# Enabling Efficient Wireless Communications: The Role of Secondary Spectrum Markets

**By**

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## I. Introduction

Economists proposed using markets to allocate spectrum as early as the 1950s.[1] Yet, that vision became a reality only in the 1990s when policymakers embraced markets via auctioning the initial rights for spectrum usage. Regardless of whether initial spectrum is allocated by comparative hearing, lottery or auction, however, any initial allocation does not necessarily ensure that the spectrum will be used efficiently in the future. In particular, the initial allocation cannot stop the inevitable downstream shifts in the supply and demand for wireless services that drive the demand for spectrum. These short-run fluctuations and long-run shifts can create significant valuation differences between an initial licensee and a prospective future user of that spectrum. In this sense, government policy can ensure efficient spectrum use only if it defines the parameters under which secondary market transactions can occur in addition to the parameters under which the spectrum is initially allocated. Well-functioning secondary markets can help ensure that, as demand and supply shift, spectrum will migrate to more efficient uses, including those by parties outside of the initial allocation.

Despite the potentially critical nature of secondary markets in maintaining efficient spectrum and wireless markets, research has focused primarily on the Federal Communication Commission's (FCC's) rules for initial distribution.[2] The relative inattention to secondary markets has, however, begun to fade recently with both policy agencies and academic scholars

[1] See Herzel (1951), Coase (1959).
[2] See, e.g., Connolly and Kwerel (2007).

providing a conceptual awareness of the potential for secondary spectrum trading to improve economic efficiencies and enable growth of wireless technologies [FCC (2000), OECD (2005)]. To date, however, this attention has been disparate and largely theoretical.

In this paper, we first examine the evolution of conceptual and policy developments directed toward secondary spectrum markets to date. Then, we seek to move beyond those efforts to empirically document the development of secondary spectrum activity in the United States and the relationship of that development to the evolving policy toward such markets. Due to the paucity of empirical information on secondary markets our goals for this paper are modest. We begin by categorizing and exploring different types of secondary spectrum markets, including the operations of mobile virtual network operators (MVNOs—mobile cellular companies, such as Virgin Mobile, that resell services and do not own their own networks), the machine-to-machine (M2M) market, and explicit sale and lease of spectrum among third parties.

Information on the latter comes from the FCC's Universal Licensing System, from which we have been able to obtain data on every spectrum license transaction since 1994. With that information we explore the depth and breadth of spectrum trading in secondary markets. We find that the FCC has radically reduced the time it takes to approve trades, making the system more akin to notification than to approval. We also find that a large amount of spectrum changes hands each year. For example, the average amount of PCS spectrum in terms of MHz-Pops that changed hands each year between 2004 and 2008, not including leases, was approximately equal to the amount of spectrum auctioned by the FCC in the 2006 AWS auction. While these conclusions do not necessarily imply that secondary markets work efficiently, they do show that policy efforts to facilitate and energize the growth of secondary spectrum markets are bearing considerable fruit.

## II. Background: Secondary Markets, Spectrum and Property Rights

Secondary markets are common in modern commerce. The market for housing, for example, is largely secondary because most houses are sold not by people who built the houses or who were their first occupants. The same is true of goods as diverse as automobiles, books, CDs and virtually everything sold at garage sales or eBay. Such secondary markets generally receive little special attention as their underlying economics are typically indistinguishable from other, initial market, transactions, and generate no substantive public policy issues. Billions of dollars of goods are thus sold in secondary markets each year with a bare minimum of special public policy oversight. That is, standard laws governing commerce generally apply to both initial and secondary market commerce. Alternatively stated, property rights endowed upon initial owners generally convey in identical fashion to purchasers of these goods in secondary market.

