Dual-Track Auction for Market-Based Determination of Spectrum Clearing

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Executive Summary

Securing U.S. technological, economic, and military leadership depends on making available additional wireless spectrum. The proliferation of next-generation technologies such as Internet of Things and other connected devices has placed tremendous demand on our spectrum resources. More spectrum is needed for commercial users while not hindering essential services provided by government agency spectrum users. This presents novel challenges as the spectrum environment has become increasingly congested and constrained. A new approach to spectrum assignment and allocation appears to be necessary. Exclusive-use licensing may not always be practical or efficient for meeting long-term spectrum needs and supporting sustainable spectrum management policies. In particular, clearing spectrum for exclusive use can be costly, time-consuming, and highly disruptive to national security and public safety incumbents.

Frameworks that enable coexistence between commercial and government users are one way to meet these growing demands, as demonstrated by the success of the Citizens Broadband Radio Service ("CBRS") model. CBRS utilizes a licensing and access framework that encourages new entrants and stimulates innovation while delivering strong protection to incumbent federal systems. While exclusive use auctions often generate higher gross proceeds to the U.S. Treasury, considering only the auction revenue ignores the substantial costs of clearing the spectrum. Total *net* proceeds may well be higher in a shared-use model, even if auction revenue is lower. Shared spectrum models also enable a more rapid and cost-effective transition, because they do not require completely clearing incumbent users from the band before new users can deploy.

This paper presents a new framework for an objective, market-based approach for deciding on the appropriate type of use for spectrum bands. Specifically, this paper details how the *market* – *i.e.*, the auction participants who plan to utilize the spectrum – can determine whether new spectrum bands for commercial use should be made available through legacy exclusive-use licensing or through shared licensing. Under the "dual-track" auction proposed herein, spectrum auction participants would bid for exclusive-use licenses or shared licenses – structured as two auctions that can be either run separately or in parallel, with bidding rounds alternating between exclusive-license bids and shared-license bids. Both auctions would consider the cost to federal incumbents (i.e., the costs to clear and relocate federal users under an exclusive licensing framework or the costs of developing federal sharing technologies to enable coexistence between federal and non-federal users under a shared-licensing framework). These

costs would be reflected in the auctions' reserve prices. The auction with the higher *net* proceeds would prevail.

Ultimately, the dual-track auction design would maximize net auction proceeds for Treasury that could be used for other initiatives, while still covering all necessary federal costs to enable commercial use in a band. The United States' pioneering work in developing and implementing novel spectrum allocation models has enabled federal entities to rely on wireless systems to protect the national security and has supported commercial users as they develop wireless technologies that deliver important public benefits. The "dual-track" auction proposed herein is not only workable, but represents a superior market-determined approach that maximizes actual net revenues to the government, while advancing future spectrum auctions to meet the critical needs of commercial and government spectrum stakeholders.

Introduction

The novel approach to spectrum auctions proposed in this paper builds on decades of spectrum auction innovation. In the 1990s, Congress abandoned its command-and-control model of allocating spectrum in favor of a market-based approach. Congress temporarily authorized the Federal Communications Commission ("FCC") to hold a spectrum auction in 1994, and its success prompted Congress to make auctions mandatory in 1997.

Other countries followed the United States' approach, and market-based auctions quickly became the default model around the world. Since then, U.S. leadership in innovative market-based mechanisms for spectrum allocation has been recognized by the 2020 Nobel Prize in Economics, the 2018 Carty Award by the National Academy of Science, the bipartisan 2014 Golden Goose Award for "federally funded basic research [that] has led to innovations or inventions with significant impact on humanity or society," and the 2021 Paul A. Volcker Career Achievement Medal for "federal employees who have led significant and sustained achievements over 20 or more years of service in government."

Initially, auctions were viewed primarily as a market-based mechanism for allocating pre-determined blocks within a frequency band, with pre-determined characteristics, to the companies best positioned to use them. As spectrum became more scarce, however, the FCC started incorporating additional features that accounted for its limited availability and allowed some of the characteristics of the spectrum, and/or its total amount, to be determined within the auction. For example, in Auction 73 (2008), the FCC required C-block spectrum to include "open-access" obligations if its price surpassed a threshold reserve level. In Auction 1001 (2016), the "Incentive Auction," the FCC ran a "forward" auction among the bidders interested in purchasing spectrum and a "reverse" auction among TV broadcasters willing to relinquish spectrum holdings. The total amount of spectrum to be reallocated from TV broadcasting to new uses was determined by the market over multiple rounds. The amount of spectrum available for repurposing was reduced until the price buyers were willing to pay exceeded the price broadcasters required to relinquish their holdings.

