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The Broadcasters' Transition Date Roulette: Strategic Aspects of the DTV Transition

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Abstract:

The analog to digital "DTV transition" completed in June 2009 was a technological event unprecedented in scale in the broadcast television industry. The final analog cutoff for TV stations culminated more than ten years of complex regulatory decisions. Facing concerns that costs and revenue could change dramatically, stations chose when to transition in response to both market and regulatory forces. The history of broadcasting reveals a continual interplay between consumer demand, technological change, and regulation. This article describes the various forces that influenced the DTV transition, and empirically examines the stations' decisions regarding when to switch. The economic and strategic aspects of the stations' business decisions are modeled with tools from decision theory and game theory that reveal the costs and benefits of switching to DTV. In the decision theoretic model we develop, a station's management considers only its own power costs and the effect of its own decision on its viewership when deciding to switch early. The game theoretic model incorporates strategic thinking, where a station manager considers the impact of other stations' decisions on its profit when making its choice. The stations' decisions are in line with the predictions of the models. The results indicate that station managers considered their cost savings and the potential to lose viewers, but also that they were thinking strategically when they made their transition decisions. The results thus provide insight into the stations' decision-making process, which can help market observers and regulators better understand the calculus of the industry.

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Strategic Aspects of the DTV Transition

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Furthermore, we expect that many stations will transition early and begin operating their final post-transition facilities in advance of the deadline and the onset of the winter months.[1]

I. Introduction

The analog to digital "DTV transition" recently completed in the U.S. was a technological event unprecedented in scale in the broadcast television industry, touching nearly every American household directly or indirectly. Consumers' demand for the new digital television (DTV) services, which have a sharper picture, smoother motion, better sound, and multiple sub-channels providing more viewing options, reflects the changing face of media delivery and consumption. On June 12, 2009, the last full-power television stations in the U.S. ceased over-the-air transmission of analog programming.[2] Today, all full-power stations transmit only DTV. The date was the culmination of more than ten years of complex regulatory decisions that provided broadcast station managers with varying regulatory conditions for voluntary transitioning and multiple mandatory cutoff dates.

Stations around the nation transitioned individually and in varying degrees of coordination with each other, both in the local markets and throughout national networks. Facing engineering and economic concerns that could change their costs and revenue dramatically, stations acted in response to both market and regulatory forces. In this article, we identify and describe the various forces that influenced the DTV transition.

[1] Third Periodic Review of the Commission's Rules and Policies Affecting the Conversion To Digital Television, MB Docket No. 07-91, Report and Order, FCC 07-228, 23 FCC Rcd. 2994, 3017 ¶ 41 (rel. December 31, 2007).

[2] In addition to the licensing of full-power stations, the FCC has licensed low-power television (LPTV) service since 1982, and more than 2,100 LPTV stations are in operation. LPTV stations "provide opportunities for locally-oriented television service in small communities"; *see* FCC, FCC Consumer Advisory: The DTV Transition and LPTV/Class A/Translator Stations (August 19, 2009), http://www.fcc.gov/cgb/consumerfacts/DTVandLPTV.html. The June 2009 DTV transition deadline did not apply to LPTV stations, although the FCC has stated that it will eventually require these stations to transition as well. We do not consider LPTV stations further in this article.

We look at both the big picture of how the transition fits into the history of broadcasting in the U.S. and a detailed examination of the stations' final decisions regarding when to switch. In the latter, we focus on the economic and strategic aspects of the stations' business decisions, modeling their choices with tools from decision theory and game theory. In particular, our empirical examination looks at the stations' decisions whether to switch off analog broadcasting on February 17, 2009, the planned transition date until Congress delayed the deadline, or whether to continue to broadcast in analog until a later date. Despite the FCC's expectation at the end of 2007 that many stations would transition even before February 2009 quoted at the beginning of this article, most did not. We examine both theory and data to explore the decision making process of broadcast station managers facing a choice of when to switch to all-digital broadcasting.

The inherent trade off between switching earlier or later depends on the costs and benefits of switching to DTV. Broadcasting in DTV requires much less power than in analog, and the electricity savings can be substantial. Balancing the cost savings are fears that technical problems or changing broadcast footprints could cost a station viewership, and therefore advertising revenue. In the decision theoretic model we develop, a station's management considers only its own costs and the effect of its own decision on its viewership when deciding to switch early. However, fears of losing viewers are heightened if other stations in the local market do not also switch to DTV early, because then rival stations might gain the lost analog viewers at least temporarily, and perhaps permanently due to habit-formation. Thus, each station must consider not only its own costs and revenues, but also the decisions made by the other stations. The game theoretic model builds on the simpler decision theoretic model to incorporate strategic thinking on the part of the station. In the game, a station manager considers the impact of other stations' decisions on its profit when making its choice.

The models predict that stations delay transition when they would see only small cost savings from transitioning relative to their expected lost revenue. In the game, such cases can become a classic Prisoners' Dilemma, wherein each station would like to lower its costs but neither does in equilibrium.[3] When, on the other hand, stations face large cost savings from switching early relative to the expected loss of viewers when transitioning (in the decision model) or the expected gain of viewers from the other stations from delaying (in the game), stations switch early.

These outcomes from the models suggest several observable implications, which we explore and test using the stations' decisions and other data from the television broadcasting industry. In general, both casual and more formal econometric examinations of the data yield results that are in line with the predictions of the models. The results indicate that station managers indeed were thinking strategically when they made their transition decisions, and were not merely considering their own cost savings apart from what other stations were doing. The results thus provide insight into the stations' decision making process, which can help market observers and regulators better understand the calculus of the industry.

The article is organized as follows. Section II contains background information on the broadcast television market, covering its regulation, engineering aspects, and the organization of the industry. Section III discusses the development of the DTV standard and the long process of the DTV transition in the U.S. Section IV presents the financial and strategic considerations that factored into a television station's decision of when to turn off analog broadcasting. Section V introduces our economic models of the transition decision and derives testable implications. The models draw on both decision theory and

[3] The Prisoners' Dilemma refers to a class of games where each player's best individual strategy is to choose an action that is the opposite of the action that the players would agree to play if they could coordinate their actions. The Prisoners' Dilemma is thus an archetype of situations in which individual incentives lead to an inefficient equilibrium, compared to the (unsustainable) cooperative outcome. For a non-technical introduction to the Prisoners' Dilemma and its influence on public policy, *see generally* WILLIAM POUNDSTONE, PRISONER'S DILEMMA (1992).

game theory. Section VI introduces the data we collect on the U.S. broadcast television market, and tests the predictions of the economic models with simple statistical analysis and with regression analysis. A final section concludes.

II. The Broadcast Television Market

We begin by explaining the history, regulatory oversight, and current state of the broadcast television market in the U.S., to set the stage for the examination of the strategic aspects of the stations' decisions regarding switching to DTV.

A. Regulatory Aspects

The recent transition of broadcast television from an analog to a digital technical standard is but the latest policy action in response to an important aspect of the industry present throughout its history: the high demand for the airwaves in the presence of competing interests. From its inception, both industry and government recognized the power of broadcast TV to reach mass markets, which created high demand for use of the radio spectrum.[4] Policymakers' desire to maximize the benefits from the use of the airwaves—a scarce resource—requires periodic rebalancing between the accommodation of incumbent technologies and the movement toward next-generation, state of the art technology. For almost a century, the evolution of the broadcast industry has been shaped by regulation.

The early age of broadcasting—at first, audio only—was a chaotic time, full of exciting advancements in technology and great experimentation. Initially, the only limitations on use of radio spectrum were those imposed by the state of the technology and laws of physics. Absent a regulatory structure, radio experimenters pushed the limits

[4] Radio spectrum refers to the portion of the electromagnetic spectrum composed of frequencies between 3kHz and 300 GHz, those best suited for communications use. Airwaves used for what consumers think of as "radio broadcasting" (i.e., AM, FM, and now HD radio) compose only a small subset of radio spectrum.

of the technology into areas that profoundly impacted commerce, entertainment, and the public good. Having played a role in both contributing to[5] and averting[6] major shipping disasters in the early 20th century, the use of wireless spectrum faced increased scrutiny from Congress. With the passage of the Radio Act of 1912, the federal government first established a system of "licensing" the use of radio spectrum under the Commerce Department, largely for reasons of maritime safety.[7] In addition to providing a means to check users' compliance with the legislation, the licenses served as a precursor to a broader notion of the federal government's ownership of the airwaves. Licensing constituted a system of government grants that constituted both permission to use spectrum under certain conditions as well as rights to certain protections from "interference."[8]

By the early 1920's, the use of radio technology had expanded so rapidly that more than 500 broadcasters filled the country on a single frequency.[9] The growth of broadcasting occurred despite the fact that the Radio Act of 1912 did not anticipate broadcasting and that broadcast licensing was initially limited to two frequencies—one of which was reserved for crop reports and weather forecasts.[10] Significant court losses for

[5] Lack of coordination between the shipboard radio operators and the bridge was a contributing factor in the sinking of the RMS *Titanic*. *See* ROBERT D. BALLARD & RICK ARCHBOLD, THE DISCOVERY OF THE TITANIC 20 (1987).

[6] After the actions of a radio operator saved the lives of 1,200 victims of a shipping accident in 1909, Congress passed the Wireless Ship Act. The 1910 law required radio equipment with a range of at least one hundred miles to be installed all U.S. ships carrying over fifty passengers and traveling over two hundred miles off the coast. *See* HUGH RICHARD SLOTTEN, RADIO AND TELEVISION REGULATION: BROADCAST TECHNOLOGY IN THE UNITED STATES 1920–1960 6-8 (2000).

[7] Observers of the events leading up to the loss of life in the sinking of the RMS *Titanic* urged changes in the U.S. and internationally to tighten procedures for the use of radios on vessels. Congress passed the Radio Act of 1912 largely in response to these concerns. The Act required all seafaring vessels to maintain constant radio watch and to keep in contact with nearby ships and coastal radio stations. The U.S. law mirrored the international treaty law negotiated in London at the International Radiotelegraphic Convention in 1912. *See* Radio Act of 1912, P.L. 264, 62nd, 37 Stat. 302 (1912) (Radio Act of 1912).

[8] Hazlett and other commentators observe that the rights and responsibilities associated with spectrum use were of chief concern at the time. *See* Thomas Hazlett, *The Rationality of U.S. Regulation of the Broadcast Spectrum*, 33 JOURNAL OF LAW AND ECONOMICS, 133, 145 (1990).

[9] *See Id*.

[10] The 1912 Act delegated the regulatory powers over radio communication to the Secretary of Commerce and Labor. *See* Radio Act of 1912, *supra* note 7.

the executive branch of the federal government, the growing economic value of and demand for spectrum, and the mounting concerns over interference and disruptions of the expectations of use of spectrum all challenged the early regulatory structure.[11] These and other factors drove the passage of the Radio Act of 1927 and its successor legislation, the Communications Act of 1934, which established the Federal Communications Commission (FCC) as the regulator of broadcast and other uses of radio spectrum.[12]

The broad goals Congress defined for the FCC in the Communications Act of 1934 were matched by the far-reaching jurisdiction it granted to the agency. From its inception, the FCC regulated both market and engineering aspects of broadcast use of spectrum.[13] Declaring that "no person shall use or operate any apparatus for the transmission of energy or communication or signal by radio…except under and in accordance with the Act and with a license…," Congress firmly established federal ownership of the airwaves by fiat. Congress intended unambiguously to bring radio use under federal control in order to encourage a greater and more effective use of radio "in the public interest, convenience, or necessity," while at the same time prohibiting outright private ownership of spectrum.

Under this Congressional mandate, and incorporating prior broadcasting determinations made under the 1927 Act by the Federal Radio Commission, the FCC

[11] The Secretary of the Department of Commerce, future president Herbert Hoover, played a strong role in shaping radio, despite Court losses that limited federal jurisdiction over radio licensing. In particular, the Court's invalidating of Hoover's denials of broadcast licenses for lack of standards, and later for federal jurisdiction outright under the existing statute hastened the legal changes establishing the modern federal regulatory structure for radio use. *See* Hoover v. Intercity Radio Co., 286 Fed. 1003 (App. D.C. 1923); United States v. Zenith Radio Corp., 12 F. 2d 614 (N.D. Ill. 1926). The decision in *United States v. Zenith Radio* marked a period of "breakdown of the law", described by some commentators as the death-knell of the burgeoning private market and judicial adjudications approaches, announcing a new federal "command and control" approach to spectrum management. *See* Hazlett, *supra* note 8, at 133-175 (discussing the history of market mechanisms for spectrum use and rejection in favor of the federal regulatory "command and control" approach).

[12] Communications Act of 1934, P.L. 416, ch. 652, 48 Stat. 1064 (June 19, 1934).

[13] The FCC's authority to "make reasonable regulations" that were "consistent with the public interest, convenience, and necessity" was not limited solely to the statutory provisions enumerated in the Communications Act. *See* National Broadcasting Co. v. United States, 319 U.S. 190, 217 (1943) (upholding the broad reading of the FCC's regulatory power as extending beyond the technical engineering characteristics of radio spectrum management).

implemented a variety of regulatory policies intended to foster the continuing growth of broadcasting and prevent interference between stations. The modern FCC regulatory framework of licensing broadcast stations geographically by service, frequency, and power, including limitations on which parties may hold licenses and procedures for denying or revoking licenses, was largely in place by 1941. The rules established the market structure that remains today. In a case that challenged the FCC's power to promulgate rules related to "chain broadcasting" by networks of stations, the Supreme Court upheld the FCC's flexibility in implementing its broad mandate. The Court concluded that the FCC's jurisdiction was not limited to the engineering aspects of radio use, but instead granted comprehensive power to promote and realize the vast potentialities of radio through "such rules and regulations[,] restrictions and conditions, not inconsistent with law, as may be necessary to carry out the provisions of th[e] Act."[14]

The advent of television created new challenges for regulation. Initially, the FCC classified the licensing of broadcast television as "experimental," mirroring the nascent state of the technical art at the time. TV broadcast's first home was in the very-high frequency (VHF) portion of the spectrum.[15] The technical standards the FCC has selected have always reflected difficult balances between feasibility of existing state of the art, accommodation of incumbent technologies, and the need to maximize the beneficial use of the radio spectrum. The great diversity of technical solutions for a "television" system with the live transmission of sound and moving images that simulated motion (at least 12.5 frames per second) drove the FCC to address the technical conflicts among companies seeking to introduce nationwide service. The FCC formed the National Television System Committee (NTSC) in 1940 to select a technical standard.

[14] *Id.* at 217 (citing the statute).

[15] *See infra* § II.B.

In 1941, the FCC commenced licensing commercial broadcast television stations under the committee's adopted standard for black-and-white television, the NTSC Standard.[16]

Technical advancement in color technologies later required the FCC to explore a new standard. In 1948, the FCC formed its Joint Technical Advisory Committee (JTAC). The FCC provisionally approved a JTAC recommendation for a color standard that would have taken advantage of new technologies exploiting the ultra-high frequency (UHF) band. However, the JTAC recommendation was not backward compatible with the existing NTSC black-and-white standard. If pursued, the FCC would have allowed the prior standard to become obsolete as consumers purchased color televisions that would use different spectrum and an incompatible technical standard—naturally making it possible to reclaim the VHF band as attrition occurred.

In the two years the color standard was being considered, the number of black and white NTSC-compatible televisions in the marketplace exploded from under a million sets in 1948 to over 10 million by 1951. Recognizing that making the millions of existing sets in the market obsolete would constitute a significant burden for consumers, the FCC reconvened the NTSC in 1950, recommending that the Committee identify a "compatible color" standard. Compatibility would protect the value of the investment consumers had made in the still relatively new NTSC black and white TV technology. In December 1953, the NTSC adopted a compatible standard. Thus, respecting consumers' existing investments in equipment was a deciding factor even in the selection of the modern analog television NTSC standard.[17] The FCC would again wrestle with this issue in the transition to DTV.

[16] In spite of other competing standards, the NTSC adopted the recommendation made in 1936 by the Radio Manufacturers Association (RMA).

[17] The first broadcast of a program using the NTSC "compatible color" system was an episode of NBC's *Kukla, Fran and Ollie* on August 30, 1953. While the broadcast was announced to the public it could only be seen in color at the network's facility.

B. Wireless Engineering and Physics

To understand the financial and strategic incentives facing television stations to switch to DTV, one must understand some of the engineering and physical principles involved with broadcasting. Two separate tracks of technology, 1) the generation and display of TV images using television cameras and video monitors (i.e., "TV sets"), and 2) the radio-frequency (RF) transmitters and receivers that carry signals through the air had evolved by the early 1930's to enable the birth of the new broadcasting industry. The early technology made use of techniques and fundamental physics that still apply today. These engineering fundamentals continue to play a role in the decision making of broadcast entities.

Major discoveries and advances of the early 20th century in the areas of physics and material science provided the technical foundations for television broadcasting for the next 75 years. Techniques for capturing and reproducing graphical images made use of both mechanical and electronic components, but by the time of the Communication Act of 1934, the fundamental technologies necessary for modern television using a solely electrical process had already emerged.[18] The radio engineering techniques to deliver the prepared moving images and sound also advanced greatly in the early age of radio. The ability to manipulate radio waves to carry information had developed by the time the regulatory structure congealed in the early 1930's. World War II spurred great advances in wireless engineering in the 1940's, making the technology ready for prime time.[19]

A complete discussion of television broadcast engineering is unnecessary for present purposes, but a basic explication of three fundamental RF engineering considerations illustrates how certain technical aspects of the DTV transition are relevant to the strategic interests of broadcast entities. Each consideration stems from the physical aspects of how radio waves propagate and are manipulated to carry information.

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[18] *See* GARY R. EDGERTON, THE COLUMBIA HISTORY OF TELEVISION 50 (2007).

[19] Pun intended.

First, a transmission effectively loses power as it travels from its source. The loss implies that the power level transmitted from the transmitter (the antenna) defines the geographic area in which reception is possible.[20] The more power transmitted, the greater is the area in which reception of the signal is possible. Broadcast TV transmitters typically transmit thousands or millions of watts and provide coverage over hundreds of square miles.