Secondary market transactions do, however, occasionally generate attention and differential treatment. Local governments often ban secondary market sales of tickets to sporting and entertainment events through anti-scalping laws. Congress even proposed legislation in late 2008 that would have made the secondary market sale of tickets to a presidential inauguration ceremony a crime punishable by a fine and imprisonment for up to one year.[3] Secondary market sales are also prohibited in other areas. For example, students admitted to a college cannot sell the right to attend that school to other prospective students who might value such admittance more than the admitted student. Such prohibitions suggest that a general way to frame the

[3] See, S. 60, which was introduced into on January 6, 2009. A similar bill was introduced into the 110th Congress. For a discussion, see http://voices.washingtonpost.com/inauguration-watch/2008/11/sen_dianne_feinstein_d-calif_i.html .

breadth of secondary markets is to consider the policy specifications of the breadth of property rights that are endowed upon the initial spectrum holder that may then be transferred in secondary markets.

In a distinction from either real or intellectual property, however, the FCC's control over spectrum extends only to its use rather than its ownership, as it grants only spectrum leases rather than ownership.[4] Thus, any discussion of "property rights" associated with either initial market allocations or allocations in a secondary market relate to usage rather than ownership rights.[5] Nonetheless, the FCC can allocate and constrain rights to spectrum along a variety of dimensions including time of use, geographic area, spectral frequency, the technology employed in transmission and receiving devices, and sometimes even how the spectrum can be used. These varied dimensions of property (or, more accurately usage) rights create the potential for regulatory policies to significantly alter the prospects for the successful emergence of secondary markets in spectrum.

Another important feature of secondary spectrum markets is that the scope for successful secondary market transactions is inextricably linked to the initially specified usage and property rights. For example, consider the willingness to pay for a license that either has or does not have the option for the licensee to trade that spectrum in a secondary market. On one hand, it would seem that more property (usage) rights for the initial holder are constrained the lower the value of initial spectrum licenses. If unable to transfer usage rights, then the asset's value is limited. On the other hand, Hazlett (2008) provides empirical evidence that countries with the most liberalized spectrum policies (including broad enabling rights to secondary spectrum markets)

[4] See 47 U.S.C. §301.
[5] For an interesting discussion of the relationship between pure property rights and those rights that may be provided by the FCC, see Shelanski and Huber (1998).

generate lower prices for spectrum. He attributes this value reduction to the increased competition that the more liberalized spectrum trading rights create.

In the United States, the first steps to vivify initial spectrum markets began in the early 1990s with spectrum auctions. These initial steps became formal US policy in 1993 with the passage of legislation authorizing the FCC to conduct auctions as a means of initial spectrum allocations to users. Subsequently, the FCC has conducted a number of successful spectrum auctions, raising billions of dollars for the U.S. Treasury. In doing so it has significantly expanded the supply of spectrum available to firms providing wireless communications and Internet services. Access to additional spectrum has set off vigorous competition among retail wireless service providers, with the price of mobile service declining from 55 cents per minute in the mid-1990s to 7 cents per minute today [See FCC (2008) and Mayo (2008)].[6]

Along with the rise of the auctioning of initial spectrum usage rights has come the emergence of critics who question the efficiency, wisdom or motives of companies who obtained the initial spectrum rights in the auctions. For example, critics question whether spectrum that is "idle" at any given moment is being efficiently used in a world in which scarcity of spectrum is the norm.[7] Some, then, have advocated a "technological" solution to spectrum shortages whereby smart wireless devices would identify and use a licensee's spectrum (or for that matter, unlicensed spectrum) that at any particular moment might be unused. The result is a political battle between holders of initial spectrum usage rights that seek to promote efficient spectrum

[6] These successes have not gone unnoticed. Indeed policy makers around the globe have recognized that economic benefits of initial auctions of spectrum rights. For example, see the assessment of the Australian Communications Authority which stated that "Auctions have proved to be quick, fair and transparent in the way that allocations are made. Underpinned by a technology approach to licensing, they have also proved to be successful in facilitating the introduction of new services, greater competition and greater choice for consumers." Australian Communications Authority (2004)

[7] See Peha (2004) for a discussion.

usage by the strengthening of property rights and those who believe that "underutilized" spectrum may be more efficiently operate in a "public" domain.