The U.S. government has also adopted a more flexible definition of "available spectrum." While it was initially assumed buyers would obtain exclusive rights to the spectrum, over time, it became viewed as economically sensible to simultaneously reserve a portion of the spectrum for other critical governmental uses (e.g., military purposes) on an "as-needed" basis. Buyers continued to use and derive value from the spectrum, while U.S military and other federal users could avoid the significant costs and disruption that they would need to incur if they had to completely vacate the spectrum. The CBRS auction is a prominent example of successful sharing between federal and commercial users.

With almost no greenfield spectrum currently available, it becomes especially important to evaluate spectrum sharing frameworks and adopt flexible ways of deciding whether particular spectrum should be fully cleared for exclusive use or made available for shared use. Exclusive-licensing can be costly, time-intensive, and highly disruptive to national security and public safety incumbents, because of the clearing required from all or part of the band. Clearing costs include costs necessary for implementing the new facilities, including equipment, engineering, and frequency coordination. This can include, for example, the costs of building new radar systems (or alternative communications technologies), where the facilities constructed are comparable to the previous ones.

In this paper, I propose an approach to addressing this issue: a “dual-track” auction format. This is the next logical step in the evolution of market-based spectrum allocation mechanisms, combining several of the ideas above. This framework offers an objective and principled way of selecting between completely clearing a band and sharing. The “dual-track” auction would conduct both auctions and allow the market to decide whether exclusive or shared use would generate the better value (net of clearing costs). A framework that uses auctions to elicit and objectively compare the net values for fully cleared spectrum and shared spectrum harnesses the market mechanism to determine the optimal social outcome.

Why should the dual-track approach be seriously considered going forward? If the revenues associated with both exclusive and shared licensing were known in advance with a high degree of certainty, the FCC could pick the option that would generate the higher net surplus and conduct a standard auction for that option accordingly. But auction revenues are notoriously hard to predict. For example, in 2023, Bazelon et al.[2] analyzed the DoD’s estimate that the cost of fully clearing 3.1–3.45 GHz spectrum would equal at least $120 billion. Bazelon et al. determined it was not clear the auction revenue for the band would exceed the clearing costs. Even if the revenue did exceed the cost, it might do so by only a small amount. At the same time, making this spectrum available for sharing in a manner similar to CBRS is estimated to cost only $4.67 billion, while the revenue from auctioning off this spectrum is estimated by Bazelon et al. to be around $23.28 billion – generating almost $19 billion in net surplus. So it is very hard to know ex ante which of the two options would result in a better ex post outcome.

[2] Bazelon, Coleman, Paroma Sanyal, and Yong Paek (2023), “Principles of Spectrum Sharing: Understanding the Value of Shared Spectrum,” Report, The Brattle Group, Available at https://spectrumfuture.com/wp-content/uploads/2023/09/Principles-of-Spectrum-Sharing-Understanding-the-Value-of-Shared-Spectrum.pdf.

The "dual-track" auction is designed to address this issue by conducting two auctions in parallel (one for fully cleared spectrum and one for shared spectrum) and choosing the one that would generate the higher *net* surplus. This format would allow the market to decide whether full clearing or sharing should be chosen for the specific band at issue.

Below I describe the details of the framework in the context of the 3.1–3.45 GHz band.[3] For concreteness and ease of exposition, this paper assumes that the clearing costs are equal to $120 billion for fully cleared spectrum and $5 billion for CBRS-style sharing. This paper also assumes that each of the two "parallel" auctions uses the FCC's standard clock-auction format, although the concept can be combined with other auction formats as well. I describe the "dual-track" auction format in detail, followed by a discussion of its properties and other caveats. As I show, not only is this model viable with proper design and forethought, but it is also a prudent and sensible approach that should be considered seriously for all spectrum auctions under consideration.

