



Lecture I: Introduction

Sarah Oh Lam, J.D., Ph.D.

Senior Fellow, Technology Policy Institute, Washington, D.C.

Spectrum Economics and Market Tools



Syllabus

Schedule

Lecture	Topics	Assignments
1	Introduction to Spectrum Economics and Market Tools: Spectrum in the News; Nobel Prize Winners	
2	Spectrum Economics: History of Auctions; Valuation Methods and Factors	
3	Market Tools Part A: Reallocation Challenges and Secondary Markets	<i>Paper Due</i>
4	Market Tools Part B: Incentive Auctions and Other Tools	<i>Student Presentations (5 minutes each)</i>
5	New Developments: Satellite Constellations, Local Governance	<i>Student Presentations (5 minutes each)</i>
6	Conclusion	<i>Final Exam</i>

This course examines spectrum economics and market tools such as auctions, secondary markets, unlicensed bands, and experimental licenses. Course material will cover the foundations of spectrum valuation, allocation methods, and economic concepts. This undergraduate course should assist in improvement of your analytical skills, particularly with regards to current advances in wireless technology.

Syllabus

The course will address the following topics: licensed vs. unlicensed spectrum; auctions and government allocations; policy challenges; and other topics in spectrum economics. We will also discuss current events in spectrum policy.

The course is primarily a lecture course, with a student presentation component. Students will also give five-minute presentations on a current event related to radio spectrum economics. Presentations can extend upon any of the “Headlines” sections in the course syllabus, or other technology event in the readings. Detailed instructions on expectations for the student presentations will be provided in a separate handout. Students can sign-up first come, first serve for their preferred week, two students per week.

Students will also write a short research paper on one of the spectrum auctions listed in the handout. Papers should include an explanation of one of these auctions with U.S. data from the U.S. Federal Communications Commission. Detailed instructions on expectations for the paper will be provided.

Research Paper Assignment

Students will write a ten-page paper describing one U.S. spectrum auction since 1994. The paper should be based on information from news articles and the U.S. Federal Communications Commission website.

The objective of this assignment is to understand how the U.S. holds spectrum auctions. First, the FCC announces that an auction will take place. Second, a process is established to create rules for the auction. Third, the auction is conducted and bidders bid for the spectrum licenses. Last, the results are announced and bidders have buildout requirements.

Step 1. Students should select one auction from the auctions section of the FCC website. Each student should select a different auction and sign-up on the online schedule. Interesting papers will likely address new technologies such as “5G” or “television band” or “C-Band” or “satellite” band.

Step 2. In a few paragraphs, explain the frequency band that was selected for auction. List any technical constraints on the usage of the band and the terms of the license. Briefly describe features of the auction based on information posted to the FCC auction page.

Step 3. Include an Introduction, Background, Auction Rules, Auction Results, International Comparisons, Conclusion, and References sections. Provide background information on your particular spectrum auction, perhaps with news headlines on the importance of that auction to the economy. If you can find out how the auction impacts new innovation, that is a very important question, but may take time to research. Provide international comparisons if any other countries have conducted auctions on that same frequency band. Find appropriate economics and financial news sources and make sure to discuss with citations. Consider whether other countries have had difficulty in auctioning this band.

Student Presentation Instructions

Students will give five-minute presentations on a topic related to course material, cited in the readings or with instructor permission. Presentations can extend upon any of the “Headlines” sections in the syllabus, another event cited in the readings, or a current event. Students should sign-up first come, first serve, on an online schedule for their preferred week and should try to select different topics. Grades will be based on an average score of 1 (low) to 5 (high) for these criteria:

1. Powerpoint slides with the headline story, from WSJ, FT, etc.
2. Explanation of the headline story to the class
3. Background information on the spectrum news event
4. Background information on frequency band at issue
5. Current state of the situation since the headline

Students should style their presentations as an objective briefing to their classmates on a particular spectrum dispute or other international spectrum event. Students should aim for clarity, simplicity, but also depth of understanding

