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ADDRESSING SPECTRUM HOLDOUTS WITH A TRANSACTION THRESHOLD: A THEORETICAL ANALYSIS

Abstract: When private parties attempt to accumulate spectrum via market transactions, they face the potential for strategic holdouts. Recently the Federal Communications Commission requested comment on a novel solution for the holdout problem: once market transactions have led to agreements with incumbents holding licenses for some large share of the required licenses (say, 80%) in the target band, the Commission would then require migration of the remaining licenses to new comparable spectrum, the costs of which are borne by the new broadband licensee. In this BULLETIN, we evaluate the suitability of such a proposal to address the holdout problem. In our model, a license aggregator seeks to obtain licenses secretly for a socially-valuable repurposing, but the probability the innovator's plan is revealed to incumbent licensees rises as more licenses are acquired, exacerbating the holdout problem. We then consider whether a transaction threshold may effectively address the holdout problem by permitting, probabilistically at least, a positive return to the innovator. We find that the Commission's proposed transaction threshold is supported by economic theory and thus would permit the socially-valuable repurposing of spectrum to occur.

I. Introduction

In repurposing spectrum to satisfy modern communications needs, the Federal Communications Commission ("FCC") faces two key challenges. First, the introduction of a new use to a spectrum band may result in interference problems, whether in-band or out-of-band.[1] Second, the spectrum most desired for new uses typically has incumbents operating within the band that must be accommodated. These are not new challenges. Historically, interference has been addressed using policies such as power limitations and guard bands. In some cases, the new use is simply deemed unsuited to the band, which is the problem presently faced by Ligado Networks.[2] Incumbents in a band have traditionally been compensated in some way, either with financial incentives, including reverse auctions, or else migrated (voluntarily or by mandate) to comparable spectrum at the expense of the new user or else funded from auction proceeds.

When private parties attempt to accumulate spectrum via market transactions, they face the potential for strategic holdouts. A holdout, recognizing the spectrum aggregator must accumulate multiple licenses with particular properties, demands a price for its property that is so high that blocks entirely a socially-valuable repurposing.[3] In real estate, the risk of the holdout leads aggregators to secretly acquire property, often using third-parties. These veiled transactions may be possible in the early stages of spectrum aggregation, but eventually the aggregation effort is revealed when government intervention may be required to modify licenses, address interference concerns, or accommodate incumbents. Consequently, by nature of the governmental approval itself, the problem of holdouts is especially problematic in spectrum markets.

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1 *See*, *e.g.*, T.R. Beard, G.S. Ford and M. Stern, *Skin in the Game: Interference, Sunk Investment, and the Repurposing of Radio Spectrum*, PHOENIX CENTER POLICY BULLETIN No. 40 (March 2017) (available at: http://phoenix-center.org/PolicyBulletin/PCPB40Final.pdf). For instance, terrestrial mobile broadband networks use relatively high-powered signals that may interfere with lower-powered transmissions such as those used by satellites.

2 D.A. Divis, *Ligado Fight Comes Down to Choice of Interference Standard*, INSIDE GNN (August 29, 2018) (available at: https://insidegnss.com/ligado-fight-comes-down-to-choice-of-interference-standard); C. Gibbs, *Ligado's Proposed IoT Network Could Cause "Significant Harmful Interference," Iridium Claims*, FIERCEWIRELESS (Aug 4, 2017) (available at: https://www.fiercewireless.com/wireless/ligado-s-proposed-iot-network-could-cause-significant-harmful-interference-iridium-claims); G.S. Ford, *Sometimes "No" is the Right Answer for Market Transactions*, FEDERALIST SOCIETY BLOG (July 17, 2018) (available at: https://fedsoc.org/commentary/blog-posts/sometimes-no-is-the-right-answer-for-market-transactions).

