific statutory authority.[10] The objective of this prohibition is to prevent a government agency from undercutting the Congressional power of the purse.

To be sure, in general, good governance requires careful spending oversight by OMB and Congress. In this case, however, **Congress should allow federal agencies to keep revenue from spectrum transactions for flexible use in authorized categories of spending.** Looser rules would make everyone better off, including American taxpayers. First, agencies highly value flexible pots of money, and the SRF in its current form is hardly motivating. Second, more flexible rules could prompt spectrum transactions that will create significant new consumer and producer surplus that will benefit the economy and American households. Third, to the extent that a greater supply of spectrum in commercial uses raises corporate income, American taxpayers will recapture some of those gains through the corporate income tax and personal income taxes on dividends and capital gains. Fourth, social benefits will likely accrue from the additional federal spending even if Congress hasn't specifically authorized every dollar. Given tight budgets these days, it is unlikely that federal agencies will squander their spectrum revenues.

One recent draft bill goes in the right direction, but not nearly far enough. The bipartisan bill, H.R. 3674, The Federal Spectrum Incentive Act of 2013, would give an agency one percent of the revenue generated by the auction of spectrum vacated by that agency. The money could be used by the agency to offset sequester budget cuts or for other federal efforts to relinquish spectrum. The broad parameters of the bill are promising, but agencies would need far more than one percent of the revenue to provide a meaningful incentive. Probably more like half the revenue would do it. In addition, the limits on what agencies could spend money on may be too restrictive. It may work better to identify broad categories of pre-authorized spending. **The Administration should work with Congress to find mutually agreeable terms, recognizing that scrupulous fiscal prudence is a false economy in this context.**

While some appropriators might blanch at the idea of pre-authorized spending, a few relevant precedents apply. One is "enhanced use leasing," as authorized for the Department of the Defense.[11] These laws allow authorized agencies to lease out underutilized real property and keep a share of the proceeds for purposes such as the "alteration, repair, improvement of property or facilities; construction or acquisition of new facilities; lease of facilities; or

[10] GAO (2006) Principles of Federal Appropriations Law, Third Edition, Volume II. http://www.gao.gov/special.pubs/d06382sp.pdf

[11] See *U.S. Code 10, Subtitle A, Part IV, Chapter 159, Section 2667*.

facilities operation support."[12] Similar provisions could apply to underutilized federal spectrum.

Another precedent appears in Forest Service law such as the Pueblo de San Ildefonso Claims Settlement Act of 2005.[13] This law allows "all monies received by the Secretary of Agriculture from the sale of National Forest System land as authorized by this Act…shall be deposited into the fund established in the Treasury of the United States pursuant to the Sisk Act and shall be available, without further appropriation, authorization, or administrative apportionment for the purchase of land by the Secretary of Agriculture for National Forest System purposes in the State of New Mexico, and for associated administrative costs." This means that when the Forest Service sells certain forest land, it can keep the money and spend it on other eligible land.

Of course, appropriators or OMB may simply cut the budget of agencies that have available spectrum revenues, but this would be a mistake. An agency may have little reason to lease out spectrum if it must give up a more certain revenue source (budget authority) in exchange with an uncertain revenue source (spectrum lease payments). If the White House and Congress are truly supportive of making more spectrum available to the private sector, then **OMB and appropriators should do what they can to preserve incentives for agencies, even if it means making unusual exceptions to budget policies**.

The net benefits to society of a significant spectrum trade are likely to far outweigh any possible efficiency losses from sub-optimal agency spending.

V. Engage Trusted Intermediaries

It is unreasonable to expect agencies, with existing staff, to develop mutually attractive spectrum deals with the private sector. It is a lot of work to analyze spectrum use and figure out ways to do things differently to free up the commercially valuable resources. Identifying profitable spectrum transactions is not the government's core competency, and managers have other mission priorities. Although a few agencies have a deep bench of radio engineers, those experts are busy perfecting warfighting systems. If agency engineers can design new systems to economize on spectrum use, their first goal would be to free up resources for redeployment to other internal needs. And to my knowledge, very few economists are currently involved in federal radio system analyses.

Fortunately, the federal government has ways to tap external experts. One is in the form of federally funded research and development centers, or FFRDCs, and the other is through private contractors. My proposal is to **empower trusted intermediaries to research and develop promising spectrum transactions between federal agencies and commercial users.** If the funding is available, agencies could welcome offloading the burden of this analysis to external experts.