Lecture I: Introduction

Spectrum Economics and Market Tools

I. Introduction

1. Spectrum in the News

2. Nobel Prize Winners

II. Spectrum Economics

1. History of Auctions
2. Spectrum Valuation Methods
3. Spectrum Valuation Factors

III. Market Tools Part A

1. Reallocation Challenges
2. Secondary Markets

IV. Market Tools Part B

1. Incentive Auctions
2. Other Tools

V. New Developments

1. Satellite Constellations
2. Local Governance

VI. Conclusion

I.I Spectrum in the News

C-Band Auction (2021)



Figure I. Headline on C-Band Auction

Kif Leswing, “Companies Have Bid \$81 Billion for the Airwaves to Build 5G, and Winners Will Be Revealed Soon,” CNBC, Jan. 31, 2021, <https://www.cnbc.com/2021/01/31/5g-spectrum-auction-bids-total-80point9-billion-winners-revealed-soon.html>.

I.I Spectrum in the News

C-Band Auction (2021)

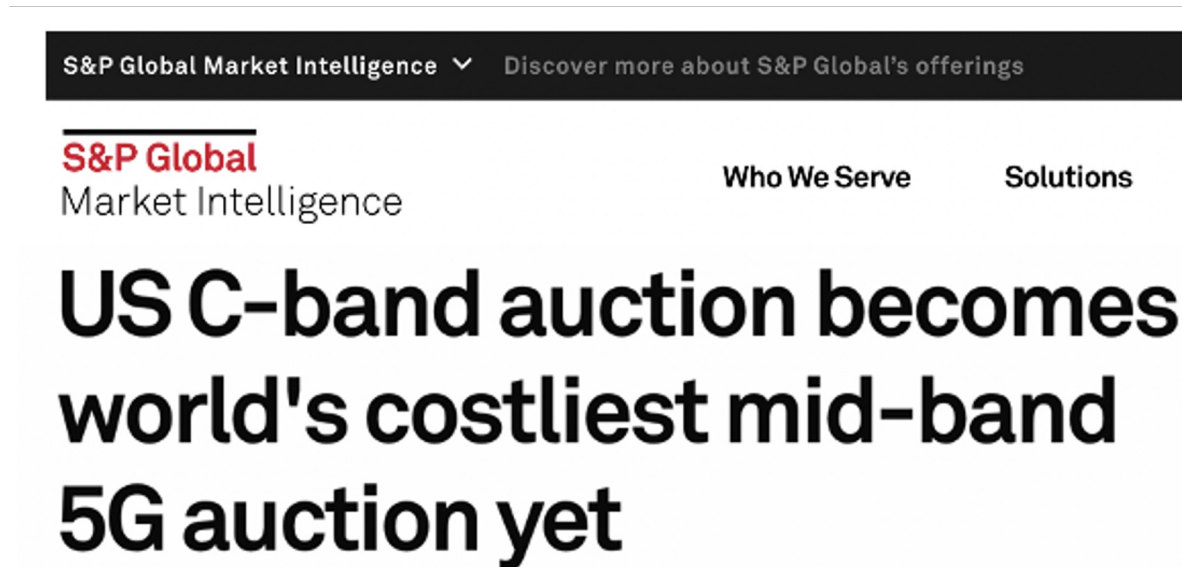


Figure 2. Headline on C-Band Auction

Julber Osio, "U.S. C-Band Auction Becomes World's Costliest Mid-Band 5G Auction Yet," S&P Global Market Intelligence, Apr. 22, 2021, <https://www.spglobal.com/marketintelligence/en/news-insights/research/us-c-band-auction-becomes-worlds-costliest-mid-band-5g-auction-yet>.

I.I Spectrum in the News

C-Band Auction (2021)

≡ FORTUNE

TECH · VERIZON

The 3 winners and many losers of the FCC's record-breaking 5G auction

BY AARON PRESSMAN

February 25, 2021 at 11:05 AM EST



Figure 3. Headline on C-Band Auction

Aaron Pressman, “The 3 Winners and Many Losers of the FCC’s Record-Breaking 5G Auction,” Fortune, Feb. 25, 2021, <https://fortune.com/2021/02/25/fcc-5g-auction-t-mobile-verizon-att/>.