Second, spectrum propagates through space undulating in waves. The physical properties of spectrum differ with the length of the waves. In particular, waves of longer length (i.e., of greater "wavelength") travel farther than those of shorter length, given that both are transmitted at the same power. Radio waves can also be characterized in terms of number of undulations the wave completes in a given period (i.e., the "frequency"), typically measured in Hertz (Hz).[21] Television stations broadcast signals to viewers over a wide swath of frequencies.[22] As mentioned above, TV broadcasting first made use of the VHF band. Signals in this band have long wavelengths that travel the farthest at the lowest power levels, and are most able to reach viewers in mountainous regions or areas with dense foliage. Television broadcast signals in the higher-frequency UHF band typically require more power to provide service over the same area as an equivalent VHF signal.[23] However, because of the number of common sources of significant interference

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[20] The reduction of power density as radio waves propagate from their source, known as *path loss*, results from a variety of conditions, including spreading losses, absorption losses, and diffraction losses. Radio applications typically evaluate "path losses" in decibels (dB). A common expression for free space path loss (FSPL) using reads:

$$FSPL = 20\log_{10}(d) + 20\log_{10}(f) + 32.44$$

where f is frequency in MHz, d is distance in km, and loss is measured in dB. *See* CLINT SMITH & DANIEL COLLINS, 3G WIRELESS NETWORKS 388 (2002).

[21] The relationship between frequency and wavelength is: $f = c/\lambda$, where f is frequency in Hertz (Hz, in cycles per second), λ is the wavelength in meters, and c is the speed of light (approximately equal to 3×10^8 meters per second).

[22] The lowest frequency currently allocated for broadcast in use (for channel 2 in the VHF band) is 54 MHz and the highest frequency (for channel 51 in the UHF band) is 698 MHz.

[23] The requirement for higher power for UHF frequencies is discussed in Appendix A of the OET Bulletin No. 69 and the Advanced Television System's Sixth Further Notice, as the "dipole factor." *See generally* OET Bulletin No. 69, *Longley-Rice Methodology for Evaluating TV Coverage and Interference*, (Feb. 6, 2004), *available at*

in the VHF band, UHF broadcast signals benefit from a more interference-free environment. The range of broadcast frequencies is divided into "channels" corresponding to the 6 MHz increments to which licenses are allocated. VHF stations broadcast over channels 2 through 13, and UHF stations transmit in channels 14 and above.[24]

Third, techniques for manipulating (i.e., "modulating") radio waves to carry information exploit different properties of radio waves. For example, amplitude modulation (AM) and frequency modulation (FM), important standards in radio broadcasting, encode information by manipulating the power level and wavelength of radio waves, respectively. An NTSC broadcast comprises an AM video signal (at 30 frames per second) and an FM audio signal. Information can also be encoded using different mathematical approaches to improve the performance, resiliency to interference, or other features. For example, DTV standards encode TV video and audio signals digitally using compression and error-correcting techniques similar to those used in modern consumer electronics equipment such as DVD players. Thus, DTV standards are referred to as "digital," as opposed to the "analog" NTSC standard. Use of digital techniques makes it possible to carry more information than an NTSC system, and with higher reliability and at much lower power.

Regardless of the modulation or engineering technique used in the broadcast, the quality of TV reception is heavily dependent on the nature and quality of the TV receiver and antenna. The effectiveness of an antenna to receive TV signals depends, among other things, on whether the physical size of the antenna appropriately matches a multiple

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http://www.fcc.gov/Bureaus/Engineering_Technology/Documents/bulletins/oet69/oet69.pdf.

[24] The FCC first adopted these channel allotments in an order in 1952. *See In the Matters of Amendment of Section 3.606 of the Commission's Rules and Regulations; Amendment of the Commission's Rules, Regulations and Engineering Standards Concerning the Television Broadcast Service; Utilization of Frequencies in the Band 470 to 890 Mcs for Television Broadcasting; Part 1 of 4*, Docket Nos. 8736 and 8975; Docket No. 9175; Docket No. 8976, 41 F.C.C. 148 (adopted April 11, 1952). Several changes in allotments were subsequently made.

of the wavelength of the desired signal. In particular, an antenna designed to receive VHF signals does not work well at pulling in UHF stations, and vice versa. In some cases, consumers having antennas with only a VHF or UHF component would lack the ability to receive some DTV transmissions, which may make use of both bands. Moreover, the quality of a receiver can be even more important when overcoming certain kinds of interference or for quality demodulation of digital signals. Unlike reception of analog transmissions, which gradually fade to "snow" as quality degrades, DTV exhibits the "digital cliff effect," so-called because reception is either perfect or non-existent, with an abrupt transition between the two states. The greater importance of the quality of the receiving equipment, along with the digital cliff, means that the transition to DTV is attended with the potential loss of viewers of a broadcast station. As we discuss below, these considerations played a role in the calculus of stations deciding when to switch to DTV.

C. Industrial Organization

The market structure, conduct, and performance of the broadcast television industry (collectively, its "industrial organization") reflect both regulatory and business considerations. Predominant among these considerations is the ownership structure of the entity holding the FCC license, the "station." Media ownership restrictions are a complicated area of regulatory practice, but several considerations have influenced the TV broadcast market and the decision making of broadcast entities. In this section, we review the formation of the television networks and sketch a picture of competition in the industry today. Understanding the relationships among stations and the revenue sources for broadcasters is important for analyzing the incentives station owners faced regarding to transition to DTV.

1. The Evolution of the Networks and the Ownership Cap

After broadcast technologies became technologically viable, their popularity exploded, and large capital backers began "selling gas stations and buying radio stations."[25] Consolidation of the ownership of stations began with the very first commercial radio licensee, Westinghouse Electric, when in 1921 it added two additional stations to its original facility, KDKA Pittsburgh.[26] Consolidation of licenses increased the potential for advertising revenue and furthered stations' financial growth. The development of networks of stations made "chain broadcasting" possible, in which media content could be broadcast simultaneously by multiple stations. Networks in this modern sense began in 1926 with the formation of the National Broadcasting Company (NBC) network, closely followed by Columbia Broadcasting System (CBS) in 1927.[27]

The formation of these networks depending on the use of telecommunications technology to connect the "chains" of stations, and the commercial relations between network owners and the stations controlled access to these fundamental tools. NBC's owner, Radio Corporation of America (RCA, a subsidiary of General Electric), was initially unable to negotiate use of the high-quality voice telephone circuits necessary to connect its stations. AT&T, the owner of the telephony network supporting the circuits, refused to deal with RCA because AT&T owned a competing radio station network (WEAF).[28] Economists refer to such denial of essential inputs by a vertically integrated firm (AT&T) to a downstream rival (RCA/NBC) as "foreclosure." RCA found a solution

[25] Use of radio in World War I advanced the art of radio considerably and accelerated its adoption. *National Broadcasting Co.,* 319 at 211.

[26] HERBERT H. HOWARD, MULTIPLE OWNERSHIP IN TV BROADCASTING HISTORICAL DEVELOPMENT AND SELECTED CASE STUDIES 20 (1979); *see also* STEPHEN DAVIS, LAW OF RADIO 140 (1927).

[27] Howard, *supra note 20,* at 29.

[28] The exhaustive NBC File of the Library of Congress contains press releases, fillings, personnel records and other items of interest from this period. *See generally*, Kathleen B. Miller *et al*, NBC: A Finding Aid to the National Broadcasting Company History Files at the Library of Congress, Motion Picture, Broadcasting and Recorded Sound Division, http://hdl.loc.gov/loc.mbrsrs/eadmbrs.rs000001 (last visited March 1, 2010); *see also* Thomas H. White, United States Early Radio History, Section 19, Consolidation Under the National Broadcasting Company, http://earlyradiohistory.us/sec019.htm (last visited Feb. 22, 2010).

to its quandary by buying the WEAF network from AT&T, thus destroying the latter's incentive to foreclose. With the new acquisition, RCA formed NBC with the WEAF chain stations (shortly thereafter renamed the NBC-Red network) and its existing WJZ network (renamed the NBC-Blue network).

Not unlike its competitors, NBC's interests and network focus were tied closely to the business strategies of its parent organization Radio Corporation of America (RCA), and its market dominance continued to draw the ire of competitors. In 1938, in response to a request by the Mutual Broadcasting System, the FCC commenced its first inquiry into competition in the broadcast industry, investigating the domination of the market by NBC and CBS.

In its 1941 report on Chain Broadcasting, the FCC expressed concern that

> common ownership of network and station places the network in a position where its interest as the owner of certain station may conflict with its interest as a network organization serving affiliated stations. The danger is present that the network organization will give preference to its own stations at the expense of its affiliates.[29]

The Commission also found that an organization operating multiple networks, such as RCA with its "two color" NBC networks, could result in an unfair competitive advantage over other networks.

In the report and through subsequent action in the 1940's, the FCC expressed its defining view that it had an obligation to restrict the number of commonly-owned stations, and to serve the public interest by preserving diversification in the ownership of networks and stations.[30] As stated in a later report,

> The purpose of the multiple ownership rules is to promote diversification of ownership in order to maximize diversification of program and service

[29] Howard, *supra note 20,* at 35; Federal Communications Commission, *Report on Chain Broadcasting* (rel. May 2, 1941) (Washington U.S. Govt. Printing office).

[30] *See* Supplemental Report on Chain Broadcasting 14 (1941); 8 Fed. Reg. 16,005 (1943); Amendment of Part 3 of the Commission's Rules, 11 Fed. Reg. 33 (Jan. 1, 1946).

> viewpoint as well as to prevent any undue concentration of economic power contrary to the public interest.[31]

Having noted that vertical integration of the network content distributor with the broadcast stations was firmly established, the FCC criticized the networks' practice of owning and operating numerous high-power stations. Such stations are known as "O&O" stations. The criticism of O&O's by the FCC led RCA to divest station ownership and network operations of its NBC Blue network of stations, albeit not until unsuccessfully challenging the FCC's authority to enforce its new policies. The Blue network, thereafter under new ownership, became the third independent national network under the moniker American Broadcasting Company (ABC).[32]

The changes in the regulatory environment resulted in a cap on the number of stations a given entity could hold, and networks facing this limitation were forced to choose which O&O's to keep. At first the cap was set at three stations,[33] but was soon raised to five.[34] Naturally enough, the networks focused on establishing ownership interests in the major TV markets, where they continue to hold their O&O stations today. In addition, mergers between networks or the holding of more than one network by an entity, known as the "dual network" rule, was also prohibited.[35] Nevertheless, networks continued to

[31] *Amendment of Multiple Ownership Rules*, 9 RR 1563 (1953). *See also* Stuart Minor Benjamin, *Evaluating the Federal Communications Commission's National Television Ownership Cap: What's Bad for Broadcasting is Good for the Country*, 46 WILLIAM & MARY LAW REVIEW 439 (2004) (expressing a contrary view on the need for an ownership cap).

[32] *National Broadcasting Co.,* 319 U.S. at 224 (concluding "that the Communications Act of 1934 authorized the Commission to promulgate regulations designed to correct the abuses disclosed by its investigation of chain broadcasting."). After internal NBC discussions dating back to 1932 and the separation of the NBC Blue and Red sales teams in 1939, NBC Blue operations had already been made independent in a newly created "Blue Network Company" by the time Supreme Court rendered its decision, and RCA subsequently filed its request to transfer and assign the network that the FCC approved on October 12, 1943.

[33] 6 FR 2284-85 (Tuesday, May 6, 1941).

[34] 9 FR 5442 (Tuesday, May 23, 1944). For a review of the changes in the national ownership cap over the years up to the passage of the Telecommunications Act of 1996, *see* Biennial Review Report, In the Matter of 1998 Biennial Regulatory Review – Review of the Commission's Broadcast Ownership Rules and Other Rules Adopted Pursuant to Section 202 of the Telecommunications Act of 1996, FCC 00-91, sec. IV.a.1.

[35] The dual network rule remained in effect until changes in the 1996 Telecommunications Act and FCC action 2001 restricted the scope of the rule. *See* 47 CFR 73.658(g) (prohibiting a television broadcast

expand their content offerings throughout the nation through "affiliate" relationships with independent stations. These affiliated stations contract with a network under a franchising agreement to broadcast the network's programming content while maintaining an independent ownership and management structure.

As demand for station licenses continued to swell after World War II, leading to the opening up of spectrum in the UHF band for broadcasting use, the FCC relaxed the ownership restriction to seven stations in 1954.[36] However, the FCC provided that no more than five VHF stations would be allowed. While the FCC differentiated the ownership restrictions for VHF and UHF channels in order to promote development of the spectrum newly available for broadcasting, entry of new UHF stations progressed slowly. UHF stations were often viewed as inferior to VHF even after technology shortcomings were addressed.[37] As discussed above, a UHF broadcast requires more power than a VHF broadcast, in addition to other engineering differences. The value of UHF station ownership was also lower because, until 1964 (when UHF tuner technology became required in all TV receivers), consumers had to buy a new antenna and either purchase a "TV-top converter" or a compatible TV receiver. As another case of a new broadcast technology requiring consumers to upgrade their home electronics equipment, UHF broadcasting was an exemplar of the 2009 U.S. DTV transition.[38]

The next change in the national television broadcast ownership rules was in 1984, when the common ownership of 12 stations was permitted.[39] The next year, the higher

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station from affiliating with a person or entity that maintains two or more networks of television broadcast stations unless such dual or multiple networks are composed of two or more persons or entities that, on February 8, 1996, were "networks" as defined in § 73.3613(a)(1) of the Commission's regulations [(that is, ABC, CBS, Fox, and NBC]); *see also* Amendment of Part 3 of the Commission's Rules, 11 FR 33 (Jan. 1, 1946) (establishing the "dual network" rule); Amendment of Section 73.658(g) of *The Commission's Rules – The Dual Network Rule*, MM Docket No. 00-108, Report and Order, FCC 01-133 (May 15, 2001).

[36] Amendment of Multiple Ownership Rules, 43 FCC 2797 (1954).

[37] UHF station management, technology and culture has been lampooned in popular culture. *See* Internet Movie Database, UHF (1989), http://www.imdb.com/title/tt0098546/ (last visited March 1, 2010).

[38] *See* All-Channel Receiver Act (ACRA), 47 U.S.C. § 303(s) (1964).

[39] *See* Amendment of Multiple Ownership Rules, (Gen. Docket 83-1009) 100 FCC 2d 17 (1984).

cap was limited by an "audience reach cap," by which the percentage of households able to view a network's O&O's could be no more than 25% of the national viewing audience.[40] The numerical limit on the number of stations was eliminated in 1996 and the audience reach cap was raised to 35%.[41] In 2003, the cap briefly rose to 45%,[42] but was reduced by Congress to 39% shortly thereafter.[43]

The import of network formation in the broadcast industry for the transition decisions concerns the locus of the decision-making. Managers of television stations that are O&O's of a network generally were not free to make their own decisions regarding when the transition to DTV, since such decisions were made at the corporate level of the network. Affiliated stations not owned by the network and other independent stations, on the other hand, had more leeway in choosing their transition timing. The distinction between the types of stations implies that it is important to control for whether a station is an O&O in the statistical regression we perform in section VI.

2. *Current Organization of the Industry*

To understand what is at stake for the stations as they switch to DTV broadcasting, the most salient facts are that station revenue comes primarily from advertising, and that advertising revenue is driven by viewership. Advertising in broadcast television markets has traditionally been priced by CPP, the cost per point of Nielsen Media Research

[40] *See* Memorandum Opinion and Order in MM Docket No. 83-1009, 100 FCC 2d 74 (1985). Due to their technical disadvantages, UHF stations are attributed with only half of the audience they can reach for purposes of computing the cap. Report and Order and Order on Reconsideration, FCC 07-216, In the Matter of 2006 Quadrennial Regulatory Review—Review of the Commission's Broadcast Ownership rules and Other Rules Adopted Pursuant to Section 202 of the Telecommunications Act of 1996, December 18, 2007, at 142.

[41] *See* Order, Implementation of Sections 202(c)(1) and 202(e) of the Telecommunications Act of 1996 (National Broadcast Television Ownership and Dual Network Operations), 11 FCC Rcd 12374 (1996).

[42] *See* 2002 Biennial Regulatiory Review—Review of the Commission's Broadcast Ownership Rules and Other Rules Adopted Pursuant to Section 202 of the Telecommunications Act of 1996, 18 FCC Rcd 13,620 (2003).

[43] *See* Consolidated Appropriations Act, Pub. L. No. 108-199, tit. VI, sec 629, 118 Stat. 3, 99-100 (2004).

Company rating "points,"[44] although more recently the industry is shifting to more direct measures of "audience impressions" (i.e., how many times the commercial is likely to be viewed).[45] The broadcast television industry has bled viewer share to cable over the years. Although the Big Three networks (ABC, CBS, and NBC) saw their share of viewers fall from 70 percent in 1986 to 27 percent in 2006, with cable television picking up most of the lost audience, advertising revenue has not fallen appreciably (at least until 2009, when the poor economy may have been partly to blame).[46] Part of the reason for the maintained levels of advertising revenue is that the networks have responded to lost viewing share by increasing the minutes of advertising each viewing hour.[47]

A network sells advertising to be aired on all of its affiliated stations, whether it owns the station or not. In 2009, advertising revenue for the five largest networks totaled $21.7 billion.[48] Nearly all of this amount is generated by sales of broadcast advertising, although some of the network revenue also comes from ads sold for programs that are streamed online. The figure for 2009 was about 8 percent lower than it was the previous year. The market share of advertising revenue was 28 percent for ABC, 29 percent for CBS, 20 percent for FOX, and 20 percent for NBC,[49] implying that there are four roughly equally sized competitors at the national level. In the local markets, the viewing (and

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[44] Nielsen ratings are the industry standard to measure the viewership of a television program or station. A Nielsen "ratings point" represents one percent of the total number of television households in the relevant geography (the nation or a local market, depending on the context). Nielsen collects information on the viewing behavior of households and individuals through paper viewing diaries and electronic metering equipment in selected homes. Regardless of method, each household in the Nielsen panel provides about a week's worth of viewing information during the "sweeps" months of November, February, May and July. In some diary markets, additional months are surveyed as well. *See* The Nielsen Company, Television: How the Numbers Come to Life: Panels, http://en-us.nielsen.com/tab/measurement/tv_research (last visited March 1, 2010).

[45] SNL KAGAN, ECONOMICS OF TV PROGRAMMING & SYNDICATION 55 (2007).

[46] Some of the market share lost by broadcast TV migrated to direct broadcast satellite and programming services from broadband providers, such as Verizon's FIOS and AT&T's U-verse.

[47] SNL KAGAN, *supra* note 45, at 5.

[48] *See* Brian Steinbery, *Most TV—Broadcast or Cable—Saw Ad Revenue Fall Last Year*, ADVERTISING AGE, Feb. 22, 2010, available at http://adage.com/mediaworks/article?article_id=142244 (citing figure from Kantar Media). The figure includes all ad revenue, not just the season "upfront' commitments often cited in the industry press.