[12] *U.S. Department of the Army guidance on enhanced use leasing* at http://eul.army.mil/aboutEUL.htm.
[13] Public Law 109-286, Sept. 27, 2006.

The intermediaries' work would specifically include examining alternatives to existing federal spectrum uses and identifying potential transactions with promising net benefits to both federal and commercial users. This would require expertise in engineering, cost analysis, commercial spectrum markets, and finance. The goal would be to identify and develop appropriate contract structures, lease terms, sharing parameters, and geographical boundaries. I am unaware of any existing FFRDC or private contractor that currently has all of these skill sets immediately ready to deploy, but several have the demonstrated capacity to gear up for the tasks I've described. A request for proposals would be necessary to identify the best intermediaries.

FFRDCs, as the name implies, are generally funded by the federal government, although some have subsidiaries that do commercial work. They perform all sorts of technical, economic, and security analyses and functions for federal agencies. Some have staff (with security clearances) already familiar with federal radio operations. These non-profit shops include RAND, MIt is Lincoln Laboratory, MITRE, and the Center for Naval Analysis. According to federal regulations, an "FFRDC meets some special long-term research or development need which cannot be met as effectively by existing in-house or contractor resources."[14]

The role I describe may be suitable for private contracting as well, and a number of firms have staff with security clearances and radio expertise. Private contractors may also have better access to experts with commercial spectrum market experience. FFRDCs have the advantage of broad existing sole-source relationships with federal agencies.[15] Using FFRDCs would not necessarily be less expensive than using a private contractor, but it could be easier and faster. On the other hand, FFRDCs usually have only one or two sponsoring agencies. That raises the question whether it would be difficult for any one particular existing FFRDC to work with a collection of agencies that share spectrum in a particular band. It may work better for NTIA to be the FFRDC sponsor.

Resolving the question of how the intermediation should be funded will take some thought. If agencies keep most of the revenue from their spectrum transactions, then they could finance further the development of further transactions themselves (if given the authority). A broadened SRF could also be a fit. Agencies may have more confidence in intermediaries that take only public funds, and it would avoid any appearance of a conflict of interest. But the current SRF authority would have to be revised to use funds to develop profitable transactions that do not specifically lead to spectrum "assigned by competitive bidding," such as barter arrangements.

[14] 48 CFR 35.017 - Federally Funded Research and Development Centers, http://www.law.cornell.edu/cfr/text/48/35.017

[15] A critique of these relationships appears in "Federally Funded Research and Development Centers: A Strategic Reassessment for Budget-Constrained Times'" by the Professional Services Council, June 5, 2010.

Another potential source of funding is the private sector. Industry stakeholders have the best information about their willingness to pay for new spectrum, and only they can estimate how they would value (or more accurately discount) non-exclusive or temporary arrangements. All else equal, it makes sense for the private sector entities that could benefit from these transactions to have some skin in the game. It would require a suitable funding vehicle, though.

One approach would allow industry consortia or foundations to supplement federal funds and/or work directly with the intermediaries. Federal regulations allow agencies to determine whether the FFRDCs they sponsor can accept work from other entities, including other federal agencies, and nonprofit or for-profit organizations.[16] If it makes sense in a particular band for only one firm to work out a deal with an intermediary, then it may be feasible to have firms bid for the right to enter into that negotiation.

Another way to put non-federal capital at risk is to allow the intermediary to benefit from a "share-in-savings contract" or other incentive arrangement. The Federal Acquisition Regulation states that "[i]ncentive contracts … are appropriate when a firm-fixed-price contract is not appropriate and the required supplies or services can be acquired at lower costs and, in certain instances, with improved delivery or technical performance, by relating the amount of profit or fee payable under the contract to the contractor's performance." The challenge would be to construct an incentive contract that rewards intermediaries for developing successful transactions and at the same time preserves agencies' confidence in them.[17] Certainly, if agencies control their spectrum, they must sign off on spectrum transactions. That means a well-designed incentive contract would give intermediaries extra compensation if they develop transactions that agencies approve.