Dual-Track Auction

1. For each of the two auctions, the FCC specifies the blocks being sold, the opening prices, and other details and constraints (bid increments, maximum allowed number of blocks a bidder can win in one geographical area, rules for updating eligibility from one round to the next, and so on). In a sense, the FCC can design each of the two auctions completely in isolation from the other one: Auction A is designed for the case of fully cleared spectrum, while Auction B is designed for the case of shared spectrum. Importantly, for each of the two auctions, the FCC also announces the corresponding reserve price. In accordance with current spectrum auction rules in the U.S., the reserve price is set at 110% of the estimated clearing cost.[4]

2. These clearing costs are estimated through a process coordinated among the federal agencies by the National Telecommunications and Information Administration ("NTIA").[5] At least six months prior to the auction, NTIA provides the FCC with an estimate of federal entities' relocation or clearing costs and the timelines for such relocation pursuant to the requirements

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[3] There are several ways in which the two auctions can in principle be combined. For example, the FCC can run one of the auctions to completion, and then run the other auction. Or it can run the two auctions completely in parallel from the start. The specific approach proposed in the following section combines the two auctions in a way that during the part of the process when both auctions are active, the tentative "net surpluses" in them are approximately equal.

[4] *See* 47 U.S.C. § 309(j)(16)(B); 47 CFR § 1.2104(c).

[5] *See* 47 U.S.C. § 923(g)(4).

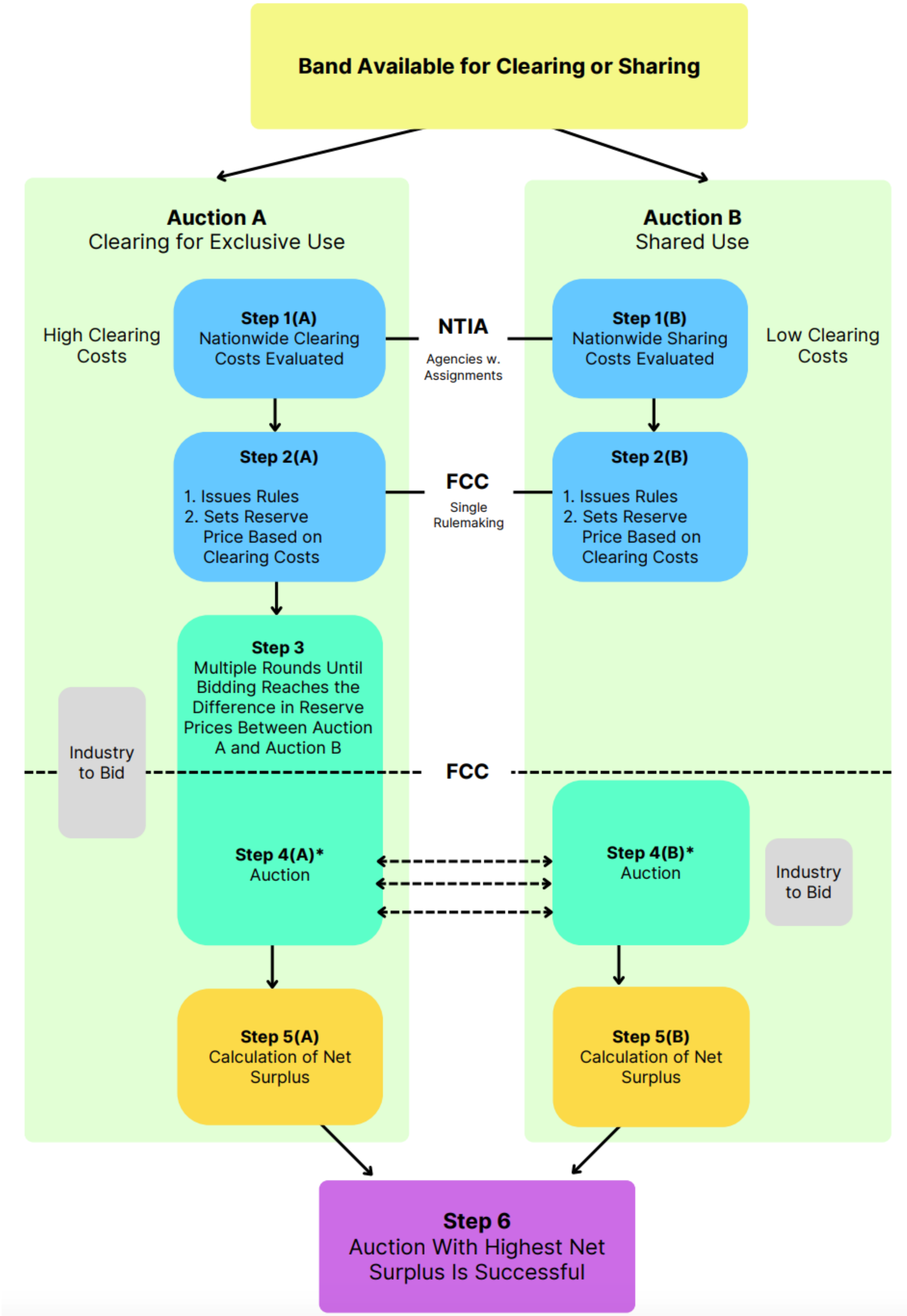
of the Commercial Spectrum Enhancement Act.[6] The federal relocation cost estimates include the costs of any modification or replacement of equipment, software, facilities, or compliance with regulations that are attributable to relocation or sharing; the costs of any engineering, software, and construction necessary to carry out the relocation or sharing activities of a Federal entity, and reasonable other costs incurred by the Federal entity related to relocation or sharing; the cost of research, engineering studies, and other expenses incurred in connection with calculating the estimated relocation or sharing costs, determining the technical or operational feasibility of relocation, and planning for or managing a relocation or sharing arrangement.[7] As mentioned above, for concreteness, I will assume that the clearing cost for Auction A is estimated to be $120 billion while the clearing cost for Auction B is estimated to be $5 billion.[8] The reserve prices are then set equal to $132B and $5.5B, respectively, and the auctions' "net surpluses" will subsequently be computed by subtracting these reserve prices from auction revenues.