3 G.S. Ford and M. Stern, *Addressing Holdouts in the Repurposing of Spectrum for Broadband Services*, PHOENIX CENTER POLICY PERSPECTIVE NO. 18-10 (December 19, 2018) (available at: http://phoenix-center.org/perspectives/Perspective18-10Final.pdf); T.R. Beard and G.S. Ford, *Expediting Spectrum Repurposing Through Market Transactions*, PHOENIX CENTER POLICY PERSPECTIVE NO. 18-08 (October 12, 2018) (available at: http://phoenix-center.org/perspectives/Perspective18-08Final.pdf); G. Calabresi and A.D. Relamed, *Property Rules, Liability Rules, and Inalienability: One View of the Cathedral*, 85 HARVARD LAW REVIEW 1089-1128 (1972) (available at: https://tinyurl.com/yd4gnfh3); F. Menezes and R. Pitchford, *A Model of Seller Holdout*, 24 ECONOMIC THEORY 231-253 (2004); T. Miceli, THE ECONOMIC THEORY OF EMINENT DOMAIN: PRIVATE PROPERTY, PUBLIC USE (2011).

(Footnote Continued….)

For example, in an ongoing proceeding in which the Agency aims to repurpose a portion of a 5x5 MHz block from narrowband to broadband use in the 900 MHz band, the Commission has proposed a novel approach to address holdouts.[4] While the Commission's stated preference is to rely primarily on market transactions for license aggregation, the need for an innovator to acquire rights to all spectrum in the proposed broadband segment licensed to site-based incumbents with widely varied interests, and the revelation of the repurposing by nature of its own proceeding, the Commission is sensibly contemplating a backstop solution for the holdout problem. Specifically, once market transactions have led to agreements with incumbents holding licenses for some large share of the site-based channels (say, 80%) in the broadband segment, the Commission would then require migration of the remaining licenses to new spectrum, the costs of which are borne by the new broadband licensee.[5] While this protection against holdouts is incomplete, it could be that a "late" intervention may increase the likelihood of a socially-valuable repurposing.

In this BULLETIN, we evaluate the suitability of such a proposal to address the holdout problem. In our model, a license aggregator seeks to secretly obtain licenses for a socially-valuable repurposing, but the probability the innovator's plan is revealed to incumbent licensees rises as more licenses are acquired, exacerbating the holdout problem. We then consider whether a transaction threshold may effectively address the holdout problem by permitting, probabilistically at least, a positive return to the innovator. We find support for the Commission's proposed transaction threshold.

II. Background

As explained at some length in our earlier work, an entrepreneurial firm that wishes to create a new or highly-valuable service by aggregating together several separate spectrum licenses with disparate ownership faces a daunting challenge.[6] If a given set of such licenses must be brought under common control in order for the business to operate, then each owner of these separate assets will recognize that her cooperation is essential, and will seek to sell that cooperation for the greatest price obtainable. However, the entrepreneur has, by this point, sunk considerable investment in acquiring some of the other needed licenses. Yet, in any bargain between a "holdout" seller and the firm, the *gains* from an agreement will form the basis for transaction price. These gains emphatically do not reflect the costs sunk by the entrepreneur to bring events

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[4] *In the Matter of Review of the Commission's Rules Governing the 896-901/935-940 MHz Band,* FCC 19-18, NOTICE OF PROPOSED RULEMAKING, __ FCC Rcd. __ (rel. March 14, 2019) (hereinafter "*900 MHz NPRM*").

[5] *Id.* at ¶ 38.

[6] G.S. Ford and M. Stern, *Addressing Holdouts in the Repurposing of Spectrum for Broadband Services*, *supra* n. 3; T.R. Beard and G.S. Ford, *Expediting Spectrum Repurposing Through Market Transactions*, *supra* n. 3.

(Footnote Continued….)

to this pass. Anticipating this, many socially-valuable projects may be eschewed entirely. Such holdout problems have long interested economists and regulators alike.[7]

Our purpose here is to extend, in a practical direction, our earlier work to more clearly highlight the importance of "where in the process" the holdout problem occurs. In particular, we want to examine the likely consequences of a property aggregation failure, due to a holdout, at different points in the process. There are several practical reasons for this. First, it is clear that there are better and worse times, from the acquiring firm's perspective, for the property aggregation process to fail. This depends, *inter alia,* on the extent to which project success will create social value, because it is (the appropriable component of) this value that informs the resolution of the disagreement between the firm and the holdout.

At the same time, though, a consideration of the potential timing of the holdout provides a useful way to think about a public policy rule which could, to some extent, mitigate the negative social consequences of holdouts. Further, as we will argue, such a rule can be crafted to simultaneously: (1) encourage socially-beneficial repurposing of property; (2) minimize the informational requirements faced by the regulator; and (3) minimize the risks to the incumbent rights holders and, in a legal sense, minimize the insult to property rights a relocation represents.