[49] The final 3% of advertising revenue earned by major networks in 2009 went to CW.

therefore the advertising revenue) shares may vary, but no network can own two stations in the same market unless one of the stations is not in the top four in terms of audience share, and there are more than seven other independent stations also in the market.[50]

In order to spread their revenue sources wider, networks also own shares in some of their programming series. Taking a stake in a series enables the network to profit from "aftermarket" revenue as well as from initial advertising sales. The additional revenue sources include broadcast syndication fees (domestic and international), "repurposing" fees from cable and direct broadcast satellite channels,[51] DVD sales, and video on demand.[52] The aftermarket revenue from a hit series is estimated to account for as much as 90 percent of the total (undiscounted) revenue stream, although aftermarket revenue composes much less of the whole revenue for non-hit series.[53]

More important for the empirical work below is the advertising revenue accruing to individual broadcast stations. Stations, even those affiliated with a network, offer their own commercial airtime—"spot advertising"—for purchase. Buyers of television spots are often local advertisers, but even when not, the network a station is affiliated with is not allowed to control the rates for spot advertising.[54] Revenue earned directly by the stations from advertising is roughly equal to the amount earned by the networks' own ad sales. In 2009, sales of local and national spot advertising garnered stations an estimated $24.1 billion.[55] As with the networks, advertising revenue for stations was down in 2009,

[50] Report and Order and Order on Reconsideration, FCC 07-216, *supra* note 40, at ¶ 87.

[51] Syndication means licensing "reruns" of a series to broadcast stations. Repurposing refers to moving content from the broadcast format to another modality such as cable.

[52] The networks first entered the video on demand market on a large scale around 2006 by selling programs on iTunes.

[53] SNL KAGAN, *supra* note 45, at 16.

[54] *See generally* B.D. McCullough & Tracy Waldon, *The Substitutability of Network and National Spot Television Advertising*, 37 Q.J. BUS. & ECON. (1998) (for discussion of how and why the FCC sought to ensure the survival of an independent advertising market, outside the control of the networks).

[55] Local spot advertising (about 55% of total spot advertising) appears only in a station's own market. National spot advertising appears in large portions of the country. A company might choose to advertise with a national spot instead of a national network commercial because it wants to target only hot, sunny states for a sunscreen ad, for example.

falling 17 percent from the previous year.[56] While local stations also earn some revenue from retransmission agreements with cable television companies and online advertising, broadcast advertising still makes up about 97 percent of the average station's revenue.[57] Protecting this dwindling revenue stream was one of the prime concerns of station managers considering when to switch to DTV. The same is true of the network O&O stations, which are a profit center for the networks. While the major networks have only small profit margins, O&O stations have profit margins of 40 to 50 percent as recently as 2007.[58]

III. The Switch to DTV

A. The Development of the DTV Standard

Since the development of the engineering and regulatory structure for broadcast television, the industry thrived in the U.S. for three quarters of a century. Six of those decades were under the NTSC color standard. Despite advances in technology that created opportunities to bring dramatic quality improvements to broadcast television, the NTSC analog standard remained largely unchanged into the 1980's. By then, however, the forces of change were already unleashed. The convergence of two factors, the increased demand for spectrum and the technological opportunities for advanced television content and devices, led to a 20 year process that culminated in the cessation of analog broadcasting on June 12, 2009. The switch to DTV realized dramatic improvements in the efficiency of the use of radio spectrum, gave greater flexibility to

[56] Michael Malone, *Study: Station Revenue Up 5.2% in 2010*, BROADCASTING & CABLE, August 18, 2009, http://www.broadcastingcable.com/article/327843-Study_Station_Revenue_Up_5_2_in_2010.php?rssid=20068 (citing a study by SNL Kagan).

[57] Katy Bachman *Report: TV Stations Finding Multiple Revenue Streams*, MEDIAWEEK, February 8, 2010, available at http://www.mediaweek.com/mw/content_display/news/local-broadcast/e3ief7f94880dc0982e7611a33c5d5ad05c (citing a study by SNL Kagan).

[58] SNL KAGAN, *supra* note 45, at 61.

broadcasters, and raised the quality of the television experience for viewers. This section recounts the history of the transition.

In the mid-1980s, Japanese electronics firms demonstrated high-definition TV (HDTV) technologies.[59] U.S. consumer electronics firms, already weakened from strong competition since the 1960's with Japanese firms, viewed HDTV as a new challenge.[60] In the 1980's, *Nippon Hoso Kyokai* (NHK), Japan's national broadcasting company, began broadcasting their HiVision HDTV system, known in the U.S. as MUSE (Multiple sub-Nyquist sampling encoding). The popular and academic press used MUSE as an example of the resurgence of Japanese R&D and electronics that appeared to portend the passing of technological leadership from U.S. firms to overseas competitors.[61] Besides reasons of industrial policy, some commentators (as well as the U.S. Defense Department) also advocated for a home-grown HDTV standard for purposes of national security.[62] Furthermore, the significant technical incompatibilities between the Japanese MUSE and the NTSC standard also lent impetus to the movement to development a North American HDTV standard.

In 1982, diverse broadcast industry interests came together to form the Advanced Television Systems Committee (ATSC) to develop a voluntary standard for an advanced

[59] Although the public often conflates HDTV and DTV, the two need not be synonymous. HDTV refers to a higher definition picture quality than that provided by an NTSC(-like) standard. Many of the early HDTV proposals, including MUSE, involved analog systems. The ATSC standard adopted for DTV in the U.S. also includes HDTV.

[60] *See generally,* CinemaSource, The Guide To Digital Television published in The History and Politics of DTV, Technical Bulletin (2002), http://www.cinemasource.com/articles/hist_politics_dtv.pdf; Jeffrey A. Hart, *The Politics of HDTV in the United States*, 22 POLICY STUDIES JOURNAL, (1994); WALTER B. EMERY, NATIONAL AND INTERNATIONAL SYSTEMS OF BROADCASTING THEIR HISTORY, OPERATION, AND CONTROL (1969) (discussing the history of Japanese broadcast technical innovations); *see also* NHK, The Evolution of TV-テレビは進化する：日本放送技術の発展小史, http://www.nhk.or.jp/strl/aboutstrl/evolution-of-tv-en/index-e.html (English and Japanese).

[61] *See generally*, JOEL BRINKLEY, DEFINING VISION: THE BATTLE FOR THE FUTURE OF TELEVISION, (1998). Some observers argued that crucial areas of TV R&D in the U.S. were beginning to erode at this time and the NHK Science and Technical Research Laboratories (STRL) and other Japanese institutions were already coming to be viewed as strong engineering R&D centers for the technology platforms of modern video technologies.

[62] *See* Kenneth D. Springer, *High Definition Television: New World Order of Fortress U.S.A.?*, 24 LAW & POLICY INT'L BUS 1323 (1992-1993).

television system to replace the aging North American NTSC television standard.[63] The ATSC initially urged adoption of the MUSE standard, but other U.S. broadcast interests opposed its incompatibility with the NTSC standard, which would require changes to channel allotments and pose other technical difficulties. The International Radio Consultative Committee (CCIR),[64] driven by European protectionist concerns,[65] declined to adopt MUSE as a standard, closing the book on the possibility of MUSE becoming an internationally recognized standard for HDTV.

Tandem to industry's growing interest in an advanced successor to NTSC, the FCC was exploring options to satisfy demand for spectrum with physical properties suitable for terrestrial radio users such as public safety (police and emergency services users) and delivery and dispatch companies. Having identified unused portions of the allocated broadcast bands as potential space for new users, the FCC issued a notice seeking comment on opportunities for further sharing between the private land mobile services and the UHF television broadcast service.[66] In its proposal, the FCC described its goal of making additional spectrum available to land mobile services in areas where it was most needed, with minimal impact on television broadcast service. Broadcasters showed

[63] The ATSC was formed out of another industry group, the Joint Committee on InterSociety Coordination ("JCIC"), composed of the Electronic Industries Association, the Institute of Electrical and Electronics Engineers, the National Association of Broadcasters, the National Cable Television Association, and the Society of Motion Picture and Television Engineers. *See Advanced Television Systems and Their Impact Upon the Existing Television Broadcast Service, Fourth Report and Order*, 11 FCC Rcd 17771 (rel. December 27, 1996) (ATS Fourth R&O).

[64] The International Radio Consultative Committee (CCIR, from the French acronym), a section of the United Nations' International Telecommunications Union, advises on spectrum allocations and communications standards.

[65] *See* LAURA D'ANDREA TYSON, WHO'S BASHING WHOM?: TRADE CONFLICT IN HIGH-TECHNOLOGY INDUSTRIES 240 (1993).

[66] *See* In the Matter of Further Sharing of the UHF Television Band by Private Land Mobile Radio Services, Notice of Proposed Rule Making, 101 FCC 2d 852 (1985). The proceeding was opened in response to various petitions and after a 1983 report by the FCC's Office of Science and Technology. *See* FCC OST, Analysis of Technical Possibilities for Further Sharing of the UHF Television Band by the Land Mobile Services in the Top Ten Land Mobile Markets, FCC/OST R83-3, October 1983.

significant interest in the proceeding, declaring strong intentions to use the frequencies identified for use with advanced television technologies.[67]

The pace of the march toward HDTV quickened in July 1987, when the FCC issued its First Notice of Inquiry on Advanced Television Service (ATS) and formed the Advisory Committee on Advanced Television Service (ACATS) to review the technical issues and provide a recommendation for a new ATS standard.[68] Momentum for a new standard further accelerated with the first congressional hearing on HDTV, held in October 1987, and the ACATS call for an open competition for development of the best ATS proposal. The Japanese analog-based MUSE standard was an early leader in these trials until 1990, when the FCC (on seeing a demonstration of the feasibility of a digital TV solution) declared that the new ATS standard would have to support a genuine HDTV signal at least twice the resolution of existing television images and be capable of being "simulcast" on different channels.

ACATS and the ATSC began collaborating on a recommendation for technical specifications for ATS. With a decision in early 1993 that a digital standard would be superior to an analog one, several former ATV competitors formed a "Grand Alliance" in May 1993 to collaborate on a single standard incorporating the best features of each system.[69] In November 1995, the ACATS recommended the Grand Alliance prototype DTV standard, which the FCC formally proposed in May as the new terrestrial

[67] In his concurring statement, Commissioner Henry Rivera stated that the action could stifle the potential of the low-power TV (LPTV) service and argued that insufficient time had been afforded to determine whether the service's spectrum needs. *See Further Sharing of the UHF Television Band by Private Land Mobile Radio Services*, 101 F.C.C. 2d 852 (Concurring Statement of Commissioner Henry Rivera).

[68] *In the Matter of Advanced Television Systems and Their Impact on the Existing Television Broadcast Service*, 2 FCC Rcd 5125, Adopted July 16, 1987; (rel. August 20, 1987) (ATS R&O).

[69] Grand Alliance was formed with the participation of AT&T (now Lucent Technologies), David Sarnoff Research Center, General Instrument Corporation, Massachusetts Institute of Technology, Philips Electronics North American Corporation, Thomson Consumer Electronics and Zenith Electronics Corporation.

broadcasting ATS standard.[70] The FCC adopted it with some modifications in December, 1996.

The ATSC standard for DTV represented a significant enhancement to the aging NTSC standard, and held numerous benefits for broadcast stations transitioning to digital.[71] Digital techniques for encoding and decoding broadcasts offer improvement of the quality of reception and resilience to interference. Under the new standard, station management can select actual channels flexibly while presenting users with a stable set of "virtual channels." Thus, management can change the actual frequency of "channel 2" without the consumer ever needing to adjust the tuning of the television set.[72] Multicasting, also enabled by the ATSC standard, allows station management to offer several channels of digital programming simultaneously using the same amount of spectrum formerly required for one analog program. Some stations took advantage of multicasting to affiliate with more than one network. ATSC also allows the carriage of diverse kinds of video, such as standard definition and high-definition video. However, the many benefits come with a transition cost. As was the case with early UHF television, consumers using an older NTSC receiver had to procure a "digital converter box" and possibly a new antenna to continue to use the television set after the DTV transition.[73]

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[70] Advanced Television Systems and Their Impact Upon the Existing Television Broadcast Service, Fifth Further Notice of Proposed Rulemaking, MM Docket No. 87-268 (rel. May 20, 1996) (proposing ATSC as the DTV standard); Advanced Television Systems and Their Impact Upon the Existing Television Broadcast Service, Fourth Report and Order, MM Docket 87-268 , FCC 96-493 (rel. December 27, 1996) (ATS Fourth Report and Order) (adopting ATSC as the new DTV standard).

[71] Congressional Research Service, CRS Report 96-401 SPR, Telecommunications Signal Transmission: Analog vs. Digital (discussing the differences between NTSC and ATSC standards); *see generally*, MICHAEL SILBERGLEID & MARK PESCATORE, THE GUIDE TO DIGITAL TELEVISION (2d ed. 1999) (discussing the technical advantages of digital television technology).

[72] *See* ATSC, *ATSC Standard: Program and System Information Protocol for Terrestrial Broadcast and Cable (PSIP)*, Document A/65:2009 (2009), available at http://www.atsc.org/cms/standards/a_65-2009.pdf (containing more details on the Virtual Channel Table).

[73] While new TV receivers sold after 2007 were required to include an ATSC tuner if an NTSC tuner was installed, the requirements were phased in gradually over the decade and admitted the possible need for the owner of an HD receiver to purchase a converter box or tuner to watch TV post-transition. *See* All-Channel Receiver Act (ACRA), 47 U.S.C. § 303(s) (1964) (implemented in FCC rules at 47 C.F.R. 15.115c and 47 C.F.R. 15.117b).

B. The Long, Slow March toward Transition

With the ATSC standard in place by the end of 1996, the pieces were in place for the FCC to reallocate broadcast spectrum among existing broadcast and new, non-broadcast users and to establish a deadline for stations to cease analog broadcasts and relinquish their licenses to excess spectrum.

1. Changes in Power Requirements and Spectrum Allocation

a) Existing License Holders

In 1997, the FCC adopted a DTV Table of Allotments that employed a "service replication/maximization" approach to provide existing broadcasters with DTV channel and power assignments that would replicate the quality and geographic area covered by their existing NTSC analog license.[74] The FCC calculated the power necessary to replicate a station's existing analog grade B broadcast contour with a DTV signal.[75] In its power calculations, the FCC attempted to balance the need to allow stations to compete effectively in the provision of DTV services while minimizing interference between stations and other services.[76] Each eligible full-power broadcaster was provided a second channel to broadcast DTV during the interim until the transition was completed, when broadcasters were required to relinquish one of the channels and return to broadcasting on a single 6 MHz channel.[77] The intent was for broadcasters to be "made whole" by the

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[74] *See* Advanced Television Systems and Their Impact Upon the Existing Television Broadcast Service, MM Docket No. 87-268, Sixth Report and Order, FCC 97-115, 12 FCC Rcd 14588 ¶ 12 (1997) (ATS Sixth Report and Order); *see also* 47 C.F.R. § 73.622. The table was released as an appendix to the Order. *See* ATS Sixth Report and Order, 12 FCC Rcd at 14693, app. B.

[75] NTSC TV broadcast coverage areas are defined by contours that define different levels of expected reception quality. *See generally,* O'Connor, R.A., *Understanding Television's Grade A and Grade B Service Contours,* BC-14 IEEE Transactions on Broadcasting 137-143, 10.1109/TBC.1968.265932, (Dec. 1968).

[76] *ATS Sixth Report and Order,* 12 FCC Rcd 14605-06, ¶ 30. Because broadcasting on the same channel in geographic proximity to another broadcaster can result in interference, from the beginning of broadcast regulation, the need to divide television channel licenses into geographic "markets" was prompted by concerns about interference.

[77] *See* 47 U.S.C. § 336(c) (requiring "that either the additional license or the original license held by the licensee be surrendered to the Commission"); *see also ATS Fifth Report and Order*, 12 FCC Rcd at 12849-50, ¶ 97. The additional channel for DTV operations was only made available to existing

replication of their existing analog service characteristics on their post-transition channel, which viewers could continue to identify as the original TV channel number using "virtual channels."

While one of the goals of the DTV transition was to replicate the pre-transition environment for broadcasters, the FCC noted that some broadcasters' post-transition channels would be entirely different than either their original NTSC analog channel or their interim second DTV channel.[78] In fact, the majority of full-power VHF stations would ultimately transition to UHF channels, with quite different propagation properties and power requirements. With stations transitioning to UHF channels, two engineering considerations became relevant for the power levels allowed by the FCC. For stations moving from a VHF channel to a UHF channel, higher power levels were necessary to replicate the original NTSC analog coverage area, given the general rule that higher frequencies require greater power to provide equivalent coverage.[79] On the other hand, error correction and other features of the DTV standard allowed the setting of lower power levels than those required for an equivalent NTSC signal.[80] The latter

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broadcasters. *See* 47 U.S.C. § 336(a)(1); *see also ATS Fifth Report and Order*, 12 FCC Rcd at 12815, ¶ 13; *see also* Budget Act of 1997, Pub. L. No. 105-33, § 3003, 11 Stat. 251, 265 (1997) (Budget Act). § 3004 (adding new § 337(e)(1) of the Communications Act) (directing that stations "may not operate at that frequency after the date on which the digital television transition period terminates, as determined by the Commission.").

[78] *ATS Sixth Report and Order* 12 FCC Rcd 14590-91, ¶ 3 n.6. Moreover, the FCC created its allotments to ensure service area "replication" but allowed stations flexibility in providing service within these new service areas. As discussed in more detail below, many stations in fact did not reach 100% coverage of their prior analog services areas.

[79] The FCC used procedures and techniques discussed in the Office of Engineering and Technologies Bulletin No. 69 in determining the appropriate power levels and in general discuss the phenomenon as the "dipole effect" defined for low-VHF, high-VHF, and UHF. *See* FCC OET, *Longley-Rice Methodology for Evaluating TV Coverage and Interference*, OET Bulletin No. 69 (Feb. 6, 2004) (OET Bulletin No. 69), *available at* www.fcc.gov/Bureaus/Engineering_Technology/Documents/bulletins/oet69/oet69.pdf. The Longley-Rice technique is widely used for predicting the geographic coverage of a radio system under certain conditions. *See* G.A. Hufford, A.G. Longley and W.A. Kissick, U.S. Department of Commerce, *A Guide to the Use of the ITS Irregular Terrain Model in the Area Prediction Mode*, Appendix, NTIA Report 82-100 (April 1982) (describing the software and modeling techniques used by the FCC for the Longley-Rice point-to-point radio propagation model); *see also* Circular letter to users of the model, dated January 30, 1985, from G.A. Hufford (identifying modifications to the computer program).