At the very least, agencies or NTIA could issue requests for information to which firms could respond with suggestions and data pertinent to potential transactions. FFRDC restrictions allow industry stakeholders to provide sensitive or proprietary information without fear of improper use or disclosure. The Commerce Spectrum Management Advisory Committee (CSMAC) advises the NTIA on a broad range of spectrum policy issues and could be a conduit for suggestions from industry, but as an official federal advisory committee, any information it provides to the government would be public.

VI. Develop Creative Deals and Technology

As much as wireless firms value unencumbered spectrum rights, the potential supply of exclusive permanent nationwide rights from federal agencies is limited. This means it is time to **develop creative transactions that**

[16] 48 CFR 35.017-1 - Sponsoring agreements. http://www.law.cornell.edu/cfr/text/48/35.017-1

[17] Federal Acquisition Regulation, Subpart 16.4—Incentive Contracts https://acquisition.gov/far/current/html/Subpart%2016_4.html#wp1078212

accommodate some continued government use or control but make available resources that firms value. Leasing is a particularly promising arrangement. Like its commercial analog but perhaps to a greater degree, government agency demand for spectrum may contain a speculative component because of the large uncertainties around how spectrum management policies, mission requirements, budgets, and technologies will evolve. In particular, agencies may wish to hold spectrum now, in excess of their current needs, because they project that their needs will grow over time, or because an emergency could erupt. They may also fear that budget limitations or future rules may make it more difficult to obtain greater spectrum in the future. The demand for temporary access to spectrum is uncertain, but temporary access may be better than no access, so it seems worth the effort to see if leases can work.

One concern agencies may have with leasing is that leasees could install equipment dependent on the spectrum they lease and then lobby Congress to keep their spectrum when the time comes for the lease to expire. Federal users have little incentive to make spectrum available temporarily to users who would be difficult to displace later. One way around this would be to mandate frequency-flexible equipment or other ways to help prevent stranded capital. Another would be to make the lease long enough to allow the full depreciation of the equipment by the time the lease is up. Given the rapid decline in equipment live cycles this may be more feasible now than it would have been even a few years ago.

Another option would be to embed a lease-to-own provision in the lease that specifies the sale price and other terms should the leasee wish to acquire the spectrum at the end of the lease period. Agencies could thus be assured that if they must permanently relinquish the spectrum, they will be appropriately compensated.

Another approach could be to lease or sell spectrum under the proviso that agencies could access it in the event of a national emergency. This will require technical solutions to ensure that federal agencies can reliably override private sector uses, and it would need contract provisions that describe the contingencies under which agencies may recall their spectrum. Commercial users would bear the risks associated with unpredictable service degradation, but they would get access to the spectrum under normal operating conditions.

Geographic sharing is another promising approach. This seems to be working well in recent spectrum transactions, in which private sector operators promise to steer clear of certain military installations. New technologies that prevent emissions in unauthorized locations could make agencies more comfortable with relinquishing spectrum.

Other creative transactions would allow federal agencies to barter spectrum rights for other goods and services, in temporary arrangements (barter lease) and permanent reallocations. If agencies can trade spectrum for, say, wireless communications services or new equipment, both parties and the American economy could be better off.

Again, I acknowledge the multitude of budget and appropriations rules that make creative deals challenging, but the welfare gains from these unorthodox trades could be extraordinary. **Congress and the White House should allow some financial innovation in their efforts to promote technological innovation.** At the same time, **they should invest in developing technologies that support more creative spectrum transactions.**

VII. Conclusion

This paper reviews the numerous impediments to encouraging greater sharing or relinquishment of spectrum to commercial users. The paper offers five pragmatic policy proposals to make federal spectrum transactions easier, faster, and more attractive for agencies.

- First, nearly every proposal to promote more efficient federal spectrum use will work better if agencies have clear, technology-neutral rights to the spectrum they occupy.
- Second, federal agencies should track how commercially valuable their spectrum rights are by preparing regular spectrum balance sheets for their most commercially valuable spectrum rights.
- Third, the paper argues that agencies should be able to keep and spend most of the revenue from spectrum transactions. In this context, the numerous policies designed to prevent agency over-spending are actually hurting American consumers by impeding efficiency-enhancing spectrum transactions.
- Fourth, I argue that policymakers should task trusted intermediary institutions, such as FFRDCs and private contractors, to develop potentially mutually beneficial spectrum deals between federal agencies and the private sector.
- Finally, the paper argues that greater spectrum sharing would be feasible with more creative contingent contracts and supporting technology.