

Economic Issues in Spectrum Utilization

Thomas W. Hazlett¹
George Mason University
Arlington Economics, LLC²

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The modern era in spectrum allocation began with cellular telephone licenses in the 1980s. Up until that point, regulators controlled virtually all dimensions of spectrum access. Licenses were exceedingly narrow, prescribing what services wireless operators could supply and precisely how they could supply them.

Micro-managing the emerging mobile networks proved impractical, however. In Canada and, indeed, around the globe, regulators thus departed from traditional models and crafted new authorizations ceding far broader discretion over how radio waves were to be utilized. Instead of mapping out just where cellular base stations could be placed, as with broadcasting stations, or how much power transmitters (or devices) could emit, as with most every other radio service, licensing authorities delegated broad decision-making to markets. With multiple wireless suppliers authorized, competitive rivalry replaced bureaucratic mandates.

The result has been extraordinarily beneficial. Mobile networks have been efficiently planned, organized, constructed, expanded, upgraded – and upgraded again and again. Millions of consumers share the airwaves licensed to operators; each subscriber enjoys the use of the spectrum, and network infrastructure, controlled and optimized by the service provider. This has enabled a mass market in mobile services.

¹ Professor of Law & Economics, George Mason University, USA, and Managing Director of Arlington Economics, LLC. He has previously held faculty positions at the University of California, Davis, the Wharton School, and the Columbia Institute for Tele-Information, and served as Chief Economist of the Federal Communications Commission. He publishes widely in law reviews and economics journals, specializing in telecommunications policy and issues relating to radio spectrum allocation. He is also a columnist for the *Financial Times*' New Technology Policy Forum. Dr. Hazlett thanks Anil Caliskan, Ph.D. and Ralitza Grigorova, J.D., both of Arlington Economics, for assistance in the preparation of this paper. He gratefully acknowledges the support of Bell Canada. The analysis and views expressed are entirely his own. Comments may be directed to him at tw hazlett@gmail.com.

² See www.ArlingtonEconomics.com.

Competition among rival networks has constrained prices, pushing them sufficiently low as to create widespread substitution – of minutes of conversation or hours of broadband access – with wired telecommunications networks. The transition from fixed to mobile, yet ongoing, underscores how a service that did not exist a quarter-century ago now challenges one of the largest and most pervasive infrastructure industries of our time.

Industry Canada believes – correctly – that much too much spectrum lies idle. If more bandwidth were being productively utilized, wireless services would be cheaper and better, delivering consumer gains, while enhanced innovation in radio devices and applications would spur capital formation, business sector efficiency, and overall GDP growth.

Complicating the matter is that what appears to regulators as “unused spectrum” may in fact be a resource productively employed. The discovery that not all network capacity is used to host communications traffic does not imply anything useful about efficiency. The relevant evidence reveals that firms acquiring the largest bandwidth holdings are those that serve the most customers and build the largest, most expensive network infrastructure. This is a set of facts that is strongly consistent with the efficiency view, and strongly inconsistent with the anticompetitive view.

Alternatively, bandwidth set aside by regulators to accommodate various services may be under-employed. Excellent examples are found in the administrative allocations governing the television band for decades.³ Broadcast signals are protected not only by restricting any other broadcasting on the same frequency, but by setting aside two or more adjacent channels (one on each side, etc.) as “taboos,” blacked out for rival use. Consider the Canadian TV band, where 67 channels are set aside in the VHF and UHF frequencies.⁴ Even in the largest and most heavily used markets, and over-counting “utilization” by including all local stations plus all stations in “outlying” areas, vast TV band capacity is left fallow. In Vancouver, some 75% of channels are currently left unused. In Toronto and Montreal there is higher utilization, but still more than half of all TV channels host no broadcast signal anywhere in the city or in any nearby city. See Table 1.⁵

³ See, e.g. Thomas Hazlett, *A Law & Economics Approach to Spectrum Property Rights: a Response to Weiser and Hatfield*, 15 GEORGE MASON LAW REVIEW 975 (2008). See also Michael Heller, *The Gridlock Economy* (2008), Chapter 4.

⁴ TV channels are allotted 6 MHz each. VHF bandwidth set aside for stations consists of 54–72 MHz; 76–88 MHz; and 174–216 MHz. UHF channels are allocated 470–608 MHz; 614–806 MHz. See Industry Canada, *SP 30-896 MHz, Part II – Spectrum Utilization Policy for the Mobile, Broadcasting and Amateur Services in Frequency Range 30-896 MHz*; <http://www.ic.gc.ca/eic/site/smt-gst.nsf/eng/sf09095.html>.