I.I Spectrum in the News

C-Band Auction (2021)



Figure 4. Headline on Satellite Talks Prior to C-Band Auction
Caleb Henry, "Satellite C-Band Is Worth Billions, But How Many?" Space News, Sept. 16, 2019,
<https://spacenews.com/satellite-c-band-is-worth-billions-but-how-many/>.

I.I Spectrum in the News

C-Band Auction (2021)



Figure 5. Headline on Defense Department Review of the C-Band Valerie Insinna and Aaron Mehta, “The Military is Scrambling to Understand the Aviation Crash Risk from a New 5G Sale,” Defense News, Dec. 21, 2020, <https://www.defensenews.com/2020/12/21/the-military-is-scrambling-to-understand-the-aviation-crash-risk-from-a-new-5g-sale/>.

I.I Spectrum in the News

FAA and 5G Interference Dispute (2022)

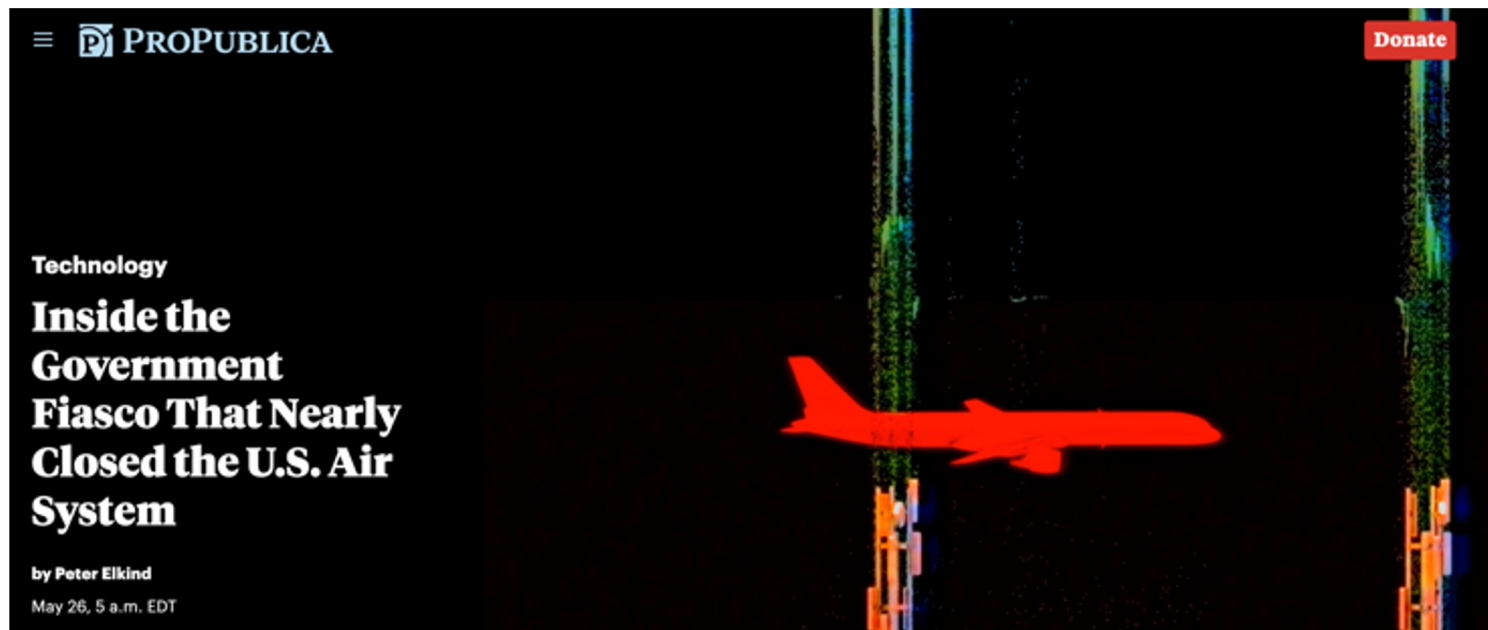


Figure 6. Headline on FAA and 5G Interference Dispute
Peter Elkind, “Inside the Government Fiasco that Nearly Closed the U.S. Air System,” ProPublica, May 25, 2022,
<https://www.propublica.org/article/fcc-faa-5g-planes-trump-biden>.