To accomplish these purposes as painlessly as possible, we introduce the following simplified model. The "innovator" is a firm with an idea: if it can successfully create a specified property portfolio, then it will realize a positive dividend. The various property the innovator will need consists of numerous "small" pieces, each owned by an incumbent who uses it to obtain a private value for itself. The innovator will sequentially seek to purchase these properties. We assume there are noise traders in such markets, so that an offer to a given incumbent does not lead the incumbent to conclude an attempted aggregation is underway.[8] However, each time the innovator goes to the market, she incurs a risk of "discovery," which we just take to mean she faces a holdout, which becomes common knowledge. At that point, the property is aggregated to greatest social use and the large dividend realized, but these gains must be shared amongst the innovator and all remaining incumbents. For simplicity, we assume the buyer and seller implement a Nash bargaining solution at this point. Despite the possibility that the innovator has incurred large costs, both in sunk initiation costs and in acquiring incumbent property, the relative bargaining positions of all the parties—the innovator and all the remaining incumbents—are identical. This weakness creates a substantial danger of losses to the innovator. In some cases,

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[7] *See supra* n. 3 and citations therein.

[8] Generally, noise traders make decisions regarding transactions without the support of professional advice or advanced fundamental analysis, trading instead on impulse and irrational exuberance, fear or greed, and overact to news (https://www.investopedia.com/terms/n/noisetrader.asp). *See*, *e.g*., F. Black, *Noise*, 41 JOURNAL OF FINANCE 529-543 (1986); A.S. Kyle, *Continuous Auctions and Insider Trading*, 53 ECONOMETRICA 1315-1336 (1985); A. Shleifer and L.H. Summers, *The Noise Trader Approach to Finance*, 4 JOURNAL OF ECONOMIC PERSPECTIVES 19-33 (1990).

these losses are so large that they will foreclose initiation of the project, even though it is socially beneficial.

What sorts of policies could mitigate this kind of market failure? If the aggregation is socially beneficial, and creates a significant premium, then why would the innovator not publicize the opportunity at time zero? We assume that the project is feasible if and only if the innovator makes a sunk investment up front. It may well be that the magnitude of this initial outlay, if it receives no consideration in the subsequent bargain, makes the initial announcement strategy unattractive. This is just the basic mechanism of the holdout. Under plausible conditions, the innovator will not be willing to undertake the project. Indeed, the innovator may well need to obtain all or virtually all of the property in order to realize a profit in the end. Thus, one regulatory innovation that can resolve this difficulty is to propose that, should the innovator obtain a critically-large percentage of the property, then she will be spared a holdout for the remaining transactions: remaining incumbents will be compelled to sell at prices that make them whole (that is, moved to new spectrum—perhaps at someone else's expense—that provides an equivalent flow of services).

In effect, this is one of the solutions to holdouts proposed by the Commission in its recently-issued *Notice of Proposed Rulemaking* to repurpose portions of the 900 MHz band for broadband use.[9] First, the Commission's *NPRM* requires the prospective broadband licensee to "reach an agreement to clear from the broadband segment, or demonstrate how it will protect, all covered incumbent licensees."[10] Covered incumbent licensees are defined as:

> Any entity that holds an existing site-based license in the 897.5-900.5/936.5-939.5 MHz band [broadband segment] that, pursuant to § 90.621 of this chapter, is required to be protected by the 900 MHz BB licensee's placement of a base station at any location within the county covered by the BB license.[11]

This scheme requires the aggregation of a large number of all of a particular sort of license from what is often a diverse set of incumbents, exacerbating the holdout problem. Second, while recognizing that the "Commission has addressed the holdout problem through mandatory relocation" in the past, the Agency proposes first to rely on "market-driven voluntary relocation" in the hopes that voluntary actions will "facilitate faster broadband deployment in the band," presumably due to a lessening of incumbent resistance.[12] Even so, the Commission recognizes that the holdout problem may impede market transactions and thus foreclose the valuable

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9 *900 MHz NPRM, supra* n. 4.

10 *Id.* at ¶ 29.

11 *Id.,* Proposed § 27.1503(d).