⁵ These percentages figure to be reduced when the analog TV band (67 channels) is reduced to the digital TV band (49 channels) as planned in the Summer 2011 transition, yet will leave large, and hugely expensive, white spaces.

TABLE 1. TV BROADCASTING AND TV BAND UTILIZATION IN CANADA⁶

<i>Market</i>	<i>no. of channels</i>	<i>Taboo Channels</i>	<i>% “Unused”</i>
Toronto	20	47	70
Montreal	21	46	69
Vancouver	17	50	75

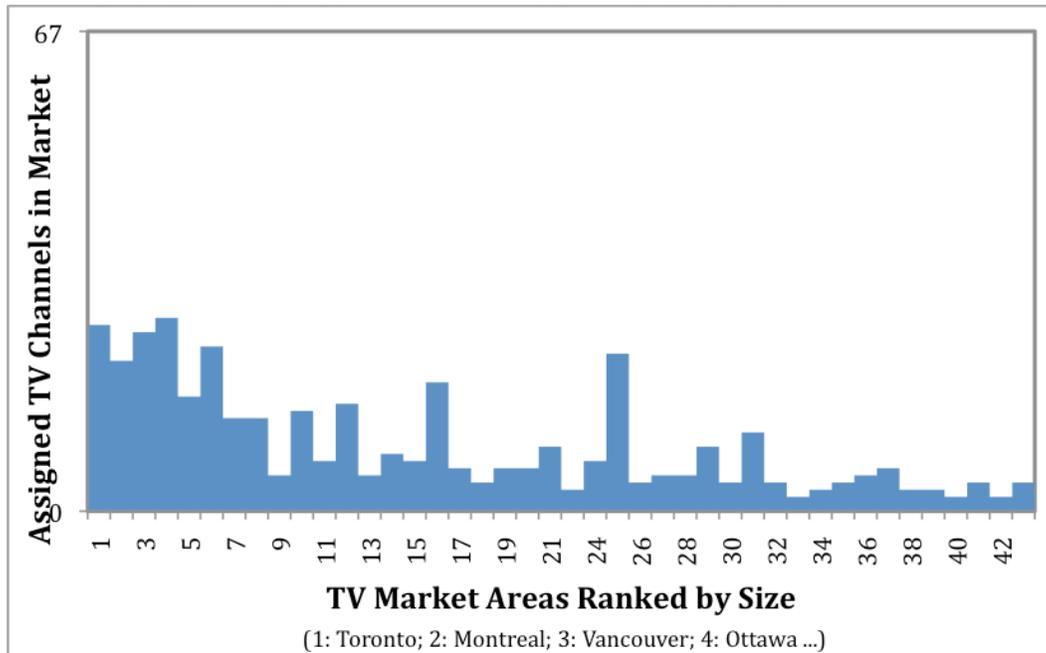
Far more wireless services could be accommodated without materially impacting the delivery of broadcast television programs. But the “use” of spectrum as buffer space is not subject to competitive market pressures; it is frozen in place, according to regulatory choices made generations ago, under traditional spectrum allocation rules. The evidence is overwhelming that airwaves do not here satisfy the most pressing consumer demands. Indeed, given Canada’s high rate of satellite and cable TV subscribership, shifting all households to a multi-channel service and freeing up the entire 402 MHz band for advanced wireless networks – including emerging 4G systems now challenging ultra-fast fixed-line Internet broadband providers in some markets – would likely prove a low-cost, high-reward social proposition, as in the U.S.⁷ Instead, terrestrial over-the-air video broadcasting, an application popularized in the 1950s, continues to consume vast bandwidth, most used for taboo channels, deterring far more valuable mobile services that – distinct from home TV reception – cannot be efficiently delivered via fixed networks.

Figure 1 expands on Table 1 by showing the number of over the air television stations across all 42 designated market areas (DMAs) in Canada. Note that the “white space” – denoting unassigned TV channels – dominates the graphic.

Station counts include licenses going through regulatory approval at the Canadian Radio-television and Telecommunications Commission, as well as operating stations. The Ottawa/Gatineau DMA features 27 channels, the highest occupancy of the 67 allocated TV channels, followed by Toronto/Hamilton/Niagara Falls with 26 and Vancouver-Victoria with 25. Even in these markets, abundant white space exists. And in aggregate, very little of the frequency space appears to host transmissions of any sort.