[80] Power levels were ultimately reduced less than was originally thought would be the case as field trials informed the engineering analysis.

consideration predominated in most cases, so that more stations saw their power requirements fall than rise.[81]

b) Reallocations and New Users

Another factor that influenced the selection of transitioning stations' channels was found in the other primary goal of the DTV transition—that of reallocating some broadcast spectrum for other uses. The Budget Act of 1997 required the FCC to reallocate 24 megahertz of spectrum in the UHF channels 60-69[82] for public safety services by January 1, 1998, and to make the remaining 36 megahertz of the band available for commercial use via competitive bidding (i.e, a spectrum auction) after January 1, 2001.[83] The FCC reallocated TV channels 63-64 and 68-69[84] to public safety radio services such as emergency dispatch.[85] The FCC reallocated TV channels 60-62 and 65-67[86] for fixed and mobile telecommunications and broadcasting, with the licenses to be assigned by competitive bidding. In addition, the FCC reallocated other spectrum, reducing the amount of spectrum devoted to television broadcast to a core spectrum of channels 2-51 after the end of the transition,[87] making channels 52-69 (totaling 108 MHz

[81] See *infra* § IV.A.

[82] These channels are the 746-806 MHz band.

[83] Budget Act, § 3004 (adding new § 337(a) and (b) of the Communications Act of 1934, as amended).

[84] These channels are the 764-776 MHz and 794-806 MHz bands, respectively.

[85] *See Reallocation of Television Channels 60-69, the 746-806 MHz Band*, ET Docket No. 97-157, Report and Order, 12 FCC Rcd 22953 (1998). As discussed in brief above, the FCC allocates spectrum on the basis of services such as for fixed or mobile use by public safety users regulated by FCC Rules in Part 90. In addition the FCC regulates users of some services in some bands on the basis of a priority of rights to protection, as "primary" or "secondary" users. *See* 47 C.F.R. et seq 2.106, Table of Allocations.

[86] These channels are the 746-764 MHz and 776-794 MHz bands, respectively.

[87] *See Second DTV Periodic Report and Order*, 19 FCC Rcd at 18292, ¶ 33. The "core spectrum" included the low-VHF channels 2 to 4 (54-72 MHz) and 5 to 6 (76-88 MHZ), VHF channels 7 to 13 (174-216 MHz) and UHF channels 14-51 (470-698 MHz), but does not include TV channel 37 (608-614 MHz), which is used for radio astronomy research. In order to protect sensitive radio astronomy operations, use of TV channel 37 was not allowed for NTSC or DTV service. *See DTV Sixth Memorandum Opinion and* Order, 13 FCC Rcd at 7419, ¶ 5; *see also* 47 C.F.R. § 73.603(c).

of spectrum) available for new uses.[88] The spectrum made available from these reallocations was highly sought after because of its valuable propagation characteristics.[89]

As discussed in more detail below, television broadcast use of channels outside the core spectrum was originally to be ended after May 2003, but the delay of the DTV transition date (ultimately to June 2009) by changes to the statute also delayed making available spectrum intended for public safety and commercial wireless uses. Furthermore, in some geographic areas broadcasters could not "move in" to their new spectrum until other stations "vacated the premises." In some cases, complicated cascading scenarios of stations vacating channels to be used by other users may have influenced broadcasters' decisions regarding when to turn off analog NTSC channels.

2. The Mandatory Transition to DTV and Cessation of Analog Broadcasting

The Congress and the FCC took steps to ensure that consumers would enjoy the benefits of DTV by adopting policies that encouraged and eventually required manufacturers and broadcasters to transition to the new standard. The policies encouraging compliance included the opportunities for broadcasters to develop temporary DTV operations on separate channels that were described in the previous section. However, achieving the ultimate goal of transitioning all broadcasting to the new DTV standard, and the concomitant freeing of broadcast spectrum for new uses, proved challenging. In this section we review the legislative history that structured the DTV transition, and the FCC regulations that specifically instructed stations how and when to transition.

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[88] Channels 52-59 were reallocated for new wireless services in 2001. *See Reallocation and Service Rules for the 698-746 MHz Spectrum Band (Television Channels 52-59)*, GN Docket No. 01-74, Report and Order, 17 FCC Rcd 1022 (2002).

[89] United States Government Accountability Office, *Digital Television Transition: Issues Related to an Information Campaign Regarding the Transition*, GAO-05-940R at 49 (Sep. 6, 2005).

a) Legislative History of the DTV Transition

Congress, in the Telecommunications Act of 1996, undertook the most significant revision of communications law since the establishment of the FCC.[90] In the section of the Act pertaining to broadcasting, Congress directed the FCC to provide new licenses (at no cost) to incumbent broadcasters for the provision of DTV broadcasting, under the condition that broadcasters would have to return either the new or original analog license at some date. The FCC issued some 1,600 licenses[91] and adopted mandatory dates that stations would have to "transition" to DTV broadcasting.[92] The deadlines depended on the size of the markets where the stations were located. Stations in the top 10 markets would have to transition by May 1, 1999; those in markets 11-30 by November 11, 1999; all other full-power commercial stations by May 1, 2002; and noncommercial stations by May 1, 2003. However, the FCC decided stations would not have to relinquish one of their channels and cease analog broadcasting until 2006.[93]

In the first of many modifications to and delays of the transition scheme, Congress revisited the issue in the Balanced Budget Act of 1997.[94] While the Act made statutory the regulatory requirement to cease analog broadcasting by the end of 2006, it relaxed the transition dates listed above by making "extensions" available. If 85 percent of households in any given market either did not have DTV-ready receivers or were

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[90] Telecommunications Act of 1996, Pub. L. No. 104-104, 110 Stat. 56 (1996) (adding section 336 to the Communications Act of 1934).

[91] The DTV spectrum that was given to broadcasters had an estimated value of between $11 billion and $70 billion. The 104th Congress debated whether to require the FCC to auction the DTV licenses, but in the end granted no authority to the FCC to auction the spectrum. Lennard G. Kruger, Congressional Research Service, *Digital Television: An Overview* (2006), available at http://www.opencrs.com/rpts/RL3126020060822.pdf, at 4.

[92] Advanced Television Systems and Their Impact Upon the Existing Television Broadcast Service, Fifth Report and Order, MM Docket No. 87-268, FCC 97-116 ¶ 76 (rel. April 21, 1997).

[93] *Id.*, ¶ 100. The FCC intention to require stations to cease analog broadcasting in 2006 was made statutory by the Balanced Budget Act of 1997 (Pub. L. No. 105-33, § 3003, 11 Stat. 251, 265 (1997))

[94] *See supra* note 93 .

subscribers of cable or satellite, the deadlines would not apply and the DTV transition in that market would not proceed.[95]

The distribution of licenses to existing licensees proceeded after an unprecedented engineering effort at the FCC that required a careful selection of channel allotments at precise power levels in each geographic market to prevent interference to non-broadcast services and broadcast stations alike. Many DTV licenses allotted spectrum in the UHF band, where higher power levels were necessary to maintain the equivalent service areas to the existing analog broadcast footprint.

In 2001, FCC Chairman Michael Powell formed the DTV Task force to track and facilitate early progress of DTV adoption. Early preparations for the transition indicated signs of concern. In the Dallas-Fort Worth area, tests by station WFAA with DTV in 1998 resulted in interference to 12 heart monitors at the Baylor University Medical Center. Additionally, stations complained of the significant cost of the transition. By 2002, about three-quarters of the 1,240 full-power broadcast stations had failed to meet their DTV construction requirements.[96] Stations complained of a variety of difficulties. Foremost among their concerns were difficulties acquiring approvals by local governments of new antenna towers and lack of funding for new facilities.

As 2006 approached, along with the date for relinquishing analog broadcast spectrum set in the Balanced Budget Act of 1997, Congress became increasingly concerned that the 85 percent "readiness" threshold would be met in few markets, preventing a timely transition. By 2005, only 3.3 percent of television households were capable of received DTV signals.[97] Debate began anew in Congress, not simply on extending the previous

[95] Balanced Budget Act of 1997, § 3003, amending 47 U.S.C. 309(j)). There were other conditions as well: if one or more of the television stations affiliated with the four national networks are not broadcasting a digital television signal; or if digital-to-analog converter technology is not generally available in the market of the licensee.

[96] General Accounting Office, *Telecommunications: Many Broadcasters Will Not Meet May 2002 Digital Television Deadline*, GAO-02-466, April 2002.

[97] *See* Evan Kwerel & Jonathan Levy, *The DTV Transition in the US, in* DIGITAL BROADCASTING:

deadline but instead focusing on adopting a new "hard" date that would not be subject to extensions or delays. In February 2006, the Deficit Reduction Act of 2005[98] set the first so-called "hard deadline," directing that the FCC terminate all analog television licenses by February 18, 2009.[99] Thus, February 17, 2009 was to be the final day of analog television broadcasting in the U.S.

Entering 2008, concerns arose in Congress again regarding the public's preparedness for the February 17, 2009 transition. In its report in November 2007, the Government Accountability Office concluded that no comprehensive plan or strategy to measure progress and results in the transition existed in the federal government, and that consumer outreach efforts were being conducted primarily by private sector stakeholders on a voluntary basis.[100] As the nation entered the final months before the February deadline, Congress' and President Obama's concerns about the NTIA's coupon program for DTV converter boxes[101] and general lack of preparedness of consumers grew. In response, the DTV Delay Act was signed into law a week before the erstwhile deadline.[102] The new deadline provided by the Act (and this time the final deadline) was June 12, 2009.

POLICY AND PRACTICE IN THE AMERICAS, EUROPE AND JAPAN 32 (Martin Cave & Kiyoshi Nakamura ed., 2002).

[98] Digital Television Transition and Public Safety Act of 2005 ("DTV Act"), Pub. L. No. 109-171, §§3001-3013, 120 Stat. 4, 21-28 (2006) (Title III of the Deficit Reduction Act of 2005, Pub. L. No. 109-171, 120 Stat. 4 (2006) ("DRA") (codified at 47 U.S.C. §§ 309(j)(14) and 337(e)) (amending Section 309(j)(14) of the Communications Act to establish February 17, 2009 as the hard deadline for termination of analog transmissions by full- power stations).

[99] *See* S. 1932, 109th Cong. §3002(b) (2006) (enacted).

[100] United States Government Accountability Office, Increased Federal Planning and Risk Management Could Further Facilitate the DTV Transition, GAO-08-43 (November 2007).

[101] The Department of Commerce's National Telecommunications and Information Administration (NTIA) administered the TV Converter Box Coupon Program authorized in the Digital Television Transition and Public Safety Act of 2005, P.L. 109-171 (2005). Households were eligible to receive two $40 "coupons" good towards the purchase of qualifying digital converter boxes. During the weeks leading up to the transition significant numbers of consumers were on a waitlist to receive coupons while expired coupons funds were recommitted and the overall total funding for the program neared exhaustion. *See generally* NTIA, TV Converter Box Coupon Program, http://www.ntia.doc.gov/dtvcoupon/ (last visited March 1, 2010).

[102] DTV Delay Act, Pub. L. No. 111-4, 123 Stat. 112 (2009); *see also Implementation of the DTV Delay Act, Report and Order and Sua Sponte Order on Reconsideration*, 24 FCC Rcd 1607 (2009); *and* Press Release, President Barack Obama, Statement of President Barack Obama on Signing the DTV Bill (Feb. 11, 2009), *available at* http://www.whitehouse.gov/the press office/Statementof

b) FCC Rules for Transitioning

From a regulatory perspective, the DTV transition was more complex than merely giving deadlines to broadcasters. Since some stations wished to cease analog broadcasting before the deadline, the FCC promulgated rules to allow the transition to proceed smoothly, without unduly hindering stations or creating confusion among consumers.[103]

Voluntary Early Transition

In December 2007, in a report and order on DTV matters ("Third Review R&O"), the FCC adopted rules allowing stations to transition in advance of the February 17, 2009 deadline then in effect.[104] The procedures allowed early termination of analog service, provided the change would facilitate certain goals of the transition. The procedures outlined eligibility requirements, required showings to the Commission, and requirements to inform viewers for early terminations prior to the last 30 days before the deadline. After the DTV Delay Act changed the transition date from February 17, 2009 to June 12, 2009, the same rules applied to the new deadline (with some modifications). The procedures for early termination vary slightly depending on the service but most importantly on *when* the change would occur.

Early Termination Prior to November 19, 2008

The Third Review R&O outlined rules for different service scenarios. One set of rules related to the termination or reduction of the existing analog NTSC service, and, in effect, governed the early DTV transition of a station.[105] The procedures for analog

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PresidentBarackObamaonSigningtheDTVBill/.

[103] The FCC also set rules for the television receiver equipment market, mandating that all devices intended for video reception (e.g., TVs and digital video recorders) manufactured after March 1, 2007, include an ATSC tuner. Certain categories of televisions had even early deadlines.

[104] *See* Third Periodic Review of the Commission's Rules and Policies Affecting the Conversion To Digital Television, MB Docket No. 07-91, Report and Order, FCC 07-229, 23 FCC Rcd 2994 (rel. December 31, 2007) (Third Review R&O).

[105] *Third Review R&O* 23 FCC Rcd 3045, ¶ 107.

termination are similar to the sets of rules for the other service changes, such as terminating ATSC service on the temporary DTV channel.[106] The first requirement is that stations must obtain approval from the FCC before making changes. Requests had to be filed 90 days in advance of the planned termination, and stations had to show that:

(1) The analog service reduction or termination was directly related to the construction and operation of its, or another station's, post-transition facilities; and[107]

(2) The station planned to notify viewers on its analog channel about the planned changes and inform them about how they can continue to receive the station.[108]

Appropriate notification of viewers of impending changes was an important component of the early termination procedures.[109] Notification was required to commence no fewer than 60 days prior to termination of the analog signal.[110]

The procedures also allowed most stations with an out-of-core DTV channel to terminate pre-transition digital service and transition directly from their analog to their post-transition digital channel (*i.e.*, "flash cut" approval)[111] and to move digital channels

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[106] As part of an early transition, stations terminating their analog and commencing DTV service on their analog channel or moving to a new channel for post-transition operations were also allowed to terminate existing digital service on their pre-transition DTV channels prior to the transition date.

[107] Examples identified as "directly related" to the construction and operation of post-transition facilities included: "(1) Stations that need to reposition their digital and analog antennas before the end of the transition; (2) Stations that need to add a third antenna to their tower but cannot do so without reducing or terminating analog service because the tower cannot support the weight of the additional transmission facilities; (3) Stations on a collocated tower that must coordinate a reduction or termination with other stations in order to configure their final, post-transition facilities; (4) Stations with equipment currently in use with their analog operations that they plan to use with their digital operations; and (5) Stations that must terminate operation on their analog channel in order to permit another station to construct its post-transition DTV facilities on that channel." *Third Review R&O* 23 FCC Rcd 3045, ¶ 116

[108] Notifications were required "every day on-air at least four times a day including at least once in primetime for the 60-day period prior to the planned service reduction or termination. These notifications must include: (1) the station's call sign and community of license; (2) the fact that the station is planning to or has reduced or terminated its analog or digital operations before the transition date; (3) the date of the planned reduction or termination; (4) what viewers can do to continue to receive the station, i.e., how and when the station's digital (5) information about the availability of digital- to-analog converter boxes in their service area; and (6) the street address, email address (if available), and phone number of the station where viewers may register comments or request information." *Id.*, ¶ 117.

[109] *See supra* note 108.

[110] *Third Review R&O* 23 FCC Rcd 3045, ¶ 114.

[111] *Id.*, ¶ 124.

to new channels.[112] The FCC viewed these early transitions favorably, identifying that they could facilitate the transition by freeing engineering, construction, and spectrum resources for those stations building later. Thus, early terminations were seen to advance the transition by setting in motion "daisy-chains" of early transitions, wherein as channels were vacated by a departing station they freed up space in the spectrum for an incoming station.

Early Termination from November 19, 2008 through February 16, 2009

The FCC provided streamlined notification procedures for stations terminating analog or digital broadcasting within 90 days of the February 17, 2009, transition date (i.e., beginning on or after November 19, 2008). The procedures required stations to file notification with the Commission 30 days in advance of the planned service reduction or termination. The station had to show that the change in service was necessary for purposes of the transition and to notify their viewers on their pre-transition channels about the planned service change and inform how consumers could continue to receive the station. The FCC did not require prior approval (as it had before).

Early Termination on February 17, 2009

The DTV Delay Act provided that stations that sought to terminate their analog service before the new June 12, 2009 deadline would be subject to the FCC's existing rules for early termination of analog service.[113] Given that until the Act was passed a

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[112] *Id.*, ¶ 121 (allowing moving from a pre-transition DTV channel to a post-transition channel, provided: "(1) The early transitioning stations will not cause impermissible interference to another station; and (2) The early transitioning stations continue to serve their existing viewers for the remainder of the transition and commence their full, authorized post-transition operations upon expiration of the February 17, 2009 transition deadline.")

[113] DTV Delay Act, § 4(a) ("Permissive Early Termination Under Existing Requirements—Nothing in this Act is intended to prevent a licensee of a television broadcast station from terminating the broadcasting of such station's analog television signal (and continuing to broadcast exclusively in the digital television service) prior to the date established by law under section 3002(b) of the Digital Television Transition and Public Safety Act of 2005 for termination of all licenses for full-power television stations in the analog television service (as amended by section 2 of this Act) so long as such prior termination is conducted in accordance with the Federal Communications Commission's requirements in

week before the erstwhile deadline stations were preparing to transition on February 17, 2009, the FCC waived generally the early termination requirements outline above for stations wishing to terminate on that day.[114] Stations were not required to submit pleadings or engineering data in support of requests to terminate analog service on February 17, 2009. Thus, stations that intended to transition and had incentive to do so were generally permitted to transition on the February 17, 2009 date. We discuss exceptions to this in section IV.B. About one-quarter of stations transitioned on this date of the original deadline, as we discuss in the empirical section below.

Early Termination after February 17, 2009

After the DTV Delay Act postponed the mandatory analog shutoff date from February to June, stations that sought to transition after February 17, 2009 were subject to the existing rules for early termination. In particular, an early termination 90 days prior to June 12, 2009 did not require FCC approval, but requests to terminate between February 18 and March 13 required advance approval and filings showing need. With no option to waive these requirements, stations effectively entering a *de facto* cooling off period immediately after the transition, with no stations transitioning between February 18 and March 13.