12 *Id.* at ¶ 38.

repurposing of the 900 MHz band. As such, the Commission proposes to combine market transactions with a backstop. Specifically, the Commission asks:

> Would requiring mandatory relocation as a component of this transition mechanism be an effective means of mitigating against holdouts, while also preserving the advantages of a purely voluntary and market-driven approach? For example, once the threshold for voluntary exchanges has been met by the prospective broadband licensee, the FCC could require mandatory relocation for the remaining incumbent(s) []. Such mandatory relocation might be applied to remaining incumbents without complex systems if, during the first year of negotiation, the prospective broadband licensee reaches agreement with or demonstrates protection to entities controlling 90% of the channels within the 900 MHz Broadband Service. The number could be reduced to 80% during a second year of voluntary negotiation.[13]

This approach to the holdout problem is somewhat novel. It gives preference to voluntary transactions in early stages, respecting the property rights of incumbents. Yet, it also attempts to address the holdout problem—a sort of market failure—with a mandatory-relocation backstop once voluntary activity reaches a sufficiently large success rate. What the Commission does not do, however, is offer an analysis that demonstrates such an approach is an effective safeguard against holdouts. To fill this gap, we turn now to a formal economic model of the proposal.

III. Economic Model of a Transaction Threshold

Suppose the innovator firm can aggregate N licenses of "identical" spectrum and create a product that is more valuable than the sum of the current uses of all the individual spectrum pieces. A shift from narrowband to broadband use would seem to qualify, as would the repurposing of underutilized spectrum. Assume for simplicity that each piece is valued V_0 at by its current owner. The innovator faces a fixed entry cost of F and has an aggregation value of V if it can acquire all N pieces. We will assume that $V > F + NV_0$ so that the project is viable and socially beneficial.

The informational environment is assumed to be initially asymmetric in that only the innovator firm(s) knows that it has an aggregation project that is worth V. Although one could model the evolution of beliefs among the incumbents as transactions proceed, our goal does not require any such complicated informational environment. Our purpose is to model the problem of the innovator, not the incumbents. Thus, for simplicity, assume that the current owners of the spectrum licenses initially believe that their piece of spectrum is only worth V_0 to the innovator firm (or anybody else). To rationalize this strong assumption, we imagine that the market is

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13 *Id*.

composed of numerous small "noise" traders, who trade for exogenous reasons, and whose trades do not cause any agents to adjust the assessments of property values.

The innovator firm will sequentially purchase pieces of spectrum at a price of V_0, attempting to keep its purposes secret, but we will assume that there is a probability, with each purchase, that their aggregation project and the value V will become known to the remaining owners. This disclosure is very unfavorable to the innovator: if this occurs, then we assume that the remaining owners will enter into a full-information Nash Bargain with the innovator firm, thereby claiming much of the project's value.

Let k denote the number spectrum pieces the innovator firm has successfully purchased at the price V_0. Similarly, let $n = N - k$ denote the number of spectrum pieces that still need to be acquired to complete the necessary aggregation. If the value V becomes known after the firm acquires k pieces of spectrum, then the Nash Bargain between the remaining $N - k$ owners and the innovator firm would solve the following maximization problem:

$$\max\left\{\left(V - \sum_{i=k+1}^{N} x_i\right)\prod_{i=k+1}^{N}(x_i - V_0)\right\}. \qquad (1)$$

There are n first-order necessary conditions for this optimization problem characterized as follows:

$$\left(V - \sum_{j=k+1}^{N} x_j\right) = (x_i - V_0)\text{, for } i = k+1,\ldots,N. \qquad (2)$$

Imposing symmetry so that $x_i = x$ for all i from $k + 1$ to N, we have:

$$V - nx = x - V_0\,. \qquad (3)$$

Hence, each of the remaining n owners would receive:

$$x = \frac{1}{n+1}(V + V_0)\,. \qquad (4)$$

This last expression contains the essence of the holdup issue. The gains to completing the project are largely expropriated by the remaining incumbent owners, and the magnitude of the sunk costs F incurred by the innovator do not affect their profits.