⁶ Provincial and Territorial Lists of Over the Air Television Stations 2010, JON C. LEBLANC WEBSITE, (visited on Nov. 30, 2010); http://www.user.dccnet.com/jonleblanc/Canada_TV_Stations/AB.html.

⁷ Richard Thaler, *The Treasure in Your T.V. Dial*, N.Y. TIMES (Feb. 27, 2010).

FIG. 1. NUMBER OF OVER-THE-AIR TV STATIONS IN CANADA BY MARKET⁸

This is not the case in the cellular bands. Relative to other bands they are intensely utilized, not only in engineering terms (relatively high levels of radio emissions are registered there⁹), but in generating valuable economic activity. This is achieved through pervasive spectrum sharing. Cellular operators could manage spectrum similar to how regulators have historically managed broadcasting for television, leaving vast “white spaces” between users. But, given their liberal licenses, they face different incentives. Squandering spectrum would dissipate profits.

Hence, licensees adopt low-power technologies, directional antennas, dynamic power controls (continually adjusting radio links to their lowest possible levels, reducing “pollution”), and sophisticated protocols enabling far higher levels of economically valued communications traffic than in broadcast TV. In short, spectrum sharing in the TV band is administered; spectrum sharing in the cellular band is competitively determined. The performance differences offer testimony in favor of the social advantage of the latter.

Allowing market rivals better access to unoccupied spectrum will speed the introduction of new technologies and assist in the productive expansion of established networks. One path, “secondary market” transactions allowing existing licensees to host new wireless services, holds great promise but is widely seen as a disappointment. Viewed properly, however, robust “spectrum trading” activity is observed. Licensees permitted liberal use of allocated spectrum capture wide and deep efficiencies, bundling

⁸Ibid. Licenses are originally provided by province and territory. They are aggregated using the DMA list in Appendix A.

⁹ See Thomas Hazlett & Evan Leo, *The Case for Liberal Licenses: An Economic and Technical Analysis*, BERKELEY TECHNOLOGY LAW JOURNAL(forthcoming, Spring 2011).

spectrum access and network services to reduce costs and ease complex coordination problems.

Spectrum could be packaged in small, raw increments and then sold to customers. However, this approach is not what is observed in the marketplace. Instead, carriers assemble large bandwidth and combine it with large networks, exploiting economies of scope, and then offer wholesale and retail wireless service packages in competition with rival networks. This model offers striking efficiencies relative to an alternative where end users buy spectrum rights, unbundled, and then assemble their own wireless services – say, by buying devices that operate without the need for extensive network infrastructure.¹⁰

Competition policy rules are general to virtually all countries, and wireless markets can be analyzed with the consumer welfare models common to antitrust authorities. Spectrum policy makers often imposed “spectrum caps” as a sort of sectoral antitrust policy, helping to spur market competitiveness. There is nonetheless a common sentiment, expressed in Industry Canada documents and elsewhere, that additional rules are needed to restrict special sorts of actions that licensees may take to “warehouse” spectrum.

Make no mistake: there is a huge “warehousing” problem in wireless. It is seen in the traditional allocation system that under-allocates spectrum and leaves far too much valuable bandwidth in inventory. This wastes productive opportunities and lowers social well-being.

Once spectrum is assigned to liberal licenses and rights are assigned to economic actors, however, warehousing incentives dissipate. Those parties holding productive spectrum rights squander them to their own financial detriment. Internalizing costs ends waste.

It is sometimes asserted that large networks tend to bid aggressively for new spectrum rights when auctions offer new rights to market participants, and that this is evidence of incentives for such networks to warehouse spectrum. Such claims overlook a far more salient fact: large networks make very productive use of bandwidth precisely because of the complementarity of the new assets with those they already hold. The efficiency explanation is as compelling as the hypothesis that spectrum is being acquired so as to facilitate monopolistic output restriction.

The alternative views can be evaluated using data from the U.S. mobile market. There, four national networks compete, with distinct size differential among the rivals: Verizon and AT&T are the largest players, with Sprint and T-Mobile markedly smaller. While free rider problems present challenges for all competitors contemplating a strategy

¹⁰ Of course, devices used in unlicensed bands – where exclusive spectrum rights are not awarded and secondary spectrum markets have not formed – are tailored to do just this. Wi-fi radios, cordless phones, remote controls, and baby monitors, all popular applications in such spectrum, are short-range communications devices that either plug into a wide area network or offer services that are extremely localized.

of output restriction, it is clear that circumstances favor the larger firms. Whatever sense it makes (or doesn't make) for a largest player to reduce output so as to raise industry price levels, it makes much less sense for smaller firms that have markedly less impact on market demand and less advantage to secure if they were to somehow increase prices to their customers.