3. Each potential bidder specifies which of the two auctions (or both) it is interested in, and what initial eligibility it wants to start with in each of the auctions[9]. A bidder's opening eligibility in Auction A can be different from its opening eligibility in Auction B. If the bidder is interested in both auctions (i.e., is potentially interested in acquiring spectrum both under exclusive and shared licensing), then the deposit it would wire to the FCC would be equal to the maximum of the two deposits it would have to wire for each of the two individual auctions. Requiring bidders to submit the maximum of the two deposits (instead of, e.g., their sum) reflects the fact that at most one of the two auctions will ultimately be successful, and so only one of the two deposits will ultimately be "binding". This requirement also makes it easier for smaller, potentially budget-constrained bidders to participate in both auctions simultaneously, instead of having to commit to one of them in advance.
    a. There is no need for the FCC to publicly disclose which of the auctions a particular bidder declared interest in. As it currently does, the FCC can disclose just the list of bidders who deposited *anything*, without providing any further details. Similarly, during the clock auction progress, there is no need to disclose the identities of the active

[6] *See id* § 923(g)(4)(A).
[7] *See id.* § 923(g)(3).
[8] These clearing cost figures are for illustration only and are based on estimates made by federal agencies. It may not always be the case that the full clearing costs for Auction A will be this high. For example, the estimated federal clearing costs for Auction 110 (3.45 GHz band) were $13.4 billion with an auction reserve price of $14.8 billion; this auction yielded $22.4 billion in net auction revenues.
[9] The common practice in FCC auctions is to require each bidder to submit a monetary deposit proportional to the maximum amount of spectrum that the bidder states to be potentially interested in acquiring ("initial eligibility").

bidders or any specific details about their behavior, beyond the aggregate variables like total demand for particular blocks and their clock price.