As of March 14, 2009 (90 days before the new statutory transition deadline), the streamlined notification procedures were again available to broadcasters. For stations terminating analog on or after March 14, the FCC required at least 30 days prior notification of termination date and viewer notifications for at least 30 days prior to the

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effect on the date of enactment of this Act, including the flexible procedures established in the Matter of Third Periodic Review of the Commission's Rules and Policies Affecting the Conversion to Digital Television (FCC 07–228, MB Docket No. 07–91, released December 31, 2007)").

[114] FCC Announces Procedures Regarding Termination of Analog Television Service On or After February 17, 2009: Termination Notifications for February 17, 2009 Must Be Filed By Monday, February 9, FCC 09-6 (rel. Feb. 5, 2009).

termination of analog service. However, stations transitioning after February 17, 2009 were subject to a number of additional public interest obligations.

Affiliates of the major networks—ABC, CBS, Fox and NBC—that wished to terminate analog service prior to June 12 were required to ensure that at least 90 percent of their analog viewers would continue to receive analog service from another major network affiliate through June 12. While the service could consist of continuing regular analog programming from one or more of the major network affiliates remaining on the air until the transition, service was also possible from an "enhanced nightlight" service making available (in analog) news, public affairs and emergency information from a major network affiliate. The Short-term Analog Flash and Emergency Readiness Act ("Analog Nightlight Act")[115] had required the Commission to develop and implement a voluntary program to "encourage and permit" analog television service for a 30-day period after the DTV transition for viewers who had not successfully transitioned by the deadline.[116] This voluntary program became required after the delay, except for noncommercial stations experiencing significant financial hardship that were allowed to terminate analog service beginning on March 27.

IV. Strategic Concerns of the DTV Transition

As the history of the legislative and regulatory action in the previous section documents, television broadcasters faced many choices of when to transition fully to DTV and turn off their analog transmissions. Like any business decision, the stations considered the costs and benefits of the various dates they were allowed to transition. This section reviews some of the primary factors influencing the stations' decisions.

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[115] Short-term Analog Flash and Emergency Readiness Act, Pub. L. No.110-459, 122 Stat. 5121 (2008) ("*Analog Nightlight Act*").

[116] The Analog Nightlight Act was enacted on December 23, 2008, prior to the enactment of the DTV Delay Act, Pub. L. No. 111-4, 123 Stat. 112 (2009), which changed the nationwide transition deadline from February 17 to June 12, 2009.

A. The Costs of the Transition for Stations

The two major cost considerations for a station contemplating the DTV transition are the cost of the new equipment necessary to begin digital broadcasting and the power savings from the cessation of analog transmission. All along, many stations complained about the high equipment costs of the transition. In 1999, Station KSTP-TV of Minneapolis-St. Paul reported spending about $1.5 million to upgrade its facilities for the transition,[117] religious network TBN spent $5 million upgrading its facilities in New York.[118] Some estimates placed the total costs of upgrading for the transition at around $1.7 billion for public television stations alone, which is greater than the annual income of such stations.[119]

On the plus side of a station's ledger are the lower electricity bills for broadcasting. As mentioned in section III.B.1.a) above, the switch to DTV had the potential to lower the power requirements needed for broadcasting. Our analysis of the station engineering data filed with the FCC indicates that the input power savings for DTV transmission over analog broadcasting was over five kilowatts (KW) for the average station.[120] Since by February 2009 stations had already begun DTV broadcasting, the relevant short-run power savings from completing the transition came from terminating analog broadcasting. Shutting down the analog transmission saved an estimated 40.3 KW of power for the average station, for an estimated reduction of about $2,500 in the monthly energy bill.[121]

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[117] *See* ROGER L. SADLER, ELECTRONIC MEDIA LAW 96 (2005).

[118] *See* George Winslow, *TBN Finishes HD Upgrade in Dallas* MULTICHANNEL NEWS, May 13, 2009, available at http://www.multichannel.com/article/232375-TBN_Finishes_HD_Upgrade_in_Dallas.php.

[119] *See* Current.org, Current Briefing: Digital Television and Public Television, http://www.current.org/dtv/ (last visited March 2, 2010).

[120] The average value of the difference in our estimate of the input power necessary for the analog and digital broadcasts of a station in our data is 5.6 KW (see Table 2). *See also infra* note 146.

[121] Assuming a station broadcasts an average of 22 hours a day for 30 days, and buys power at the state average commercial retail electricity price (data from 1Q2009), the average savings from turning off analog transmission is estimated from our data to be $2,575/month. This calculation does not include ancillary electrical costs of operating the transmitter such as de-icing equipment for the antenna, liquid chillers for transmission tubes, and environmental cooling (air conditioning) to remove the heat load from the transmitter.

Thus, by switching, stations could realize savings estimated to be perhaps several thousand dollars per month or more.[122] For the PBS network alone, the electricity cost savings for the February to June period were $22 million, which is the main reason most public television stations cited for transitioning in February.[123]

Many stations cited the high cost of maintaining duplicate analog and digital facilities to justify their requests to terminate the analog transmission. In some cases, engineering concerns prevented the use of the same antennas or other facilities for DTV as for analog broadcasting. In other cases, stations chose to construct separate facilities.[124] Older analog broadcast transmitters can be particularly expensive to maintain, since procuring replacement parts can be difficult, and even routine maintenance can require specialized engineering expertise. The costs of continuing to operate older facilities, created an additional business risk when maintaining an analog facility in tandem with a operational DTV facility.

Some costs of the transition were less certain for stations. In an era of declining broadcast viewership, stations were understandably skittish about losing viewers because of unforeseen technical problems or lack of readiness on the part of viewing households.[125] Furthermore, even if all went well with the transition, service footprints

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[122] Various industry sources provide monthly estimates of electricity cost savings per station ranging from several thousand dollars to $20,000 and higher (Andrew M. Seder, "WNEP to Keep Analog Signal Going", AP Newswire, February 19, 2009; Daily Press, "2 local stations plan to go digital Feb. 17," Daily Press (Newport News, VA) Via Acquire Media NewsEdge, February 10, 2009, available at http://www.tmcnet.com/usubmit/2009/02/10/3977517.htm; Jennifer Konfrst, "Why is IPTV continuing analog broadcasting past Feb. 17?" *Iowa Public Television* blog entry posted February 9, 2009, available at http://iowadigitaltv.blogspot.com/2009/02/why-is-iptv-continuing-analog.html?showComment=1234230120000). Conversations with FCC staff indicate that a savings of $20,000 would likely be extreme.

[123] *See* DiPaolo, Dan (2009). "WJAC to continue offering analog broadcast," Daily American, February 7, available at http://www.dailyamerican.com/articles/2009/02/08/news/news/news894.txt.

[124] For example, the TBN network stated that "we have a lot of legacy facilities that are aging and dying; and we decided that rather than keeping a limping facility together, we would just start from scratch and go HD from stem to stern" (Winslow, *supra* note 118).

[125] See, e.g., Dennis Haarsager, "Over-the-Air Strategies 2007-2009," presentation at 2007 PBMA Conference, May 31, 2007 (PowerPoint slides available at http://www.bloobble.com/broadband-presentations/presentations?itemid=433), warning that (at the time) many viewers lacked basic information about the DTV transition and that losing OTA-only viewers could translate to losing one-fifth of PBS

were changing in some locations, leading to a loss of some viewers. One study claimed that there would be "significant gaps" in DTV signal coverage across the country, since most consumers were unaware that they would have to add or upgrade their antennas.[126] As explained in section II.C.2 above, a loss of viewers translates into lost advertising dollars for stations, and thus represents a real (if uncertain) consideration for station managers.

B. Other Strategic Aspects of the Transition

In the economic models of stations' decision-making developed in the next section, we take the change in electricity costs and the potential to lose viewers as the salient strategic considerations for station managers. Since we consider the stations' decision made right before the erstwhile February deadline, we do not need to consider the stations' expenditure on new or upgraded facilities, since those were already in place. However, there are a few other factors that also may have influenced when stations turned off their analog broadcasts. Two of these are cost-sharing and coordination among broadcasters and explicit intervention by the FCC.

The costs of educating consumers about the DTV transition were a concern to broadcast stations. The FCC reported that, in many markets, broadcasters cooperated in funding and operating call centers, walk-in centers, and other consumer-education efforts. In some markets, some stations actively ran the facilities with their own staff, with other broadcasters participating passively in the efforts by providing funding.[127] As another

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members.

[126] Centris, *New Research Sheds Light on Major Glitch in the DTV Transition* , press release, New York, February 12, 2008, available from http://www.centris.com/pages/viewnews.aspx?newsID=34&SiteID=9. The Centris study claimed to use a more realistic engineering model of household reception than the FCC was using, and that the results showed that there was little continuous DTV coverage beyond 35 miles from the broadcast antenna.

[127] In the State of Oregon and in other parts of the country, Public Broadcast stations with existing facilities for handling large call volumes served as the call centers for the entire broadcast market. *See generally* Oregon Public Broadcasting, Digital TV Transition Happens today!, June 12, 2009, available at http://www.facebook.com/note.php?note_id=91606741957.

example of cost-sharing, stations in some markets actively coordinated the decision (and in some cases pooled resources) to satisfy the obligation for at least one station to continue analog broadcasting after all other stations switched to DTV.[128] In both examples, a passive firm might weigh an active firm's ability to recoup some value from operating the call center or remaining analog against the costs the firm would incur. We do not explicitly model these considerations.

In some cases, the flurry of regulatory activity in the final few weeks before February 17, 2009 resulted in stations not being able to transition when they wished. Although, as noted above, stations that wished to transition on February 17 were generally allowed to do so, the FCC reserved the right to require a station to continue its analog broadcasts under certain conditions. The FCC specifically stated it would consider such action if it found that most stations in a market were planning to terminate service, and that "the market is one in which many viewers are unprepared for the transition or at risk if the transition proceeds."[129] As late as February 10, the FCC was still reminding broadcasters that it could yet find some of their plans "contrary to the public interest,"[130] and its decisions were released the next day.[131] As a result, while 26 percent of the stations expressed the desire to transition on February 17, not all of them did so. About 10 percent (43) of the stations wishing to switch off their analog broadcasts on February 17 ultimately chose not to, thus avoiding having to comply with the additional requirements

[128] Implementation of Short-Term Analog Flash and Emergency Readiness Act; Establishment of DTV Transition "Analog Nightlight" Program, MB Docket No. 08-255, Report and Order, FCC 09-2 (rel. Jan 15, 2009) ("Analog Nightlight Order"). 121 stations were reported to have provided nightlight service in 87 markets after the June 12 transition.

[129] FCC Public Notice, *FCC Announces Procedures Regarding Termination of Analog Television Service On or After February 17, 2009*, FCC 09-6, February 5, 2009.

[130] FCC Public Notice, *FCC Releases Lists of Stations Whose Analog Operations Terminate Before February 17, 2009 or that Intend to Terminate Analog Operations on February 17, 2009*, DA 09-221, February 10, 2009.

[131] FCC Public Notice, "FCC Requires Public Interest Conditions for Certain Analog TV Terminations on February 17, 2009; Certain Stations Must Respond by Friday, February 13, 2009," FCC 09-7, (rel. Feb. 11, 2009) ("February 11th Public Notice").

placed upon them if they would have proceeded with the transition.[132] These stations may have deemed some of the extra requirements, such as continuing to operate walk-in consumer information and help centers and providing toll-free engineering support to viewers, to be more expensive than postponing the transition.[133] In the next section, we distinguish between the *desire* to transition early, based on the financial costs and benefits, and the actual *decision* to transition early, complicated by the last-minute regulatory intervention.

V. Economic Models of the Transition Decision

In this section, we present two economic models of the stations' decisions of when to transition to DTV. We consider both decision theoretic and game theoretic models. In both models, we assume a station's management considers its own costs and viewership when deciding to switch early. The game theoretic model, in addition, incorporates strategic thinking on the part of management (hereafter, the "station"). In particular, in the game, a station also looks to the decisions it expects other stations in its market to make, and considers the impact of the others' decisions on its profit. We test the implications of the models in the empirical work in the following sections.

A. Decision Theoretic Model

For clarity of presentation, we model a local television market with only two stations, labeled 1 and 2. Each station is assumed to want to maximize its profit during the transition period, and sets aside the impact of its current actions on profits after the transition period. A station earns profits by selling advertising at rate p per viewer.[134]

[132] FCC Public Notice, *FCC Releases Lists of TV Stations' Responses to Requirements for Analog Termination on February 17, 2009*, DA 09-245, February 13, 2009.

[133] The list of the eight measures the FCC required a station in one of the "unprepared" markets to fulfill in order to terminate on February 17, 2009, is contained in the *February 11th Public Notice*.

[134] Broadcast advertising prices within a DMA and daypart are largely proportional to the Nielsen point rating of a show (which measures viewership). Negotiations between advertisers and stations can lead to other prices, which we ignore in the model. We also set aside the fact that pq varies by daypart.

Revenue from advertising is pq, where q is the station's viewership.[135] A station incurs only fixed costs C to broadcast in the short run, which are of the form

$$C = F + wx \qquad (1)$$

where F includes labor, rent, capital, and other non-power costs, w is the price of electricity, and x is the amount of electricity used, which is a function of technical characteristics of the tower, antenna, and cooling systems used.

The action a available to each station is to transition early to digital broadcasting and turn off analog on February 17, 2009 (action $a = D$), or to continue analog broadcasting for the time being (action $a = A$). We refer to switching on or before February 17 as switching "early". Viewership may be affected by the decision. If station i switches to DTV early, assume that there is a chance that something goes wrong with the transition, so that when switching the station loses fraction ϕ_i of the original q_i^0 viewers in expectation.[136] Thus, the risk a station takes from action D is losing viewers. The benefit for the station of transitioning early is the power savings: $x_i(A) > x_i(D)$ (that is, it takes less power for station i to broadcast DTV than in analog). The ad price p, the price of electricity w, and the non-power cost F are invariant with respect to a station's action, the latter because this is a short-run analysis.[137] There is no economic switching cost, since every station was supposed to be ready to switch in February and the FCC required no additional filings to justify switching on February 17.[138] Thus, by the time that the switching decision was to be made, switching costs were already sunk. We leave out the

[135] We assume that ad prices per viewer will be unaffected by the transition.

[136] To be precise, $\phi_i q_i^0$ is the expected value of the number of lost viewers, and so incorporates all known changes in the broadcast footprint due to the transition as well as the probability of losing viewers due to unforeseen problems.

[137] We are also assuming that the transition decisions, which needed to be finalized in the space of about a week before February 17, were made without enough time to alter the engineering details of the two options facing the station. In other words, for purposes of our modeling we take ϕ to be exogenously determined.

[138] *See supra* § III.B.2.b).

possibility that the superior quality or additional video and audio channels enabled by DTV would increase viewership.

The profit, π, of station i, given its action a_i, can therefore be expressed as:

$$\pi_i(a_i) = pq_i(a_i) - C_i(a_i) \quad (1)$$

where

$$C_i(a_i) = F_i + wx_i(a_i) \quad (2)$$

$$q_i(A) = q_i^0 \quad (3)$$

$$q_i(D) = q_i^0 - \phi_i q_i^0 \quad (4)$$

In equations (1)-(4), q_i denotes the expected number of viewers for station i during the transition period. We assume that the stations are risk neutral.

Given the profit function, we can now examine a station's decision to switch to DTV. The expected payoff for station i is $\pi_i(A) = pq_i^0 - C_i(A)$ if it stays analog, or $\pi_i(D) = p(1 - \phi_i)q_i^0 - C_i(D)$ if it switches to DTV. For convenience, define $d_i = \phi_i p q_i^0$, the expected lost revenue from transitioning early, and define $\Delta_i = w[x_i(A) - x_i(D)]$, the cost savings from turning off analog. A station decides to switch early (action D) if and only if $d_i < \Delta_i$. This condition states that the benefits of transitioning (the cost savings Δ) outweigh the expected costs (d). The decision rule for switching to DTV, in the absence of strategic considerations, merely has the firm comparing its own costs and benefits of switching, regardless of the characteristics or expected decisions of the other station.

The empirical implications from the decision model are:

1. A station is more likely to transition early the greater is its Δ. This implies that higher energy cost savings from transition make the decision to transition early more likely.
2. A station is more likely to transition early the lower is its d. This implies that a lower probability of losing viewers and a lower amount of advertising revenue potentially lost make the decision to transition early more likely.

Each statement is to be understood holding other factors constant. We explore these implications in the following empirical sections.

B. Game Theoretic Model

The game theoretic approach to law and economics emphasizes the interdependency of payoffs in a multiple agent setting—in this case, the fact that one station's profit depends on the other station's decision.[139] In the game, viewership q for a station depends on *both* stations' actions. If station i switches to DTV early when the other station continues its analog broadcasting, the $\phi_i q_i^0$ viewers leaving the station are picked up by the other station.[140] If both stations stay analog or both switch, there is no change in viewership.

The profit of station i is now a function of both its and its opponent's actions:

$$\pi(a_i, a_j) = pq_i(a_i, a_j) - C_i(a_i) \quad (5)$$

where

$$q_i(A,A) = q_i(D,D) = q_i^0 \quad (6)$$

$$q_i(A,D) = q_i^0 + \phi_j q_j^0 \quad (7)$$

$$q_i(D,A) = q_i^0 - \phi_i q_i^0 \quad (8)$$

Given the profit functions, we can now examine a station's strategic incentive to switch to DTV. The payoff matrix for station 1 is:

[139] DOUGLAS G. BAIRD, ROBERT H. GERTNER, & RANDAL C. PICKER, GAME THEORY AND THE LAW 1 (1994).

[140] For simplicity, we assume there is no leakage of viewership to cable or satellite television. Around the time of the transition, industry observers expected few over-the-air viewers to switch to cable or satellite; *see* Virgil Dickson, *Time Will Tell: Too Early to Say Whether DTV is Pushing Consumers to DBS*, 29 COMMUNICATIONS DAILY, March 23, 2009, at 8-9. Nielsen estimates that about one-fifth of over-the-air viewers readied for the transition by subscribing to cable; *see* John Eggerton, *Nielsen: Viewing Rebounds After Early Post-DTV Decline,* BROADCASTING & CABLE, July 23, 2009, available at http://www.broadcastingcable.com/article/316241-Nielsen_Viewing_Rebounds_After_Early_Post_DTV_Decline.php. Modifying the model by assuming that a constant fraction of viewers "leak" to cable instead of going to the other station would change none of the predictions of the model.