This inter-firm variance allows us to make predictions based on the competing theories, defined thusly:

(A) *the anticompetitive view*: the larger networks are buying bandwidth so as to keep the inputs away from their rivals, reducing industry output and raising prices.

(B) *the efficiency view*: the larger networks place a relatively high value on spectrum given they use it more intensely, serving larger customer bases.

Two testable implications allow us to evaluate the rival hypotheses. First, if networks with large spectrum holdings are amassing bandwidth to restrict output, then their subscriber and/or usage levels should decline relative to other networks. Alternatively, if such networks are acquiring spectrum and using it to serve more customers than rivals, then the implication is that bandwidth is being acquired for productive purposes. Second, if strategic spectrum purchases are being executed to block rivals from gaining access to spectrum, then the acquiring firms would be "hoarding" spectrum, if not by letting it sit idle, but by under-utilizing it. In that case, they amass bandwidth but economize on capital outlays relative to the expenditures undertaken by firms with no such anticompetitive motive. Alternatively, were the spectrum acquired for productive purposes, then large bandwidth owners would also be the largest investors in network infrastructure.

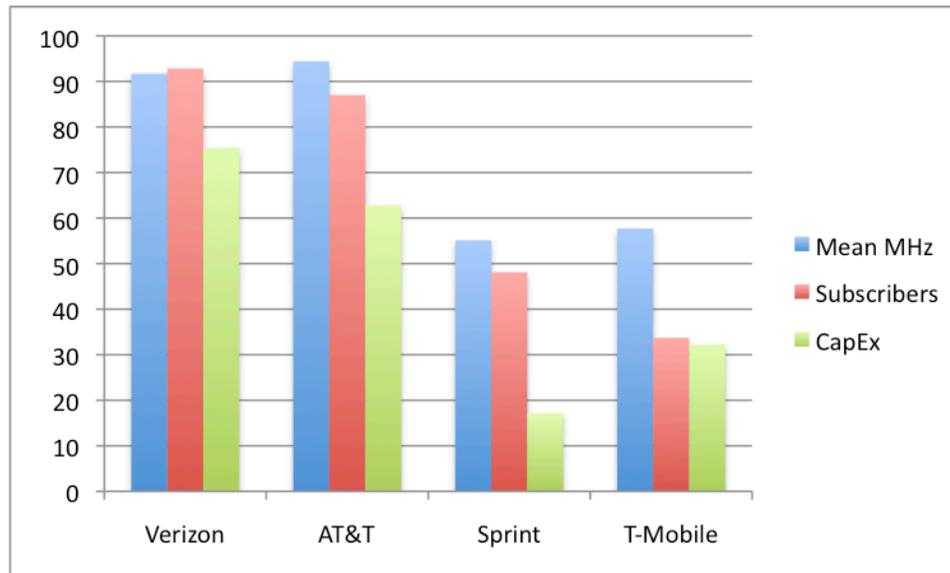
FIG. 2 U.S. MOBILE CARRIERS' SPECTRUM, SUBSCRIBERS AND CAPEX¹¹

Figure 2 displays data for the four major U.S. networks. Verizon and AT&T own mobile licenses giving them control of over 90 MHz, on average, in the top ten markets. Sprint and T-Mobile, in contrast, have acquired less than 60 MHz. But the carriers acquiring the largest spectrum footprints are serving considerably more customers. The two large networks serve about 90 million each; the two smaller less than 50 million (T-Mobile under 35 million). In terms of physical infrastructure, it is clear that the larger networks invest far more aggressively. Their annual capital expenditures by 2Q2010 were about 2-4 times the levels undertaken by the two smaller firms.

The evidence clearly reveals that the firms acquiring the largest bandwidth holdings are those that serve the most customers and build the largest, most expensive network infrastructure. This is a set of facts that is strongly consistent with the efficiency view, and strongly inconsistent with the anticompetitive view.