The total cost of the N units of spectrum, assuming full- information revelation occurs after k units are acquired at V_0, is given by:

$$\text{Cost}(k) = \frac{n}{n+1}(V + V_0) + kV_0\,. \tag{5}$$

The associated profit is, therefore:

$$\pi(k) = V - \frac{n}{n+1}(V + V_0) - kV_0 - F\,. \tag{6}$$

If there is ultimately no information revelation and the innovator firm acquires all pieces of spectrum at V_0, then the profit will clearly be positive as $\pi(N) = V - NV_0 - F > 0$. However, generally speaking, the profit levels for $k < N$ can be negative. Hence, whether the innovator undertakes the socially beneficial aggregation of the spectrum will depend on the expected profit of the innovator at the point of entry. A negative expectation would cause the innovator to forgo entry and thus the socially beneficial aggregation project would never take place. In other words, the problem is not that worthwhile projects underway are never completed: rather, worthwhile projects never get started.

The relevant question for the innovator is whether the project offers a positive expectation initially. This depends, *inter alia,* on the probabilities the project is unmasked before completion, and these will vary as the amount of property aggregated increases. To examine *ex ante* profitability, we need to specify the probabilities at each stage of spectrum acquisition that the private value V of the innovator firm becomes known. Let p_k denote this probability at step k. Generally, we would expect p_k to be rising with k as more time passes and more spectrum is acquired. Thus, we may assume:

$$0 \le p_0 \le p_1 \le \cdots \le p_{N-1} \le p_N = 1\,. \tag{7}$$

Note that we set p_N equal to one for pure notational convenience since it does not matter whether there is information revelation after all N pieces have already been acquired. The expected profit of the innovator at the point of entry will be:

$$E = p_0\pi(0) + p_1(1-p_0)\pi(1) + p_2(1-p_0)(1-p_1)\pi(2) + \cdots + p_N\prod_{i=0}^{N-1}(1-p_i)\pi(N) \tag{8}$$

This expected value can certainly be negative due to the inherent hold-up problem and thus socially beneficial entry and aggregation will not occur.

The nature of the problem does suggest one potential means for ameliorating the holdup inefficiency. The regulator can ameliorate holdups by instituting a rule requiring that, after the innovator firm has acquired a sufficient fraction of the spectrum, the regulator will mandate that the remaining pieces be sold to the innovator for replacement value (V_0). If we denote this sufficient level in our model as $\bar{k}$, then we would have:

$$\pi(\bar{k}) = \pi(\bar{k}+1) = \cdots = \pi(N) > 0 \,. \tag{9}$$

The effect of such a rule is to eliminate the risks of a holdup at a late stage in the aggregation process. It is precisely at such times that revelation of the project is presumably most likely. By reducing those specific risks, it is probable that socially desirable aggregation will be economic.

Such a policy also has several practical advantages. It cannot be used by firms to acquire others' property unless and until they have made a sufficiently-large commitment, which greatly reduces the potential for strategic misuse. Additionally, the informational requirements for the regulator appear realistic, the main difficulty being some arguments over the incumbent valuations V_0. Finally, a policy of this sort goes some distance in protecting the property rights of the original holders. No mandatory transfers of property are allowed until the innovator has undergone a robust and successful private effort to acquire the rights through negotiation.

Clearly there will always exist a $\bar{k}$ sufficiently low such that E can be made positive and socially beneficial entry will thus occur. As long as the probabilities of information revelation are relatively low early on, the $\bar{k}$ sufficient to generate a positive expectation (and thus socially beneficial entry) could be set relatively high, such as 80%.

IV. Numerical Example

Whether or not a transactions threshold, as proposed by the Commission in its *900 MHz NPRM*, is effective or required depends on a number of factors. Different sellers may value their licenses differently, and markets may be heterogenous in their value. There is no uniform threshold suitable to all situations, either across or within a specific band. In this section, we offer a simple simulation of the theoretical model for illustration purposes, not to determine some sort of "optimal" threshold.