The ability to infer whether and the extent to which spectrum is being used efficiently simply based on snapshot examinations of its usage characteristics is, however, limited. On the one hand, the presence of unused licensed spectrum at a point in time does not by itself necessarily indicate that spectrum is being used inefficiently any more than empty houses during the day while their owners are at work necessarily means that those houses are being used inefficiently. Similarly, full use of spectrum does not by itself indicate efficient use. Television broadcasters, for example, may fully use their allotted frequencies, but few argue that over-the-air television is the most efficient use of spectrum. On the other hand, if unused spectrum leased to auction winners represents an entry barrier to new firms that could succeed in the market but for access to spectrum, then idle spectrum may indeed indicate a problem. Thus, while we cannot draw immediate conclusions regarding the efficiency of spectrum usage by initial spectrum usage rights holders, we do know that maintaining efficiency of spectrum use over time requires the presence of secondary markets with low transactions costs. So, even an initial allocation that yields a highly efficient allocation of spectrum will be of diminishing value without policies that enable secondary markets. It is critical, then, to understand the evolution of the FCC's efforts to enable the emergence of secondary spectrum markets.

## III. The Economic and Policy Evolution in Secondary Spectrum Markets

Policy parameters associated with initial spectrum auctions, and in particular the property rights endowed upon initial spectrum holders with respect to secondary market transfers define how well a secondary market could work. In this regard, prior to the FCC's spectrum auctions in

the 1990s, the rights to transfer spectrum among private parties were bureaucratically constrained. Spectrum holders were not permitted to engage in market-based transfers of spectrum rights without formal, often time consuming and onerous, FCC approval.

With the general push to initial spectrum market auctions, however, academics and policymakers became aware that a potential existed for a secondary market to emerge and reinforce the efficiencies created through the auctions. License holders of initial spectrum rights too, have begun to see secondary market transactions as an important catalyst to, if not prerequisite for, the growth of wireless markets.

The first substantive policy efforts toward a market-enabling approach toward secondary spectrum began in May of 2000, when the FCC held a public forum to highlight the need to move away from what then-Chairman Kenard referred to as a "Mother May I" approach to spectrum usage. Under the "Mother May I" approach, spectrum licensees must ask the FCC's permission anytime they seek to employ an alternative use of the spectrum they control. In contrast to such an approach, the Chairman offered a vision of a system in which "the spectrum resource can be seen more as a commodity that can move freely in the marketplace, because that's how spectrum can best meet the market demands of today and of the future."[8] At this same forum, Commissioner Harold Furchtgott-Roth observed that "What we find today in spectrum markets is relatively few transactions involved in what might be called a secondary market. Once we have initial allocations for spectrum, they tend to be ossified there."[9] Academics, too, began to champion the development of policies that would enable the emergence of well-functioning secondary markets for spectrum. For example, Professor Cramton stated that "secondary markets are essential for the efficient and intensive use of

[8] Statement of Chairman William Kennard, Federal Communications Commission (2000), p. 7.
[9] Statement of Commissioner Harold Furchgott-Roth, Federal Communications Commission (2000), p. 14.

spectrum. Secondary markets identify gains from trade that are unrealized by the primary market which in this case is the FCC spectrum auctions."[10]

Later in 2000, the FCC issued a Policy Statement, stating in part that "While secondary markets are not a substitute for finding additional spectrum when needed and should not supplant our spectrum allocation process, a robust and effective secondary market for spectrum usage rights could help alleviate spectrum shortages by making unused or underutilized spectrum held by existing licensees more readily available to other users and uses and help to promote the development of new, spectrum efficient technologies."[11] The FCC observed, though, that "the secondary market remains underdeveloped."[12] In the FCC's Policy Statement, the Commission identified a set of preconditions or "certain essential elements" for such markets to most effectively operate. These included: "1) clearly defined economic rights; 2) full information on prices and products available to all participants; 3) mechanisms for bringing buyers and sellers together to make transactions with a minimum of administrative costs and delays; 4) easy entry and exit to the market by both buyers and sellers; and 5) effective competition with many buyers and sellers."[13]