Efficient spectrum use is also fully consistent with the existence of some level of “slack,” what is known as “holding inventories” in other markets. Economical deployment lags exist. Infrastructure – base stations, backhaul, and mobile radios – make airwaves far more valuable. Because the operator will exploit this demand by charging for the use of the network, it has strong incentives to put such capital in place. But speed

¹¹ Mean MHz are calculated for the top ten U.S. markets using data from Stifel Nicolaus, *Washington Telecom, Media and Tech Insider* (March 28, 2008), p. 9. Subscribership and capital expenditure data are from Bank of America/Merrill Lynch, *Global Wireless Matrix 3Q2010* (Sep. 24, 2010), pp. 203-204. Capital expenditure data are provided only for Verizon and AT&T. Using the mean increase in CapEx for these two bigger carriers from 2009 to 2010 as a multiplier, the 2Q2010 CapEx for Sprint and T-Mobile were forecast from 2009 data collected from Bank of America/Merrill Lynch, *Global Wireless Matrix 2Q2010* (June 25, 2009).

is a costly input; building networks more quickly costs more, all else equal.¹² Taking due time to architect new systems, assemble labor, procure physical inputs, and arrange other assets – such as leases for preferred tower sites – generally lowers costs. It is also the case that waiting produces an important economic benefit, option value.¹³ The ability to deploy superior systems or technologies as they become available over time is one clear consideration in constructing, expanding, or upgrading wireless networks.

Hence, not all spectrum resources should always be fully committed, or used to maximize capacity, in networks. At any point in time, there will predictably be efficiency reasons to not deploy certain assets. In addition to husbanding resources on an optimal investment time path, networks are regularly built and operated so as to reserve some – indeed, abundant – slack capacity during ordinary operations. This allows not only for traffic fluctuations over standard daily or seasonal cycles, with peak times seeing higher utilization rates, but provides relatively low-cost provision of both emergency capacity (expansion) and standard growth trends.

The bottom line is that the discovery that not all network capacity is used to host communications traffic does not imply anything useful about efficiency. On the one hand, it is difficult to define what “full employment” might mean for a wireless network, given that there are always ways to squeeze more output out of given spectral inputs. The easy example is to think of cellular networks, where cell-splitting yields more intense spectrum re-use. But the more general economic principle is that, by applying more capital (more base stations, better handsets, more advanced technology) it is always possible to engineer additional communications. The efficiency test is whether that extra increment produces benefits greater than the costs required. And that trade-off cannot be purely discerned from examining technical deployments to observe where “white spaces” are found.

It can be discerned, however, by observing how enterprises deploy their assets. A simple analogy is found in the housing market. A canvassing of suburban homes in any major U.S. or Canadian city could produce the conclusion that considerable under-deployment exists in that large numbers of unoccupied bedrooms are found. A family of four living in a five-bedroom home leaves at least one bedroom vacant every night. During the day, vacancy rates are even higher – typically 100%. But the outcome is not properly defined as inefficient or wasteful. That is because homeowners are free to increase occupancy levels, taking in relatives, renting out rooms to strangers, or trading for a smaller home. The utilization rates we observe tell us very little. By their revealed preference, however, we discern that vacant bedrooms are valuable. We conclude that they are generally worth what the owners pay for them.

¹² The classic essay on the relationship of costs and production time is Armen Alchian, *Costs and Outputs*, in M. Abramowitz, et al., eds., *The Allocation of Economic Resources: Essays in Honor of Bernard Francis Haley* (Stanford University Press: 1959), pp. 23-40.

¹³ Avinish K. Dixit and Robert S. Pindyck, *Investment Under Uncertainty* (Princeton University Press: 1994).

The analogy is directly transferable to wireless markets, although it may be noted that individual homeowners are unlikely to possess market power whereas a large wireless network may enjoy that ability. Yet a firm that could restrict output, increasing prices above competitive levels, will have no need to “warehouse” spectrum. The operator would still seek to minimize costs by efficiently using all bandwidth inputs available to the network, just as a competitive firm would.

The implication of market power is not that less spectrum will be deployed, but that it will accommodate less economic activity due to the higher prices charged for access. The wireless monopolist would not be effectively constrained by a mandate that all of its spectrum be “used.” It would be non-binding. But even if it were not, the spectrum could be “deployed” by using it for access at monopoly prices. It is not possible to objectively measure the economic level of spectrum (or bedroom) “deployment” to discern “warehousing.” A requirement that spectrum be used can be satisfied by using it in a cheap, if relatively unproductive, way.

The consumer issue to which “warehousing” concerns are inaccurately pointed is found in the standard antitrust models: inadequate market rivalry. The solution is to put abundant spectrum resources into the marketplace under rules that allow competitors maximum scope for efficient behavior. Market structure is the proper focus, not spectrum utilization. There, the cost-minimization incentives of for-profit firms are far more reliable than prices or allocations administratively imposed.