4. To begin the dual-track auction, the first round of Auction A is conducted. The round of Auction A is conducted first because initially, Auction A is "behind" Auction B - its "net surplus" (the difference between the revenue at clock prices and the reserve price) at opening prices is much lower (i.e., much more negative) than that of Auction B. Note that even if the revenue of Auction B is assumed to be zero (no interest from bidders in the opening round), Auction A would still be "behind."
5. Auction A continues on its own, with no rounds of Auction B being conducted, until eventually, one of two cases will happen:
    a. Case 1. The revenue in Auction A never reaches $126.5 billion, i.e., the clock auction ends with a revenue of less than $126.5B. In that case, the FCC announces that the spectrum will not be fully cleared, and simply conducts Auction B for CBRS-style shared spectrum. (Note that $126.5B here is the difference between the reserve prices of the two options, $132B - $5.5B. As long as the revenue in Auction A is under $126.5B, Option B is preferable even if the revenue in Auction B is literally zero.)
    b. Case 2. The revenue in Auction A reaches $126.5 billion. The rest of the auction description below considers this case - this initiates the "dual-track" element of the framework.
6. As soon as the clock revenue in Auction A exceeds $126.5 billion, Auction A is paused, and the first round of Auction B is conducted. Once that round is conducted, the FCC computes "net surplus" for each of the two auctions: the difference between that auction's clock revenue and its reserve price. Note that initially, both of these numbers can be negative.
7. From this point on, the FCC uses the following rule to determine which auction's round (Auction A's or Auction B's) should be conducted next: it should be the round for the auction that is currently "behind", i.e., whose net surplus is lower. (Note that this is the rule that has been implicitly used in the auction so far, and is why the auction opened with several rounds of Auction A). In the highly unlikely event that the two surpluses are exactly the same, the FCC can use a predetermined tie-breaking rule (for example, the auction that first reached this number is considered to be "ahead").
8. As long as there is excess demand in both Auction A and Auction B, both auctions continue, each time using the rule in point 6 to determine which of the two auctions has its round conducted next.


Band Available for Clearing or Sharing
Auction A
Clearing for Exclusive Use
Auction B
Shared Use
High Clearing Costs
Step 1(A)
Nationwide Clearing Costs Evaluated
NTIA
Agencies w. Assignments
Step 1(B)
Nationwide Sharing Costs Evaluated
Low Clearing Costs
Step 2(A)
1. Issues Rules
2. Sets Reserve Price Based on Clearing Costs
FCC
Single Rulemaking
Step 2(B)
1. Issues Rules
2. Sets Reserve Price Based on Clearing Costs
Step 3
Multiple Rounds Until Bidding Reaches the Difference in Reserve Prices Between Auction A and Auction B
Industry to Bid
FCC
Step 4(A)*
Auction
Step 4(B)*
Auction
Industry to Bid
Step 5(A)
Calculation of Net Surplus
Step 5(B)
Calculation of Net Surplus
Step 6
Auction With Highest Net Surplus Is Successful

9. Other than the timing of the rounds, each auction is conducted completely independently of one another. For example, a bidder cannot "transfer" bidding eligibility from Auction A to Auction B or vice versa at any point.
10. Eventually, one of the auctions will close - the demand in that auction will be less than or equal to the available supply of blocks.
    a. If at this point this "closed" auction is still behind the other, "open" auction (i.e., its net surplus is lower) *or* if the closed auction's net surplus is negative, it is declared to be unsuccessful. From this point on, the other, open auction is simply conducted on its own, and if its revenue eventually exceeds its reserve price (i.e., its net surplus is positive), the auction is successful and the FCC does full clearing or implements sharing in accordance with the rules of the second auction. If by contrast that auction's final revenue is also lower than its reserve price, the auction is also declared unsuccessful, and no clearing and spectrum allocation takes place.
    b. If instead the closed auction both has positive net surplus and is ahead of the still-open auction, then from this point on, the latter auction continues on its own, until it closes as well (i.e., until its demand is less than or equal to its supply). At that point, whichever of the two auctions has the higher net surplus is declared successful, and the clearing and allocation associated with this successful auction take place. The other auction is declared unsuccessful.[10]

Discussion

1. Choosing the clearing option with the higher net surplus in effect "lets the market speak," using the same underlying logic as the one that's been guiding spectrum allocation in the United States for the past three decades by allowing auction participants to determine the winning auction.