I.I Spectrum in the News

FAA and 5G Interference Dispute (2022)



Figure 7. Headline on Conflict between Federal Agencies in Washington D.C.
John Hendel, “How Washington Flew into a 5G Mess,” Politico, Jan. 19, 2022,
<https://www.politico.com/news/2022/01/19/5g-flights-spectrum-mess-washington-527425>.

I.I Spectrum in the News

FAA and 5G Interference Dispute (2022)



Figure 8. Headline on Replacement of Radar Altimeters

Peter Elkind, “Inside the Government Fiasco that Nearly Closed the U.S. Air System,” ProPublica, May 25, 2022, <https://www.propublica.org/article/fcc-faa-5g-planes-trump-biden>.

I.I Spectrum in the News

FAA and 5G Interference Dispute (2022)



Figure 9. Headline on FCC’s Receiver Standards Proceeding
Jon Brodtkin, “FCC Considers Crackdown on Bad Wireless Receivers After 5G/Altimeter Debacle,” Ars Technica, March 3, 2022, <https://arstechnica.com/tech-policy/2022/03/fcc-considers-crackdown-on-bad-wireless-receivers-after-5g-altimeter-debacle/>.

I.I Spectrum in the News

FAA and 5G Interference Dispute (2022)



Figure 10. Headline on the Need for Clarity on Interference Disputes

Gregory Polek, “Airlines Clamor for Clarity on Altimeter Upgrades for 5G,” AINOnline, Aug. 12, 2022,
<https://www.ainonline.com/aviation-news/air-transport/2022-08-12/airlines-clamor-clarity-altimeter-upgrades-5g>.

I.I Spectrum in the News

FAA and 5G Interference Dispute (2022)

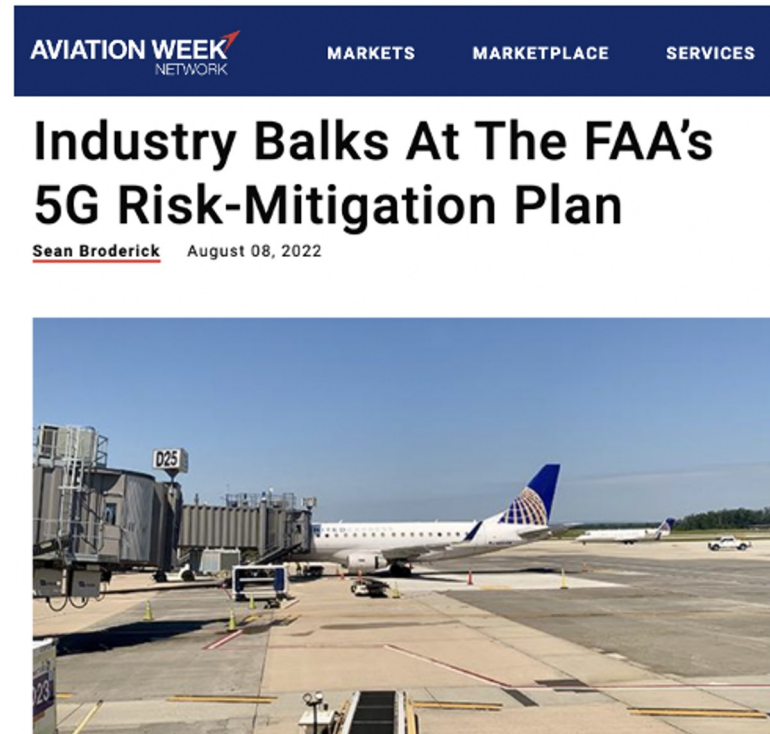


Figure I I. Headline on Ongoing Negotiations on 5G Risk Mitigation

Gregory Polek, "Airlines Clamor for Clarity on Altimeter Upgrades for 5G," AINOnline, Aug. 12, 2022,

<https://www.ainonline.com/aviation-news/air-transport/2022-08-12/airlines-clamor-clarity-altimeter-upgrades-5g>.