In 2003, the FCC took several substantive measures toward facilitating the development of secondary markets in spectrum.[14] In particular, the FCC established two categories of leasing arrangements available to holders of initial spectrum rights. The first, known as "spectrum manager" leasing permits parties to engage in leasing arrangements without prior approval by the FCC as long as the licensee retains both *de jure* control of the license and *de facto* control over

[10] Statement of Professor Peter Cramton, Federal Communications Commission (2000), p. 18.
[11] Federal Communications Commission (2000b), p. 1.
[12] Federal Communications Commission (2000b), p. 7.

[13] Federal Communications Commission (2000b), p. 8 (footnote omitted).
[14] Federal Communications Commission (2003).

the leased spectrum. The second, known as "*de facto* transfer" leasing creates a streamlined approval process for leases that involve a transfer of the *de facto* control of the license.

While this initial streamlined approval process for license transfers reduced the bureaucratic challenge of spectrum leasing, the Commission sought in 2004 to further reduce administrative delays for secondary spectrum leasing.[15] In particular, the FCC moved to forbear from requirements for leasing parties to provide prior public notice. In those circumstances where leasing arrangements do not trigger specific concerns enumerated by the Commission, it also moved to forbear from a requirement for individualized Commission review of proposed *de facto* leasing transfers. Concerns that would prevent immediate forbearance include: (1) violations of eligibility and use restrictions; (2) foreign ownership; (3) transfers by designated entity and entrepreneur licenses; (4) harm to competition, and (5) other public interest concerns. Thus, absent a concern triggered by any of these, the Commission now permits immediate approval of the spectrum lease. And even when the parties cannot certify that none of these concerns are triggered, they face a streamlined 21-day process. Importantly, the Commission has also moved to harmonize the regulatory treatment of "spectrum manager" and "*de facto*" leases, short term and long term leases, and leases by both telecommunications firms and non-telecommunications firms that hold spectrum licenses and wish to offer these in secondary markets. Finally, in 2004 the Commission extended leasing rights to an expanded set of spectrum-based services that had heretofore been barred from participation in secondary markets. These included, for instance, the authorization of public safety service license holders to participate in secondary spectrum market leasing. Notably, however, the Commission declined to extend secondary market leasing rights between these public safety license holders and firms that may employ that spectrum for purposes other than public safety or for commercial purposes.

[15] Federal Communications Commission (2004)

While the FCC's has undertaken a number of specific measures to facilitate the emergence of secondary spectrum markets, the multidimensional nature of spectrum and the associated complexity of spectrum contracts do not immediately and easily lend themselves to satisfying the FCC's "certain essential elements" for these markets to successfully emerge. For example, a buyer may wish to contract for a particular block of time, geographic area and spectral frequency.[16] Secondary users may also vary in their demand for, and willingness to pay for, interruptible spectrum rights.[17] Similarly, initial spectrum holders have particular "inventories" that are not necessarily malleable to demanders' needs. And, of course, successful secondary market transfers require an alignment of the buyers' demands for spectrum of a particular dimension with the willingness of spectrum holders to supply spectrum in that same dimension.