		Station 2's Action	
		A	***D***
Station 1's profit	***A***	$pq_1^0 - C_1(A)$	$p(q_1^0 + \phi_2 q_2^0) - C_1(A)$
	D	$p(1 - \phi_1)q_1^0 - C_1(D)$	$pq_1^0 - C_1(D)$

If station 1 expects that station 2 will choose to stay with analog (action *A*), then (comparing the payoffs to 1 in the first column of the matrix) 1 chooses to switch early (action *D*) if and only if $d_1 < \Delta_1$, as in the decision theoretic model. If, instead, station 1 expects that station 2 will choose to switch early (action *D*), then (comparing the payoffs in the second column of the matrix) 1 chooses to also switch early if and only if $d_2 < \Delta_1$. If not, then the expected benefits to station 1 of letting station 2 move first (d_2) would outweigh the costs of transitioning and station 1 would stay with analog. In this case, the best response of station 1 is clearly strategic. When the other station is going to switch to DTV, station 1 recognizes that the other stations' viewers at risk are what matters for its decision; if something goes wrong with station 2's transition, some of its viewers will migrate to station 1.

The best responses for station 1 can now be summarized: if station 2 plays *A*, play *D* if and only if $d_1 < \Delta_1$; if station 2 plays *D*, play *D* if and only if $d_2 < \Delta_1$. The decision facing station 2 involves the same considerations and results in a similar set of best responses. While one can proceed to find the Nash equilibrium of the game,[141] the best responses already furnish us with the implications we wish to test. Note that implications 1 and 2 from the decision theoretic model also apply to the game theoretic model. The game provides an additional implication not found in the previous model:

3. When its rival switches to DTV, a station is more likely to transition early the greater the difference between its Δ and its rival's *d*. This implies that a lower

[141] Nash equilibrium depends on the relative sizes of Δ_1, Δ_2, d_1, and d_2. The various permutations of the magnitudes boil down to four cases for Nash equilibrium in pure strategies; *see* James Miller & James E. Prieger, *The Broadcasters' Transition Date Roulette: Strategic Aspects of the DTV Transition*, paper presented at Telecommunications Policy Research Conference, (Aug. 20, 2009), available at http://tprcweb.com/images/stories/papers/DTV%20paper%20TPRC%20version%20as%20submitted.pdf, at 24-25. The economic fundamentals in the market (viewership, costs, and the expected loss of viewership upon transition) determine into which case the market falls.

> expected number of the *rival's* viewers potentially gained (or the lower the value of the advertising revenue from those viewers) make the decision to transition early more likely.

VI. Empirical Examination of the Transition

In this section, we describe the data we collect on the U.S. broadcast television market and test the predictions of the economic models.

A. Data

To analyze stations' decisions and test the implications of our models, we gathered data from a variety of sources.[142]

1. *Stations' Decisions and Characteristics*

The stations' transition decisions are taken from FCC reports stating which stations had switched to DTV before February 17, which switched on that date, and which had planned to switch then but changed their decision in response to FCC action.[143]

The local viewing market, the state of location, network affiliation of a station, and viewership is from Warren's *TV and Cable Factbook* proprietary database.[144] Only full-power stations are included in our data. Viewership is measured as the number of noncable viewing households who watched the station at least once in the week, averaged over the weeks of Nielsen's sweeps month. Viewing households outside the home DMA of the station, if any exist, are included in the count. Since the count of noncable households includes subscribers to alternative distribution systems such as satellite, we adjust viewership by multiplying the figure by the fraction in the DMA of noncable

[142] No confidential FCC data are used, although some data come from proprietary industry databases as noted below.

[143] *See generally* Appendix A to *FCC Public Notice DA 09-221* (February 10, 2009) (for stations terminating analog broadcasting before February 17 and for stations planning to terminate on February 17); *see generally* Appendices to *FCC Public Notice DA 09-245* (February 13, 2009) (for which stations were allowed to actually terminate on February 17). *See also supra* § IV.B.

[144] All variables except viewership are from the online subscription database, and are current as of the decision time (February 2009). Viewership is from the 2008 printed copy of the Factbook; *see generally* Warren Communications News, TELEVISION AND CABLE FACTBOOK 2008 (2007).

viewers that receive programming over the air (OTA).[145] Our resulting measure is an estimate of q_i, the OTA viewership stations had before the February 2009 decision period. In the estimations we multiply the latter viewership variable by the ad price per viewer (described in the next section), to measure pq^0, the revenue importance of the viewership at stake.

We also gathered data pertaining to Δ_i, the change in the cost of the electricity input. We make one change from the theoretical model: since most stations were already broadcasting in DTV by February 2009, the change in the energy bill for a station comes from turning off the analog transmission. The change in the power requirement from completing the switch to DTV (measured as the input power required for the analog transmission) is estimated from public FCC sources.[146] The data needed to estimate the power requirement for analog broadcasting is available for only about 74 percent of commercial stations, which reduces the sample size of estimations including this variable. The price of electricity facing each station is taken to be the state average commercial retail electricity price for the first quarter of 2009, from the Energy Information Administration.[147] The product of the latter two variables is our estimate of the cost savings per hour of broadcasting from turning off analog transmission.

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[145] The latter variables are from the Television Bureau of Advertising website, TVB.org, and are for February 2009.

[146] The peak power transmitted by a station's digital and analog antenna can be found from the FCC's Media Bureau Consolidated Database System (CDBS); *see* FCC Media Bureau, Index of Media Bureau CDBS Public Database Files, http://www.fcc.gov/mb/databases/cdbs/ (last visited March 1, 2010). For analog stations this includes only the visual power transmitted. However, total peak power also includes aural power. Furthermore, to find the prime (input) power requirement for broadcasting, one must also consider the relationship between average and peak power and the "cabinet efficiency" in converting input power to RF. Based on discussions with staff from the FCC's Office of Engineering and Technology, we assumed that the aural/visual power ratio was 0.2 for VHF stations and 0.1 for UHF stations, that the cabinet efficiency was 0.7 for analog transmission and 0.5 for DTV, and that average visual power is 0.37 times peak visual power for analog transmission (the latter consideration is irrelevant for DTV). Starting with the "peak power transmitted" found in the CBDS, x, the assumptions imply that our estimate of prime power, y, is $y = (0.37 \times x + 0.2 \times x)/0.7$ for NTSC (analog) VHF stations, $y = (0.37 \times x + 0.1 \times x)/0.7$ for NTSC (analog) UHF stations, and $y = x/0.5$ for DTV stations.

[147] EIA, *Average Retail Price of Electricity to Ultimate Customers by End-Use Sector, by State, Year-to-Date through April 2009 and 2008 (Cents per kilowatthour) (Table 5.6B)*, ELECTRIC POWER MONTHLY, (July 10, 2009), available at http://www.eia.doe.gov/cneaf/electricity/epm/table5_6_b.html.

Two variables relate to ϕ_i, which is the expected fraction of viewers lost because of the transition. The FCC released estimates of the interference a station's digital broadcast was expected to receive from other broadcasts in the area, and we use the fraction of the DTV broadcast footprint so affected.[148] The second variable is an estimate of the loss in population covered by the broadcast of the station when switching to digital transmission is publicly available from the FCC for some stations, and known to be less than 2 percent for the rest.[149]

2. Market Information

We take the relevant market for a station to be the Nielsen DMA in which the station is licensed.[150] While a station's footprint does not exactly match a DMA, and not all stations overlap fully with each other within a DMA, the DMA is the standard market definition for television broadcasting in industry and in academic research.[151]

DMA level variables were collected from the *SRDS Media Solutions* database, which include demographic variables from Claritas and ad price data from SQAD.[152] We supplemented this primary source with data from Nielsen on the number of TV

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[148] *See* Appendix B to MO&O on Recon of the Seventh R&O and Eighth R&O, FCC-08-72 (rel. March 6, 2008).

[149] The coverage data are from the FCC; *see* FCC, Map Book For Full-Service Digital Television Stations Having Significant Changes in Coverage (archived Dec. 23, 2008), http://www.fcc.gov/dtv/markets/report2.html. The data on population covered is available for the 319 stations for which FCC analysis showed that more than two percent of the population covered by the station's analog service would not be covered by its digital service.

[150] The Designated Market Area is a geographic area defined by Nielsen Media Research Company. Each DMA is a group of counties comprising the major viewing audience for the television stations located in the metropolitan area. DMAs are substantially similar to the Standard Metropolitan Statistical Areas (SMSA's) defined by the Census Bureau. There are 210 DMAs in our analysis.

[151] *See generally* Keith Brown & Peter J. Alexander, *Market Structure, Viewer Welfare, and Advertising Rates in Local Broadcast Television Markets*, 86 ECONOMICS LETTERS 331–337 (2005).

[152] The ad prices are the SQAD Cost-Per-Point (CPP) in the DMA the previous quarter (4Q08). The ad prices per viewer that we use are derived from the CPP as follows. Let p = ad price per viewers, s = SQAD CPP, r = Nielsen rating points, V = viewing TV households, T = TV households, and A = ad price. The CPP's, when multiplied by the relevant Nielsen rating points, yield the average ad cost in the DMA, and so $A = sr$. Since one ratings point represents one percent of the total number of TV households, we have $r = 100V/T$. Since $p = A/V$, we have: $p = sr/V = 100s/T$. We observe both s and T in the data, and use them to thus calculate p.

households in each DMA,[153] from TVB on the number of OTA-only households,[154] and from the NTIA on the waitlists for DTV converter box coupons at the time of the transition.[155] We also collected data from a Nielsen report on the state of DTV "readiness" just before the transition, which are available only for a small subset of DMAs.[156] Two variables are available: the fraction of households that are completely and partially unready for the digital transition.[157] For use in DMA-level analysis, we calculated a weighted average electricity price (see above for source) based on the number of stations located in each state when a DMA spans states.

B. Empirical Results

We conducted our analysis at two levels: market and individual station. Summary statistics for the data are in Tables 1 and 2.

1. Market Level Analysis

We begin with a summary of the market-level transition decisions. We calculate the fraction of stations within each DMA that transitioned before, on, and after February 17, and present summary statistics for the 210 observations (one per DMA) of these variables in Table 3. On average in a DMA, 25 percent of stations switched on February 17. However, 28 percent of stations on average desired to switch on February 17, so about 3

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[153] *See* The Nielsen Company, Local Television Market Universe Estimates: Comparisons of 2008-09 and 2009-10 Market Ranks, http://en-us.nielsen.com/etc/content/nielsen_dotcom/en_us/home/measurement/tv_research.mbt.39577.RelatedLinks.13293.MediaPath.pdf (last visited August 1, 2009).

[154] Data are for February, 2009, taken from the Television Bureau of Advertising website; *see* TVB, Local Cable Reach Guide Feb'09, http://tvb.org/pdf/rcentral/Local_Cable_Reach_Guide_DMA_Interconnect_UEs_Feb09.pdf (last visited August 21, 2009).

[155] The NTIA data are from their web site; *see* NTIA, Coupon and Household Wait List By DMA, https://www.ntiadtv.gov/docs/Coupons_and_Households_by_DMA.xls (last visited Feb. 20, 2009).

[156] *See* The Nielsen Company, 5.7% of U.S. Households – or 6.5 Million Homes – Still Unprepared for the Switch to Digital Television (news release, January 22, 2009), http://blog.nielsen.com/nielsenwire/wp-content/uploads/2009/01/press-release-on-dtv-jan-2009_012209.pdf.

[157] Partially unready households have at least one television in the household able to receive DTV programming and one television that cannot. For a completely unready household, no television sets can receive DTV programming.

percent wanted to switch but changed their plans in response to the FCC's imposition of additional requirements. On average, 13 percent of stations had already switched before February 17, giving a total of 38 percent on average that switched on or before February 17. This means that about two of the eight stations in an average DMA switched on February 17, one station switched before that, and the remaining five waited until later to turn off analog broadcasting. There are some markets where no station switched, and other markets where all switched early. In both cases, particularly the latter, these are usually markets with few (or even only a single) stations.

For each statistic, the median is lower than the mean, implying that the distribution is not symmetric. For example, in the median DMA, one of five stations switched on February 17 and only 33 percent transitioned early. The full distribution is shown in Figure 1. This histogram shows that in 31 markets no station transitioned early, and in 13 markets all did. In the middle range, the weight of the distribution is toward the low end (representing not switching early).

To characterize how the decisions relate to market characteristics, we calculate correlation coefficients between the fraction of stations switching early (on or before February 17) and a host of demographic and economic variables. The results are in graphical form in Figure 2, with the correlation coefficient on the *y*-axis. Although we will mention which results are in accord with the theoretical models, the presentation is for descriptive purposes only. Some of the correlations may suggest but none imply causality, because the pairwise correlation coefficients do not control for other factors.

Panel (a) of Figure 2 shows that switching early is negatively correlated with the size of the market, whether size is measured by the number of stations, the number of households with televisions, households receiving OTA-only broadcasts (i.e., no subscription television), or total households, or the adult population in the DMA. All but the first correlation are significant.[158] These measures of market size are proxies for q^0 in d from the theoretical model, so finding that larger markets show less early transitioning is in accord with empirical implications 2 and 3 from the models. Note that with market-level data we cannot distinguish between the decision theoretic and game theoretic models.

In panel (b) we show that early switching displays a U-shaped correlation with age of the household head. For the youngest and oldest age categories, correlation is positive, while it is negative for the middle ages. While this may merely be an artifact of the data, the relationship is remarkable smooth. Given that one recent marketing survey[159] listed the Baby Boomer generation as the most sought-after advertising demographic, and Generation X as the next most sought after, perhaps the significant negative correlations for these groups reflect broadcasters' fears of losing these high-value viewers. This is the interpretation suggested by implications 2 and 3, since presumably ad price p is highest in areas with large proportions of viewers in these desirable demographic groups. Similarly, panel (c) shows that the highest income brackets also display negative correlation with early transitioning. High-income groups are also valuable viewers in terms of ad sales.

In panel (d) we look at the correlations with racial and ethnic composition. The only significant correlation is with the fraction of population that is Hispanic, which is negative. After Boomers and Gen X'ers, Hispanics are the third most sought-after demographic group for advertisers,[160] and were more than twice as likely as whites to be unready for the DTV transition,[161] and so this finding is also in accord with implications 2 and 3.

[158] Bars in the darker color on the graphs indicate the statistical significance of the correlation coefficient at the 5% level.

[159] *See* Anderson Analytics, Marketing Executives Networking Group (MENG) Releases First Annual Survey of Top Marketing Trends for 2008 (press release, Nov. 27, 2007), http://www.andersonanalytics.com/newsfiles/20071127.pdf.

[160] *Id*.

[161] As of February 1, 2009, 8.5 percent of Hispanic TV households were unready for the transition,

We next look in panel (e) at several variables associated with ϕ, the expected fraction of viewers lost from transition. Transitioning early is negatively (but not significantly) correlated with the number of coupon requests, households, and OTA-only households on the NTIA waitlist at the time of the transition (all taken as a fraction of the number of TV households in the DMA). Since these are measures of lack of readiness for the DTV transition, they serve as proxies for ϕ. Thus, implications 2 and 3 predict the negative correlation we find. Early switching is also negatively correlated with Nielsen's two measures of "unreadiness" for transition, the percentage of partially and completely DTV-unready households. Only the latter is significant, but these provide further evidence in accord with the models.

Finally, we look at correlation with ad prices in panel (f). Implication 2 predicts that higher ad prices will be associated with less early transitioning, and that is the case, although none are significant.[162] Not depicted in Figure 2 is the correlation with electricity prices, which is positive, in accord with implication 1, but is small and insignificant. The unemployment rate in the DMA is not significantly correlated with the transition decision, although to the extent that local economic conditions affect local ad prices the model suggests it might be.

In summary, the analysis of the DMA-level data shows that stations were less likely to switch to DTV-only broadcasting in markets where the cost of losing viewers was higher and where households were less ready for the transition. However, such results, while consonant with the implications of the economics models of the stations' decision-making, require further exploration. Given the correlation among many of the market and demographic variables, multiple regression techniques are required to make a

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compared to 4.1 percent of white households. *See* The Nielsen Company, 3.1% of U.S. Homes Still Unready for Digital Transition (news release, May 1, 2009), http://blog.nielsen.com/nielsenwire/media_entertainment/31-of-us-homes-still-unready-for-digital-transition/.

[162] The ad prices are split by daypart, which are Prime Access (6 - 7 PM), Prime (7 - 10 PM), Late News (10 - 10:30 PM) and Late Fringe (10:30 PM - 12 AM).

stronger case for the causal impact of any of these variables on stations' decisions. Furthermore, to distinguish between the decision theoretic model and the game, analysis must be conducted at the level of the station.

2. Individual Stations' Decisions

We turn now to our data on the decisions made by individual stations. There are 1,740 stations we analyze, which are the full-power commercial and non-commercial stations broadcasting at the time of the transition in the 50 U.S. states and Washington, D.C.[163] We begin with preliminary analysis of the stations' decisions, and then consider a regression framework to better identify which potentially causal factors matter.

a) Preliminary Analysis

Table 2 and Figure 3 show that 36 percent of the full-power stations transitioned early, switching on or before February 17.[164] Figure 3 reveals considerable variation among networks, however. The three traditional networks were more conservative than most others, switching early only 30-33 percent of the time. FOX and the CW were about average, while Ion and Univision were far below average (16 percent and 17 percent, resp.). PBS and stations in the "other" category (independents, non-PBS public or educational stations, and niche networks) were more likely to switch early than average (44 percent and 40 percent, resp.). PBS does not rely on paid advertising to generate station revenue, and its viewers may be less likely to turn to other networks should problems arise due to the unique nature of public programming. Thus, in terms of the models, the expected revenue cost of transitioning is probably lower for a PBS station, which may explain why so many of them wished to switch early. Finally, the network O&O stations were very unlikely to switch early: only 10 percent did so. The networks

[163] We do not include the stations from Puerto Rico, Guam, and the U.S. Virgin Islands in our data, although they appear in the FCC data.

[164] The figure differs slightly from the figure in Table 3 of 38% because the former is a simple average of stations, and the latter is an average over DMA's of the fraction within the DMA (an [unweighted] average of an average).