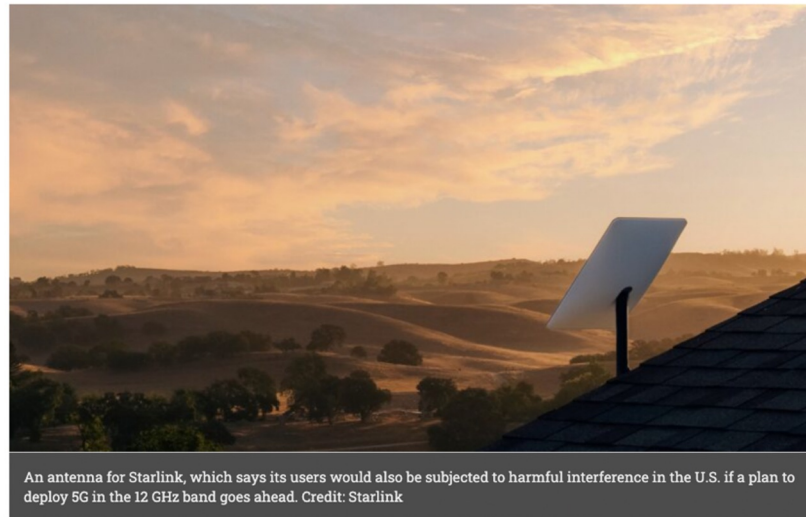
I.I Spectrum in the News

Starlink and 5G in the 12 GHz Band

SPACENEWS

SpaceX says 5G plan could disrupt Starlink more than previously thought

by Jason Rainbow — October 5, 2022



An antenna for Starlink, which says its users would also be subjected to harmful interference in the U.S. if a plan to deploy 5G in the 12 GHz band goes ahead. Credit: Starlink

Figure 12. Headline on Starlink and 5G in the 12 GHz Band

Jason Rainbow, “SpaceX Says 5G Plan Could Disrupt Starlink More Than Previously Thought,” Space News, Oct. 5, 2022, <https://spacenews.com/spacex-says-5g-plan-could-disrupt-starlink-more-than-previously-thought/>.

I.2 Nobel Prize Winners

Nobel Prizes in Economics Related to Spectrum Auctions

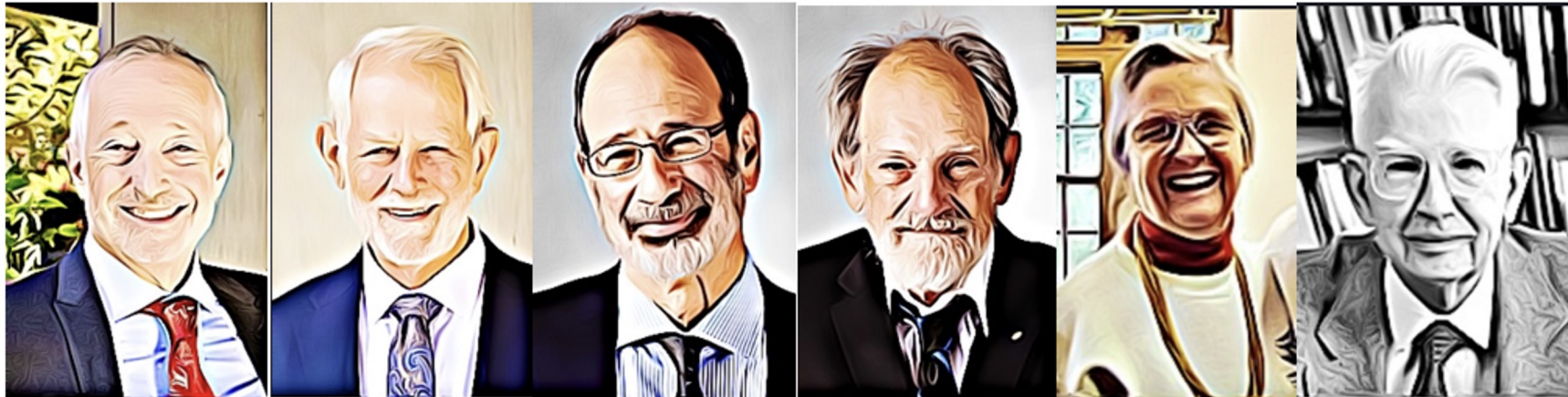


Figure 13. Nobel Prize Economists with Contributions to Spectrum Economics
Photo Credit: <https://www.nobelprize.org>, © The Nobel Foundation. Photo: U. Montan.