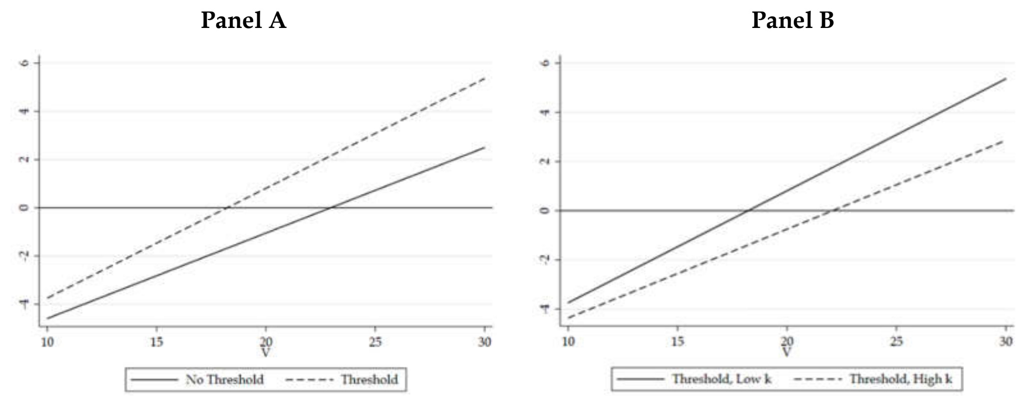
To begin, assume that the value to the innovator of a successful repurposing is $V = 21$. The value of each of ten licenses that must be aggregated by the innovator is $V_0 = 1$. The innovator incurs fixed cost $F = 2$, so the innovator's net value of the aggregation is 9 units [= 21 – 10 – 2], assuming all licenses were obtained at V_0, which assumes that the incumbent license holders are ignorant of the repurposing and sell the license for 1.0 unit. There is, however, a probability that the incumbents are aware of the innovator's plan. We assume that the probability of revelation is low for the first five transactions (0.10) but rises by 0.05 for the sixth transaction and an additional 0.5 for each transaction thereafter. These values reflect the probability of having to engage in a full-information Nash Bargain with license holders—the source of the holdout problem. These assumptions and calibrations are consistent with our previous theoretical discussion.

An innovator's value is realized only if all ten licenses are acquired. Falling short of the acquiring all the licenses has no positive payoff to the innovator. In this scenario, absent a transaction threshold, the innovator sees about a 19% probability of success of acquiring all ten of the necessary licenses. For the first transaction, the Nash Bargain renders a cost to the innovator of 20 = [(10/11)(21 + 1) + 0] and a profit of -1 once accounting for fixed cost which are ignored by the seller (by Eqs. 5 and 6). If the first seller is fully aware of the innovator's plan, then the first licensee is the holdout that blocks the repurposing. The probability of a Nash Bargain at this stage is assumed to be only 0.10, so the expected profit at the first stage is -0.10. At each stage, these expected losses accumulate as a result of the potential Nash Bargain based on the innovator's payoff, until the final stage when, if successful, the innovator receives its payoff of 9 units. For the repurposing to occur, the final payoff must exceed the expected losses along the way.

In this illustrative example, assessing the expected payoff from accumulating the ten licenses, the innovator foresees a cumulative expected payoff of -0.69. The probability of holdouts forecloses the repurposing. Now, say the regulator sets a transaction threshold of 80%, meaning once the eighth license is obtained, the remaining license holders will be forced to relocate to another band and the innovator receives its reward. The expected payoff comes earlier, reducing the accumulation of losses at later stages. With an 80% threshold, the expected payoff of initiating the repurposing is now 1.26. In this scenario, the threshold works as intended—the innovator pursues the socially-valuable repurposing.

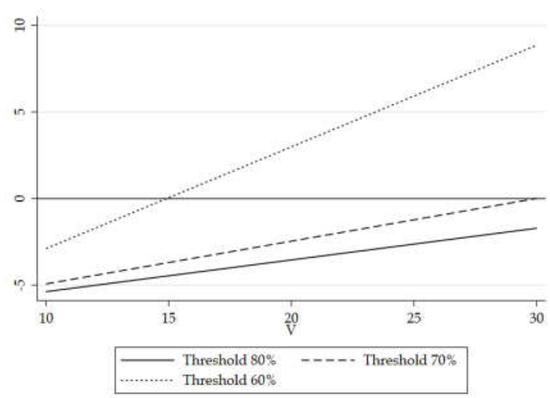
In order to see the comparative statics of the model, we turn to some figures. In Panel A of Figure 1, we use the same inputs as outlined above but permit V to vary between 10 and 30. As shown in the figure, the innovator's payoff is always larger under a threshold rule, though not always large enough to make the repurposing worth undertaking. That is, when V is small, it may be that the project is not worth undertaking with or without a rule. It is always true, however, that the threshold rule makes a valuable transaction more likely.