ABC, CBS, Fox, and NBC/Telemundo all agreed to delay their DTV transition to June for the stations they owned.[165]

In Figure 4 we break out the transition decision by the quartile of the size of the television market (based on Nielsen rankings of TV markets). As expected, larger markets are associated with a lower probability of switching early.

b) Regression Analysis

In the last part of this section, we present the results from several regressions of the decision to switch early on the station and market characteristics. The regression models allow us to hold constant other factors, allowing cleaner tests of the theory and stronger evidence for (although not proof of) causality.

All estimations are probit regression models with a binary dependent variable.[166] The dependent variable y takes the value one if the station transitioned early (or wanted to, depending on the estimation, as described below), and is zero otherwise. In a probit model with a vector of regressors x, the probability that $y = 1$ is $\Phi(x\beta)$, where Φ is the cumulative distribution function of the standard normal distribution and β are the regression coefficients. The *marginal effect* of a regressor is the effect of a one unit change in x on the probability that $y = 1$ (i.e., on the probability that a station switches early). In Tables 4 and 5 we present the marginal effects (and their standard errors) rather than the (less informative) regression coefficients.[167]

[165] *See* WLIO & WOHL Technology Blog Page, Network Owned Stations (February 9, 2009), http://www.wlio.net/index.php?m=02&y=09&entry=entry090217-073628 (citing NAB Smart Brief of Feb. 6, 2009). Most of the O&O's that switched were owned by ION and TBN.

[166] The regressions are estimated using Stata 11, with the "probit" and "margins" commands.

[167] In the familiar ordinary least squares model, the marginal effects are simply the regression coefficients. In nonlinear models such as probit, the two differ. We compute the marginal effects in the tables as the average marginal effects in the sample, using discrete changes in x for binary regressors and derivatives for continuous regressors. *See* WILLIAM H. GREENE, ECONOMETRIC ANALYSIS §19.3 (4th ed. 2000).

Analysis of All Stations' Decisions

In the first two estimations, in Table 4, the dependent variable is 1 if the station actually transitioned early, regardless of what its earlier plans were. Estimation 1 includes all stations, including noncommercial stations and those which had already transitioned before February 17. Given that the latter are not strategic players in the game modeled above, the results from Estimation 1 are meant to be descriptive only.

In Estimation 1 in Table 4, the size of the market at risk, as measured by the number of OTA-only TV households in the DMA, network indicators, and demographic variables are included. We use OTA-only households to proxy q in the model instead of total television households (which includes cable and satellite viewers) because OTA viewers are the ones at risk of switching to another station if problems with the transition develop. In Estimation 1, we do not use the station-specific viewership variable, because it is not available for noncommercial stations. A second variable captures the fraction of television households in the DMA that are OTA-only. Although the models above suggest that only the number of OTA viewers matters, not the proportion of viewers that are OTA-only, we include it to account for possible risk aversion on the part of the station (the phenomenon of shying away when "too many eggs are in one basket"). If this form of risk aversion is present on the part of the stations, then even after controlling for the level of OTA-only viewership, the fraction of OTA viewers will have an additional negative impact on the likelihood of switching early.

We also control for the number of stations in the market. Given that we do not vary the number of stations in the theoretical models, we add this variable to the econometric models to control for heterogeneity among markets and have no expectation concerning its sign. The demographic controls included are related to the racial composition, ethnicity, age, and income in the DMA.

In accord with our models and the results discussed above (see discussion of Figure 2(a)), market size (as measured by the number of OTA-only households in the DMA) has a large, significantly negative impact on the decision to switch early. The marginal effect of -0.67 for the OTA households variable, which is denominated in millions, implies that an extra million OTA households in the DMA is associated with a 67 percentage point decrease in the probability that the station switches early. The fraction of OTA-only viewers in the DMA has a negative impact, in line with the notion of risk aversion, but it is not statistically significant. We do not include this variable in the following estimations.

The coefficients for the network variables are in accord with the results in Figure 4. The largest impact among the network variables is for network O&O's. Other things equal, if a station is an O&O it is 26 percentage points less likely to switch early. Consistent with the correlations we found in the DMA-level analysis, and consistent with the implications of the model, we find significant negative coefficients for Hispanics, the prime age group, and high-income households. Since these variables are proportions, the marginal effects are the increase (in percentage points) of a one percentage point increase in the regressor. For example, the marginal effect of -0.40 for Hispanics implies that an extra percentage point of the DMA population that is Hispanic lowers the probability that a station in the DMA switches early by 0.4 percentage points, *ceteris paribus*. The coefficient for the Asian group is positive, possibly indicating that advertisers perceive them to be a less-desirable demographic segment,[168] but more likely due to the outlying observations from Hawaii.[169]

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[168] The marketing report cited above did not rank Asians among the highly sought after demographic groups; *see* Anderson Analytics *supra* note 159. Asian Americans have also been called the "invisible" demographic on-screen in broadcasting; *see* Michael Hong, *The Invisible Asian-Americans*, 135 BROADCASTING & CABLE, January 17, 2005, at 78).

[169] All Hawaiian stations switched early, and the Honolulu DMA has a fraction of Asians that is twice as high as the next highest DMA. If Hawaii is dropped from the sample, then the Asian marginal effect loses statistical significance.

Analysis of Commercial Stations' Decisions: Actual Transitions

In Estimations 2 through 4, we limit the sample to commercial stations. The models above tacitly assumed that stations are run commercially for profit, and the profit calculus for noncommercial stations (chiefly PBS stations) may differ. For example, one would not expect ad prices to matter for PBS and educational stations, and including noncommercial stations in the sample would partially obscure the impact of regressors involving ad prices. In the following estimations, we replace the DMA-level market size with the station-specific variable for the OTA viewership (which is available only for commercial stations), multiplied by the advertising price per viewer for a local prime time ad. The latter variable, denoted "OTA viewership revenue/ad" in Tables 3 and 4, is the revenue per ad (in $1000's) at risk from the transition. Empirical implication 2 from the models suggests that higher ad revenue at risk (due to either higher ad prices per viewer or more viewers) should decrease the likelihood of switching early. We also replace the count of stations with the number of commercial stations in Estimations 2 through 4.

In Estimation 2, also in Table 4, the marginal effect of *OTA viewership revenue/ad* is negative and highly statistically significant, as suggested by the theory. The marginal effect of -0.21 means that when the ad revenue per ad from OTA viewers for the station rises by one thousand dollars per ad, the likelihood the station switches early falls by about a fifth of a percentage point.[170] Thus, when the opportunity cost of switching from the financial impact of potentially lost viewers rises, stations are significantly less likely to switch early.

Also new to Estimations 2 through 4 is a variables pertaining to the stations' benefits from switching. We include the power savings from turning off analog transmission multiplied by the electricity price, denoted *Electricity Price* × *Power* in Tables 4 and 5.

[170] An increase in *OTA viewership revenue/ad*ad of $1,000 corresponds to an increase of one-third of a standard deviation of this variable.

Due to the skewed nature of the power cost savings, it enters the regression in log form. In Estimation 2, we find a positive and statistically significant coefficient for the power cost variable, as expected from empirical implication 1 from the models. The marginal effect of 0.042 for the log of *Electricity Price* × *Power* implies that when the regressor doubles (a 100 percent increase) it increases the probability of switching early by 4.2 percentage points. Thus, when the benefit to switching from reduced operating costs rises, stations are more likely to switch.

Analysis of Commercial Stations' Decisions: Desired Transitions

Since we want to focus on the strategic aspects of the decision as modeled above, rather than outcomes influenced by regulatory decree apart from direct profit considerations, we further refine our dependent variable and sample for Estimations 3 and 4 (Table 5). The dependent variable is these estimations is the decision made to transition early, before the FCC intervened in the final week and some stations backed away from their plans they had announced earlier. Any station that had already transitioned before February 17 is removed from the sample, since their decision was already made and they neither face the decision problem nor play the strategic game modeled above. There are still over 800 stations in the sample for Estimation 3.

The impacts of the variables included in Estimation 2 pertaining to the stations' benefits and costs from switching are similar in Estimation 3. That is, the significance and magnitude of the marginal effects of *OTA viewership revenue/ad* and *Electricity Price* × *Power* are about the same in Estimations 2 and 3. The new variables in Estimation 3 are two pertaining to the expected fraction of viewers lost through the transition (ϕ_i in the theory models). As such, we expect their coefficients to be negative. The first is the expected interference with a station's DTV broadcast from the other stations in the DMA. The impact of the interference is negative as expected but insignificant in Estimations 3 and 4.

The other variable related to ϕ_i is the fraction of potential analog viewers that would not be able to receive a digital broadcast (*% Pop. lost by transition*). Since the variable is not observed in the public FCC data when it is under two percent of the population, in the regression specification we let those stations be the omitted category and allow the other stations' variable to enter as a two-part linear spline.[171] The spline was found to be necessary to remove the undue influence of a few outliers (the top 2 percent of observations). The main part of the spline, for stations potentially losing between two and 32 percent of their analog viewers, has a statistically significant and negative marginal effect. The magnitude of the effect implies that when the population losing the station's broadcast increases by one percentage point in this region, the station's likelihood of switching decreases by 0.81 percentage points, *ceteris paribus*. The marginal effect for the top part of the spline is positive but not even close to being statistically significant. Thus, in accord with the models, the variables capturing the danger of losing viewers during the transition are generally associated with a lower likelihood of switching.

The first three estimations explore variables pertaining to the first two empirical implications, which apply equally to the decision theoretic and game theoretic models. To explore specifically whether stations are acting strategically, we test implication 3 from the game theoretic model by including in Estimation 4 three variables that pertain to d_j, a station's *rival's* revenue cost of switching early. Recall that when the rival switches early and puts its viewers at risk, the rival's loss becomes the station's gain. Implication 3 suggests that when the rival switches early, a variable pertaining to d_j should have the same impact on a station's decision as if it pertained to d_i—that is, was a station's own characteristic. We include variables measuring the average of the OTA viewership revenue per ad, the DTV interference, and the population lost by switching for the *other*

[171] For a discussion of splines in regression, *see* GREENE, *supra* note 167, at §8.2.6.

stations in the DMA. Since implication 3 applies only when the rival switches early (because that is the only way a station might gain their viewers), when calculating the averages we include only other stations that wished to switch early.[172] The game implies that each of these variables should have negative marginal effects.

If the stations are not acting strategically, and pay no attention to their rivals' expected actions, then characteristics of the other stations in the DMA should have no impact on a station's decision. However, for a clean test of this hypothesis, we need to correct for potential endogeneity of the other stations' characteristics. Since only stations switching early are included in the average of other stations' characteristics, if there are unobserved causal factors in the DMA that affect all stations' incentives to transition, then the new variables in Estimation 4 will be endogenous in the regression. Such endogeneity would invalidate the results of probit estimation, by finding a link between rival's characteristics and the decision of a station to switch that is driven by the unobserved common factor in the DMA rather than the strategic interactions we wish to isolate. Our solution is to add DMA-level fixed effects to the estimation, removing the influence of unobserved factors in the DMA.[173] A consequence of using a fixed-effects estimation is that any variable not varying within the DMA (such as the demographic variables) is absorbed into the fixed effects, and any observations from any DMA with no

[172] A possible objection to only including other stations that wanted to switch early is that a station would not observe which those would be until after its own decision had to be made. However, in the Nash equilibrium of a full information game such as ours, each player chooses its best action in response to what it expects the other players to do, and its expectations turn out to be correct.

[173] *See* BADI H. BALTAGI, ECONOMETRIC ANALYSIS OF PANEL DATA §2.2 (3d ed. 2005) (for fixed effect models generally), § 11.1 (for the probit fixed effect model). In general, fixed effects models remove the endogeneity problems caused by variables that are correlated with unobserved factors common to the unit of observation (the DMA, in our case). There is a technical issue regarding the asymptotic properties of the probit fixed effects model that affects the consistency of the regression coefficients (the "incidental parameters problem"). We use the probit model nevertheless in Estimation 4 for consonance with the previous estimations. When the specification in Estimation 4 is estimated with either the linear probability fixed effects model or the conditional logit model (results not shown), neither of which suffers from the incidental parameters problem, our conclusions regarding the sign and significance of the marginal effects of the strategic variables are unchanged.

variation in the dependent variable are dropped. This reduces the sample size to 504 stations in Estimation 4.

The results in Estimation 4, also in Table 5, are in line with the game theory, suggesting that stations are indeed acting strategically. The more ad revenue from OTA viewers the rival stations transitioning on February 17 have, the less likely a station is to switch itself. The impact is large (twice as large as the marginal effect of the station's own ad revenue variable) and statistically significant at the 1 percent level. Furthermore, the more population lost by rival stations, the lower the probability that a station transitions early. The marginal effect is again larger than the own-station variable's impact and is highly significant. The impact of the interference the rival stations are likely to have is negative, in accord with the theory, but statistically insignificant. For all three of the "strategic" d_j variables, which are jointly statistically significant,[174] the marginal effects are larger than impact of the corresponding d_i variable, highlighting the importance of the strategic considerations. The signs of the other variables in Estimation 4 are similar to those in Estimation 3.[175]

VII. Conclusions

Throughout the history of the broadcast industry, regulators have faced difficult decisions in determining how best to fulfill their statutory mandate to serve the public interest when changing technology promises new benefits for consumers but threatens to

[174] A test of the joint statistical significance of the three variables new to Estimation 4 returns a chi-square(3) statistic of 42.9, with a *p*-value of nearly 0.

[175] Some readers of early versions of this article noted that since stations faced many times when they could have chosen to switch to DTV before February 17, 2009, that perhaps the econometric model should account for the multiple decision periods. One way to do this is to change the dependent variable to an ordinal variable taking value 0 if switched after February 17, 1 if switched on February 17, and 2 if switched before then. Then an ordered probit model can be used in place of the simple probit. Repeating Estimations 2 and 3 with this new definition of the dependent variable and the ordered probit model yields results that are substantially similar to those presented in Tables 4 and 5. In particular, the coefficients of the viewership, power cost, and ad price variables that are significant in the probit model are also significant (with the same signs) in the ordered probit model. The exception is the *% Pop. lost by transition* variable, the coefficient of which has the same sign as in the probit model but is not significant in the ordered probit model.

leave some behind. While we have focused on the DTV transition, issues such as standard setting, coordination of industry and consumers on all sides of a network market, backward compatibility, and the proper balance between economic incentives and regulatory compulsion have arisen in many situations. Some innovations, such as FM radio broadcasting, color television, or the use of the telephone network for Internet access, have succeeded in the marketplace, while others (e.g. AM stereo radio) have failed. Regardless, regulators are better able to design appropriate rules—and to evaluate the success of the regulatory efforts—when they understand the financial and strategic incentives facing industry participants.

The models introduced in this article prove to be useful tools for understanding the strategic thinking of the broadcasting entities. The decision theoretic model formalizes the natural intuition that stations choose to transition earlier when the benefits are higher or the costs are lower. Empirical testing of the model yields results that are in line with the predictions. A more interesting (and less obvious) set of results comes from the game theoretical model, which shows that when a station's management also considers what its rivals will do, the audience size of the other stations (as well as the chances that the station might gain some of these viewers) becomes strategically important.

One insight from the game is that when many players (or, equivalently, players with a large share of consumers) are expected to switch to the new technology early, the incentives for other players to delay increases. These strategic incentives make it more difficult than it otherwise would be for all players in a market to coordinate their actions on adopting the new technology. In situations where the regulator wishes the transition to proceed uniformly, it may want to give more preference to mandatory cutoffs than to purely voluntary measures in such cases. In the present case of the DTV transition, however, the strategic incentive for some stations to delay was in accord with the FCC's desire to protect consumers in certain “at risk” markets by ensuring that some analog viewing options remained temporarily after February 2009.

Given that today’s technological *dernier cri* may quickly become yesterday’s obsolete historical curiosity, it is certain that the DTV transition will not be the final technological sea-change that the FCC will oversee, perhaps even in broadcasting. Insights gained from this examination may thus provide useful to future regulatory endeavors.

Variable	Mean	Std. Dev.	Min	Max
stations	8.319	5.204	1.000	27.000
TV households	545,032	831,576	3,940	7,433,820
OTA-only households	60,207	87,275	370	798,570
households	551,089	825,845	4,000	7,546,000
Adult pop	1,105,026	1,733,035	7,600	15,900,000
age0_18	0.002	0.001	0.000	0.005
age18_24	0.056	0.015	0.029	0.142
age25_34	0.158	0.017	0.113	0.220
age35_44	0.182	0.018	0.100	0.236
age45_54	0.207	0.013	0.162	0.271
age55_64	0.170	0.012	0.131	0.212
age65up	0.225	0.035	0.111	0.369
white	0.810	0.124	0.288	0.976
black	0.097	0.107	0.000	0.592
asian	0.024	0.041	0.000	0.507
race_other	0.068	0.067	0.010	0.355
Hispanic	0.096	0.145	0.004	0.940
HH income $10-20K	0.132	0.027	0.058	0.206
HH income $20-35K	0.229	0.026	0.133	0.278
HH income $35-50K	0.196	0.015	0.152	0.229
HH income $50-75K	0.187	0.024	0.117	0.235
HH income $75-100K	0.094	0.025	0.048	0.167
HH income $100-125K	0.030	0.013	0.010	0.083
HH income $125-150K	0.016	0.008	0.004	0.053
HH income above $150K	0.023	0.012	0.007	0.085
female	0.512	0.010	0.474	0.532
Commercial Electricity Price	9.539	2.441	6.090	20.890
Unemployment rate	0.064	0.024	0.029	0.274
Ad price/viewer, prime access	0.025	0.023	0.008	0.305
Ad price/viewer, prime	0.046	0.049	0.016	0.635
Ad price/viewer, late news	0.032	0.032	0.012	0.431
Ad price/viewer, late fringe	0.024	0.032	0.007	0.431
NTIA waitlist: coupons	0.036	0.011	0.008	0.080
NTIA waitlist: households	0.020	0.006	0.005	0.042
NTIA waitlist: OTA-only HH's	0.009	0.003	0.002	0.020
% HH's partially unready	12.634	3.919	4.930	22.170
% HH's completely unready	5.400	2.275	1.760	12.240

Table notes: there are 210 DMAs. All variables are observed for each DMA except the Nielsen unreadiness figures, which are available for 56 markets.