[10] Note that this framework determines whether an auction has exceeded the reserve price, and which of the two auctions has a higher net surplus, based on the final aggregate clock price (and not the additional revenue in the assignment phase) of each auction. This is consistent with current practice in the U.S. (E.g., Paragraph 122 of the FCC's Public Notice DA 21-655 (2021) on Auction 110 states, "As in prior Commission auctions, we will assess whether the reserve price is met— whether the auction will generate sufficient total cash proceeds—based on bids in the clock phase of the auction and not the assignment phase. Total cash proceeds from assignment phase payments are expected to be small relative to those from the clock phase and therefore less likely to contribute significantly to meeting the reserve price.") In principle, revenue from the assignment phase can also be incorporated into the framework to determine which (if any) of the two auctions is successful.

2. While not the only possible way to combine the two auctions, running them in parallel and keeping them “on par” in terms of net surplus during the competitive phase ensures that the two clearing options are treated symmetrically, with neither one having an ex ante advantage. By contrast, running one of the two auctions first and then running the other one second would skew the incentives in the second auction, because bidders under that option would know which aggregate number would “beat” the first option. So bidders who prefer the second option will try to ensure that the net surplus in that auction exceeds the “target,” while at the same time some other bidders who prefer the first option may try to “tank” the second auction to ensure that the target is not reached. The net effect of these behaviors is ambiguous, but it clearly does not put the two options on an equal footing.
3. Keeping the two auctions “isolated” (e.g., not allowing bidders to transfer bidding eligibility from one of them to the other) minimizes new opportunities for “gaming the auction.” It also gives the FCC flexibility in how each of the two auctions is designed (e.g., the round-to-round clock price increments can be different between the two auctions, the design and number of blocks can be different, and so on).
4. There is only a limited amount of distortion that a bidder can introduce if it strongly prefers one option over the other. Suppose Bidder D strongly prefers Auction A to Auction B. Then the way for the bidder to skew auction outcomes is to inflate its bids in Auction A and reduce them in Auction B. This behavior is unlikely to result in substantial economic distortion to the overall outcome, for several reasons. First, such behavior would be aligned with the true economic value, reflecting Bidder D’s underlying preferences for one option over the other. Second, inflating the bids in Auction A would go part of the way to “undoing” the common problem of “demand reduction” in multi-unit auctions,[11] bringing prices closer to the true underlying economic values. Third, as long as there is robust demand for spectrum from other bidders in Auction B, there is only a limited amount of impact that Bidder D can have on it by excessively shading its bids - and if there is *not* robust demand from other bidders in Auction B, *and* Bidder D strongly prefers option A to option B, then option A is likely the socially preferred one, and Bidder D’s so-called “distortion” points in the socially efficient direction reflecting marketplace demand. Of course, the same logic applies in the symmetric case when Bidder D instead strongly prefers Auction B to Auction A and tries to skew the outcome in that direction.

[11] Ausubel, Lawrence M., Peter Cramton, Marek Pycia, Marzena Rostek, and Marek Weretka (2014), “Demand Reduction and Inefficiency in Multi-Unit Auctions,” *Review of Economic Studies,* vol. 81(4), October 2014, pp. 1366–1400, Available at https://doi.org/10.1093/restud/rdu023

5. One type of gaming worth cautioning in this instance (more than in typical auctions) is a case of a bidder who wins some blocks, helping push the outcome toward a particular option, and then defaults on the payment for those blocks after the auction. Of course, this could occur even in a "regular," non-"dual track" auction. Such a case is highly undesirable, but the abandoned blocks can be re-auctioned, with some of the revenue recovered. In the "dual-track" auction, especially one with high clearing costs, such a default may lead to the wrong clearing option being selected - and then insufficient funds being raised to pay for it. A number of tools can be used to mitigate this risk. First, the punishment for such a default should be very severe, more so than in a typical auction. Second, at some points in the auction the bidders may be required to "re-up" their deposits to more closely reflect the current price of the package they are bidding on (as opposed to the cost of the deposits being based only on the opening prices). Note that these concerns do not "kick in" until the dual-track nature of the auction begins in earnest (i.e., Case 2 in point 3b in the description of the auction), so these modifications would not significantly complicate or slow down the auction.

Conclusion

This proposed "dual-track" auction format marks a logical next step in the evolution of market-based spectrum allocation mechanisms, at a time when novel solutions are needed given the absence of greenfield spectrum. This framework offers an objective and principled market-based approach to selecting between clearing a band for exclusive use and making it available for shared use by relying on an auction mechanism to determine which approach would generate a higher net surplus and the superior social outcome.