I.2 Nobel Prize Winners

Paul Milgrom and Robert B. Wilson (2020)



Figure 14. Paul Milgrom

Source: https://en.wikipedia.org/wiki/Paul_Milgrom

I.2 Nobel Prize Winners

Paul Milgrom and Robert B. Wilson (2020)



Figure 15. Robert Wilson
Robert B. Wilson, Photo Gallery, The Nobel Prize, <https://www.nobelprize.org/prizes/economic-sciences/2020/wilson/photo-gallery/>.

I.2 Nobel Prize Winners

Paul Milgrom and Robert B. Wilson (2020)



Figure I6. Paul Milgrom and Robert Wilson
Interview with Robert B. Wilson, February 2021, The Nobel Prize, <https://www.nobelprize.org/prizes/economic-sciences/2020/wilson/167537-robert-wilson-interview/>.

I.2 Nobel Prize Winners

Paul Milgrom and Robert B. Wilson (2020)



Figure 17. Paul Milgrom and Robert Wilson

Paul Hannon and David Harrison, Nobel Prize in Economic Sciences Is Awarded to U.S. Academics, Oct. 12, 2020, Wall St. J., <https://www.wsj.com/articles/nobel-prize-in-economic-sciences-is-awarded-to-u-s-academics-for-invention-of-new-auction-formats-11602496403>.

I.2 Nobel Prize Winners

Alvin Roth and Lloyd S. Shapley (2012)



Figure 18. Alvin Roth
Stanford Engineering, Engineering Alum Awarded 2012 Nobel Prize in Economics, October 19, 2012,
<https://engineering.stanford.edu/news/engineering-alum-awarded-2012-nobel-prize-economics>.

I.2 Nobel Prize Winners

Alvin Roth and Lloyd S. Shapley (2012)



Figure 19. Lloyd Shapley
RAND Corporation, RAND's Lloyd Shapley Wins Nobel Prize in Economics,
<https://www.rand.org/blog/2012/10/rands-lloyd-shapley-wins-nobel-prize-in-economics.html>.

I.2 Nobel Prize Winners

Elinor Ostrom (2009)



Figure 20. Elinor Ostrom

Kenneth J. Arrow, Robert O. Keohane, and Simon A. Levin, Elinor Ostrom: An Uncommon Woman for the Commons, PNAS, Vol. 109 No. 33,

<https://www.pnas.org/doi/10.1073/pnas.1210827109>

I.2 Nobel Prize Winners

Ronald Coase (1991)



Figure 21. Ronald Coase

Patrick J. Lyons, Ronald H. Coase, 'Accidental' Economist Who Won a Nobel Prize, Dies at 102, N.Y. Times, Sept. 3, 2013, <https://www.nytimes.com/2013/09/04/business/economy/ronald-h-coase-nobel-winning-economist-dies-at-102.html>.

Lecture I: Introduction

Spectrum Economics and Market Tools

I. Introduction

1. Spectrum in the News

2. Nobel Prize Winners

II. Spectrum Economics

1. History of Auctions
2. Spectrum Valuation Methods
3. Spectrum Valuation Factors

III. Market Tools Part A

1. Reallocation Challenges
2. Secondary Markets

IV. Market Tools Part B

1. Incentive Auctions
2. Other Tools

V. New Developments

1. Satellite Constellations
2. Local Governance

VI. Conclusion



www.nrao.edu
science.nrao.edu
public.nrao.edu

*The National Radio Astronomy Observatory is a facility of the National Science Foundation
operated under cooperative agreement by Associated Universities, Inc.*