Figure 1. Expected Payoffs to the Innovator



In Panel B of Figure 1, we again allow V to vary but increase the probability the incumbent licensees are aware of the innovator's plan. We increase p_k by 0.15 for each k above the fifth license (versus 0.05 in the benchmark case). Both lines in Panel B are the expected payoffs to the innovator under a threshold rule. With the higher probabilities p_k, expected profits shift downward and to the right. As p_k increases, it becomes more difficult, under any scenario, for the innovator to succeed in its repurposing effort. If the probabilities are high, therefore, a lower threshold may be required to limit holdouts from impeding a repurposing. In this example, a threshold of 70% at the higher value of p_k provides similar outcomes to those illustrated in Panel A.

Figure 2. Alternative Thresholds



In Figure 2, we assume a more extreme case where a regulatory proceeding reveals the plans of the innovator after it has acquired five licenses, so that the probability the incumbent licensee is aware of the repurposing in very high (p_k = 80% for the sixth through tenth license). We do not assume all parties are fully aware of the aggregation or its value due to the presence of "noise" traders. In this scenario, neither a threshold rule of 70% nor 80% are sufficient to secure the repurposing. The threshold must fall to 60% for the innovator to proceed. In the *900 MHz NPRM*, the Commission inquired about the reasonableness of a 90% threshold for the first year (90%) and an (80%) threshold for the second, but now that the repurposing cat is out of the bag, a lower threshold may be required.

V. Conclusion

At the request of private entities, an ongoing proceeding at the FCC seeks to repurpose portions of a 5x5 block of prime 900 MHz spectrum from narrowband to broadband uses. Most incumbents in the band view this repurposing as favorable.[14] Thus far, pieces of the band have been aggregated using market transactions, and the Commission hopes that additional deals for the voluntary relocation of incumbents will free up the required amount of spectrum. All the elements of a holdout scenario in this band are, however, present. Thinking outside the box, the Commission has proposed to rely on market transactions to the greatest extent possible but proposes a backstop to address holdouts. Specifically, once market activity secures some share of the required licenses, say 80%, then the remaining incumbents will be relocated to comparable spectrum, at no cost to themselves, that offers an equivalent level of service. Such relocation has precedent, including the relocation of incumbents in the 800 MHz band, which proceeded without incident.[15]

Will such a proposal guard against holdouts? In this BULLETIN, we offer a theoretical analysis of the proposal and show that, under some conditions, a transaction threshold does permit the socially-valuable repurposing of spectrum to occur, even though without the threshold the project would fail. The success of the transaction threshold depends on a number of factors and

[14] *See, e.g.*, Comments of Utilities Technology Council, WT-Docket No. 17-200 (available at: https://ecfsapi.fcc.gov/file/10604580916794/Comments%20of%20UTC%20(final).pdf); Comments of Southern California Edison, WT-Docket 17-200 (available at: https://ecfsapi.fcc.gov/file/10603183212010/SCE%20Comments%20(Final)%206-3%20(01320170xB3D1E).docx); Comments of Duke Energy, WT-Docket 17-200 (available at: https://ecfsapi.fcc.gov/file/106031913304973/Duke%20Energy%20900%20MHz%20NPRM%20Comments.pdf).

[15] *See, e.g., In the matter of Improving Public Safety Communications in the 800 MHz Band; Consolidating the 800 And 900 MHz Industrial/Land Transportation And Business Pool Channels; Amendment of Part 2 of the Commission's Rules to Allocate Spectrum Below 3 GHz For Mobile and Fixed Services to Support the Introduction of New Advanced Wireless Services, Including Third Generation Wireless Systems; Petition For Rulemaking of the Wireless Information Networks Forum Concerning the Unlicensed Personal Communications Service; Petition For Rulemaking of UT Starcom, Inc., Concerning the Unlicensed Personal Communications Service; Amendment of Section 2.106 of the Commission's Rules to Allocate Spectrum At 2 GHz For Use By the Mobile Satellite Service,* FCC 04-168, REPORT AND ORDER, FIFTH REPORT AND ORDER, FOURTH MEMORANDUM OPINION AND ORDER, AND ORDER, 19 FCC Rcd. 14969 (rel. August 6, 2004).

it is unlikely that any single threshold is ideal in all settings. Nonetheless, the Commission's proposal is supported by economic theory. With the innovative repurposing plan now exposed, it may be, however, that a lower threshold than those proposed (80% to 90%) may be required.

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