Table 1: Summary statistics for the DMA level data

Variable	Obs	Mean	Std. Dev.	Min	Max
Switched on Feb. 17, 2009	1,740	0.236	0.425	0.000	1.000
Desired to switch on Feb 17	1,740	0.261	0.439	0.000	1.000
Switched before Feb. 17	1,740	0.124	0.329	0.000	1.000
Switch on or before Feb. 17	1,740	0.359	0.480	0.000	1.000
OTA-only households in DMA (M)	1,740	0.096	0.125	0.000	0.799
OTA viewership of station (M)	1,245	0.029	0.051	0.000	0.498
OTA viewership revenue/ad ($K)	1,245	1.175	2.968	0.000	37.455
Stations in DMA	1,740	11.549	6.176	1.000	27.000
Commercial stations in DMA	1,374	9.217	5.155	1.000	25.000
Network: ABC	1,740	0.122	0.327	0.000	1.000
Network: CBS	1,740	0.126	0.332	0.000	1.000
Network: NBC	1,740	0.128	0.334	0.000	1.000
Network: FOX	1,740	0.111	0.314	0.000	1.000
Network: CW	1,740	0.057	0.232	0.000	1.000
Network: ION	1,740	0.035	0.184	0.000	1.000
Network: PBS	1,740	0.203	0.402	0.000	1.000
Network: Univision	1,740	0.024	0.152	0.000	1.000
Hispanic	1,740	0.108	0.141	0.004	0.940
Asian	1,740	0.036	0.068	0.000	0.507
Black	1,740	0.098	0.100	0.000	0.592
Other race	1,740	0.078	0.070	0.010	0.355
Age 25-54	1,740	0.554	0.035	0.434	0.637
Household Income > $100,000	1,740	0.079	0.039	0.022	0.219
Commercial Electricity Price (cents/KWH)	1,740	9.688	2.784	6.090	20.890
Ad price/viewer, prime ($)	1,740	0.037	0.023	0.016	0.635
NTIA waitlist (households)	1,740	0.020	0.005	0.005	0.042
Estimated input power (analog, KW)	1,300	40.270	65.684	0.000	1342.9
Electricity Price × Power (log)	1,299	-1.447	1.162	-7.732	2.988
Power savings, digital vs. analog (KW)	1,030	5.600	4.671	-134.9	1310.3
% DTV interference (pop.)	1,738	0.017	0.045	0.000	0.565
% pop. lost by transition is observed	1,740	0.163	0.370	0.000	1.000
% pop. lost by transition (when observed)	284	0.108	0.113	0.020	0.714

Table notes: the variable "% pop. lost by transition" is observed in the FCC public data only for stations for which it is greater than 2%.

Table 2: Summary statistics for the Station level data

Variable	Mean	Median	Std. Dev.	Min	Max
Fraction of stations in DMA that:					
Switched on Feb. 17	0.247	0.2	0.235	0	1
Desired to switch on Feb 17	0.283	0.222	0.258	0	1
Switched before Feb. 17	0.133	0	0.207	0	1
Switch on or before Feb. 17	0.380	0.333	0.292	0	1

Table 3: Summary Statistics for Stations' Decisions to Turn off Analog Broadcasting

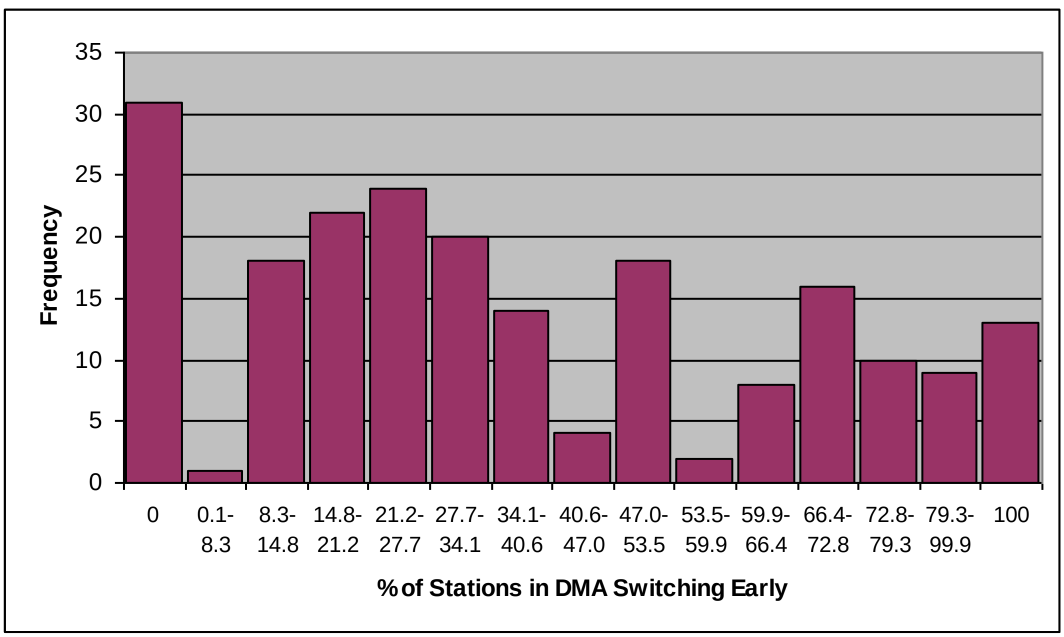
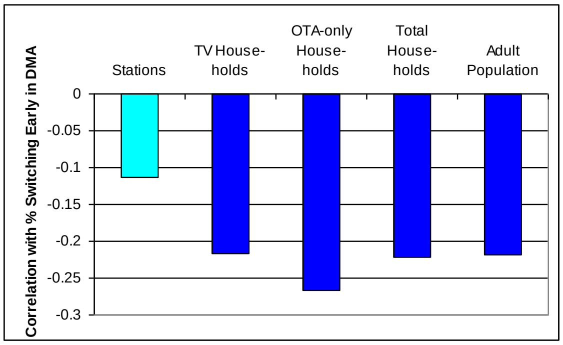
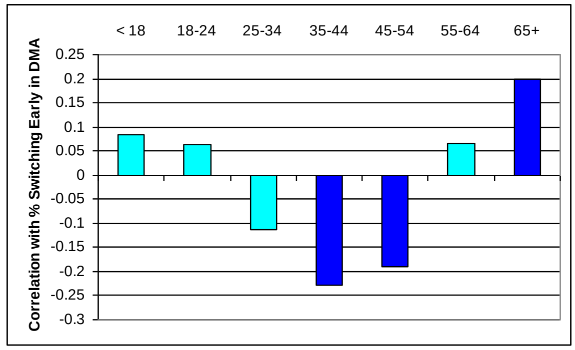


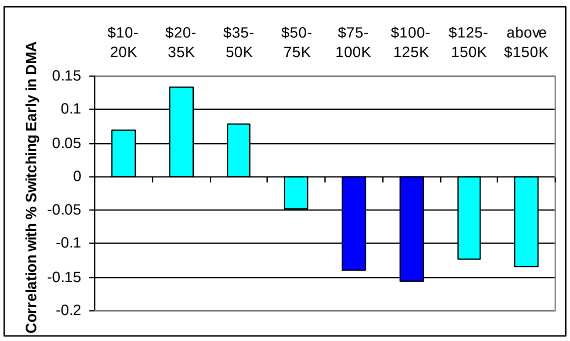
Figure 1: Histogram of Stations' Decisions to Switch Early



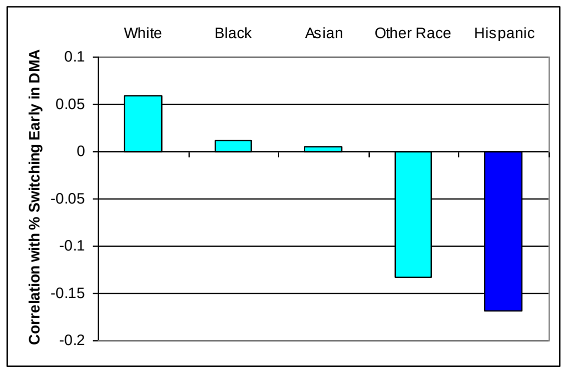
(a) Correlation with Size of Market



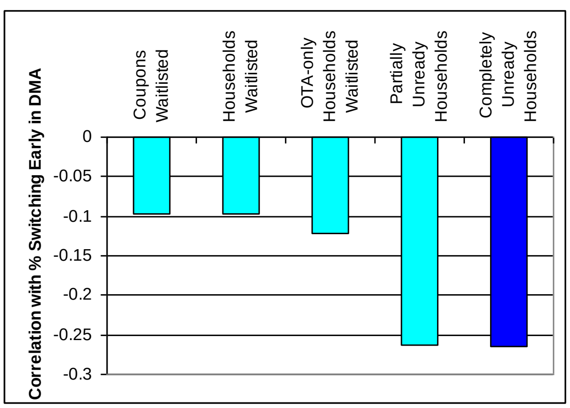
(b) Correlation with Age of Head of Household



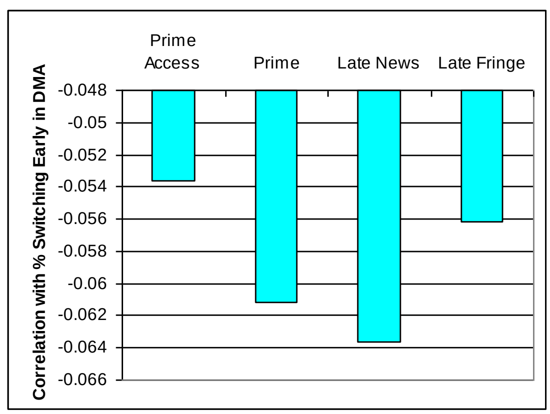
(c) Correlation with Household Income



(d) Correlation with Race and Ethnicity



(e) Correlation with NTIA Waitlist for Converter Coupons and Household DTV Readiness



(f) Correlation with Ad Price per Viewer, by Daypart (SQAD Data)

Note: lighter bars indicate that the correlation is not statistically significant at the 5% level.

Figure 2: Correlation of Stations' Decisions to Stop Analog Broadcasting Early with Various Factors (DMA level data)

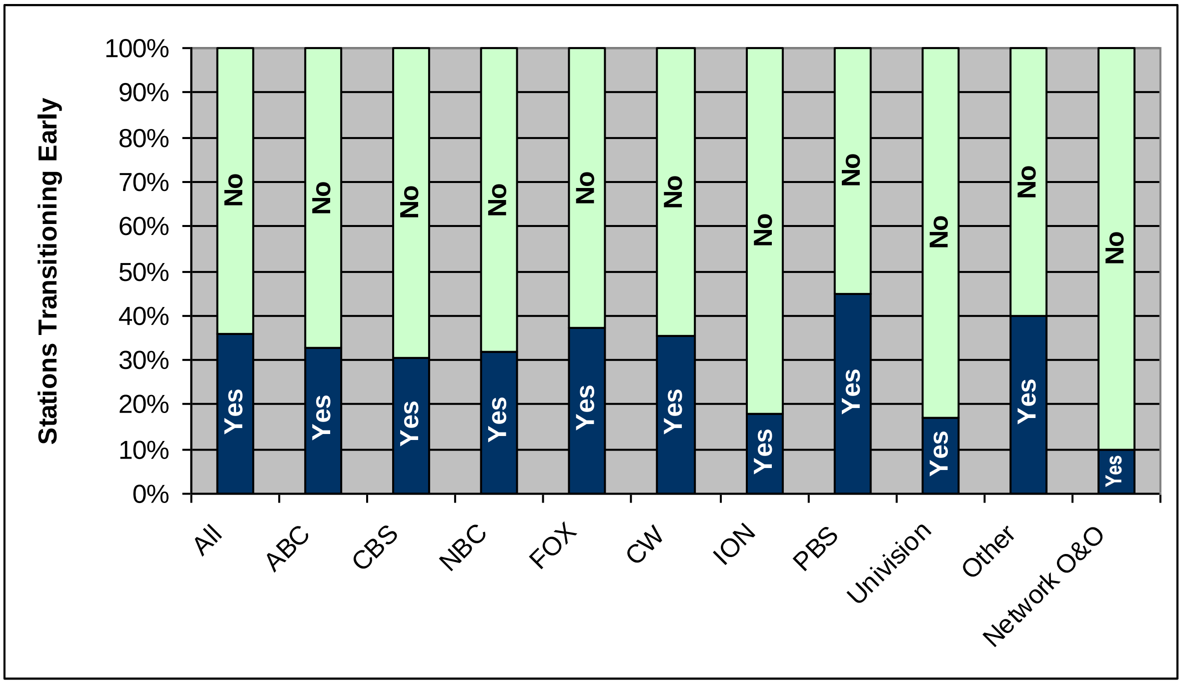


Figure 3: Transition Decisions by Network

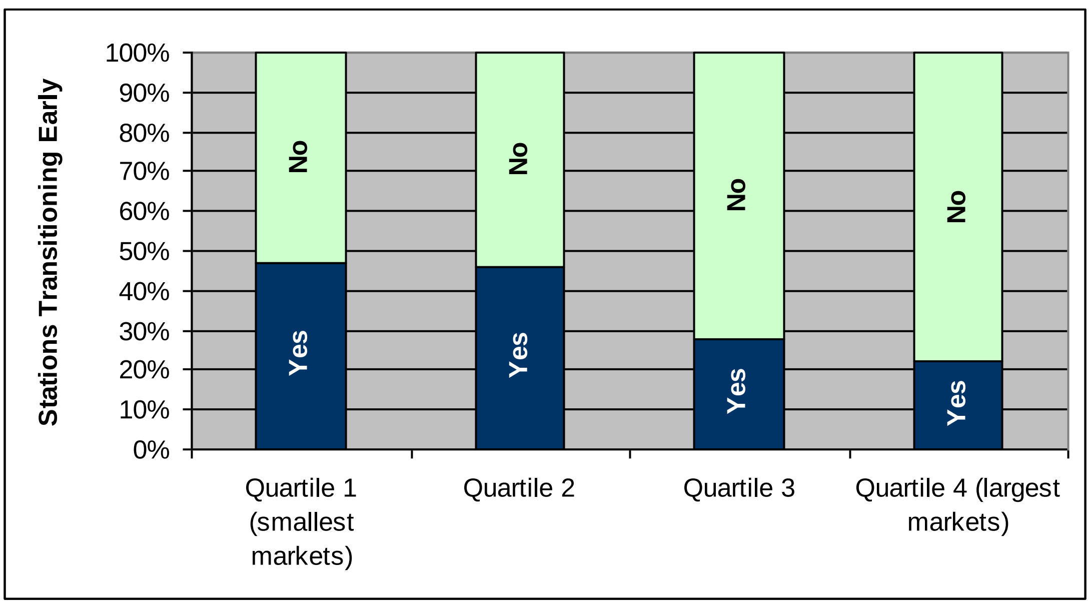


Figure 4: Transition Decisions by Nielsen TV Rank Quartiles

Y = Actually Transitioned Early	**Estimation 1** All Stations		**Estimation 2** Commercial Stations	
Variable	Marginal effect	s.e.	Marginal effect	s.e.
OTA-only households in DMA	-0.673**	0.167	0.153	0.293
OTA viewership revenue/ad			-0.213**	0.031
% OTA-only in DMA	-0.448	0.306		
Stations in DMA	0.004	0.003		
Commercial stations in DMA			-0.005	0.005
Network owned & operated	-0.263**	0.034	-0.265**	0.037
Network: ABC	-0.164**	0.033	-0.041	0.048
Network: CBS	-0.176**	0.032	-0.038	0.051
Network: CW	-0.015	0.084	-0.015	0.056
Network: FOX	-0.115**	0.037	-0.004	0.051
Network: ION	-0.172**	0.033	-0.107	0.090
Network: NBC	-0.092*	0.046	-0.085	0.048
Network: PBS	-0.056	0.033		
Network: Univision	-0.128	0.075	-0.131	0.079
Hispanic	-0.398**	0.154	-0.032	0.202
Asian	1.144**	0.322	1.136*	0.472
Black	-0.078	0.127	-0.468**	0.149
Other race	0.533	0.317	-0.352	0.413
Age 25-54	-1.128*	0.463	-0.759	0.541
Income > $100K	-1.187*	0.535	0.725	0.658
Electricity Price $\times$ Power (log)			0.042**	0.015
χ^2 stat (*p*-value)	236.03	(0.000)	208.64	(0.000)
Likelihood:	-1018.1		-474.4	
N	1,740		924	

* indicates significance at the 5% level, ** indicates significance at the 1% level.

Table notes: Regressions are probit models for the binary dependent variable in the column heading. $Y = 1$ if station transitioned on or before February 17, 2009, 0 otherwise. In Estimation 2, only commercial stations are included. The marginal effects are the average change in Pr(Y=1) in the sample due to a one unit increase in the regressor (approximated with the derivative for continuous regressors). The estimations also include a constant, which does not have a marginal effect.

Table 4: Probit Regression Analysis of Stations' Decisions to Transition Early to DTV

Y = Desired to Transition Early	**Estimation 3** Commercial Stations		**Estimation 4** Commercial Stations	
Variable	Marginal effect	s.e.	Marginal effect	s.e.
OTA viewership revenue/ad	-0.182**	0.028	-0.332**	0.053
Commercial stations in DMA	-0.003	0.004		
Network owned & operated	-0.248**	0.037		
Electricity price × power (log)	0.049**	0.016	0.086**	0.024
DTV interference	-0.368	0.412	-0.196	0.664
% pop. lost by transition (between 2 and 32%)	-0.813*	0.359	-2.177**	0.690
% pop. lost by transition (above 32%)	1.347	1.224	5.354	5.674
Others' OTA viewership ad rev.			-0.609**	0.099
Others' DTV interference			-1.442	1.249
Others' pop. lost by transition			-5.119**	1.701
Network indicator variables	included		included	
Demographic controls	included		no	
DMA fixed effects	no		included	
χ^2 stat (*p*-value)	178.64	(0.000)	258.88	(0.000)
Likelihood:	-407.5		-199.6	
N	831		504	

* indicates significance at the 5% level, ** indicates significance at the 1% level.
Table notes: Sample includes only stations not transitioning before February 17. Regressions are probit models for the binary dependent variable $Y = 1$ if station planned to transition on February 17, 0 otherwise. The *pop. lost by transition* variable enters the specification in a two-part linear spline with knot placed at about the 98th percentile, and the impact of this variable when it is below 2% is absorbed into the constant. Included in the regression specification but not shown in the table are all the network and demographic variables included in Estimation 2. The last three variables ("Others' *x*") are the average value of *x* for the other stations in the DMA that transitioned on February 17. Variables in Estimation 3 but not in Estimation 4 do not vary within a DMA and so are included in the fixed effects. See also notes to previous estimation table.

Table 5: Probit Regression Analysis – Additional Specifications