Thus, while the multidimensional nature of the demand for, and supply of, secondary market spectrum could stimulate entrepreneurial development in spectrum that might otherwise go unused by the initial market licensee, the potential complexity may pose challenges. Hatfield and Weiser (2008) have argued that while not imposing insurmountable challenges to the emergence of spectrum markets, the multidimensional nature of secondary market transactions introduces more complexity into potential transactions than are commonly appreciated. Cramton makes the point more graphically: "spectrum isn't like pork bellies. Pork bellies are nice."[18]

[16] See Peha and Panichpapiboon (2004) for a discussion of the potential for "real-time" secondary spectrum markets.
[17] Bykowsky (2003) describes the potential for public agencies that hold spectrum licenses to lease their spectrum rights in secondary markets on a callable basis. Such spectrum could, then, ordinarily be used by a private high-value user but could be recalled in the event that the public agency required the spectrum during an emergency or peak period.
[18] Statement of Professor Peter Cramton, Federal Communications Commission (2000), p. 37.

In the end, whether the FCC's policies have proven successful in overcoming the complexities associated with secondary market transactions is ultimately an empirical question. It is to that question that we now turn.

## IV. Secondary Spectrum Markets Overview

A secondary market is a market in which a seller of a good is not the one who sold the good for the first time. While this concept appears straightforward on its face, distinctions between secondary-market transactions and others can blur in practice. For example, most people would probably consider a firm that reserves hotel rooms in bulk and then rents them out at slightly higher prices or a firm that buys event tickets in bulk and then resells them to individuals to be engaged in secondary market transactions. Yet, few people would consider purchases of food in a supermarket to be secondary market transactions, even though the supermarket is likely to have purchased large quantities of its products from distributors who, in turn, purchased the food from producers.

For the purpose of this paper, we consider a secondary spectrum market transaction to be any transaction that provides use of the spectrum to an entity other than the original license holder or the license holder's direct end-user customers. This definition yields three areas of focus: (1) the operations of mobile virtual network operators (MVNOs, such as Virgin Mobile); (2) the operations of machine-to-machine (M2M) firms; and, (3) trades or leases of spectrum licenses. In the sections below we discuss in more detail the MVNO, M2M, and secondary market for spectrum licenses.

**MVNOs**

MVNOs negotiate wholesale access to carriers' infrastructure and spectrum and then sell it to end users under their own brand name. This secondary use of spectrum has been quite vibrant in recent years, with between 43 and 55 MVNOs in total, offering service through purchases from all major facilities-based carriers.[19] These firms provide services to over 18 million customers, roughly 7 percent of all wireless subscribers. One analysis suggested that MVNO revenues in North America were $3.2 billion in 2006 and would exceed $10 billion by 2013.[20] Tracfone is the largest MVNO, with 11.2 million subscribers and $1.5 billion in revenues in 2008.[21] Virgin Mobile is somewhat smaller, with $1.3 billion in 2008 revenues (2008 10K).

**Machine-to-machine (M2M)**

Machine-to-machine, or M2M, refers to data communications between remote machines and processes. M2M includes applications such as telemetry used by NASA to monitor spacecraft, systems that allow firms to track mobile assets such as trucks, and systems that allow energy companies to monitor electricity use. Some M2M applications use WiFi or other technologies over unlicensed spectrum for very short distance transmission (within a house, for example) to communicate with a TCP-IP network. Other applications require guaranteed service quality levels over long distances or for mobile applications, or both, and operate using licensed spectrum and existing networks operated by facilities-based operators.

[19] Federal Communications Commission (2009). See also, http://www.telecomsmarketresearch.com/research/TMAAAQPN-WCIS-Insight--Global-MVNO-Operations---A-study-of-current-business-models-and-emerging-opportunities.shtml

[20] http://findarticles.com/p/articles/mi_m0EIN/is_2007_Oct_23/ai_n27417031/

[21] http://www.americamovil.com/docs/reportes/eng/2008_4.pdf

These applications include services provided directly to consumers, such as private vehicle assistance like OnStar, home security systems, and Amazon, which uses Sprint's network to send books and other materials to its Kindle devices. Other applications are for firms' internal uses, such as supply-chain management using RFID devices, fleet management, and remote control of plant and equipment. Government agencies including the U.S. Department of Homeland Security also use M2M for monitoring critical infrastructure and managing highway traffic.

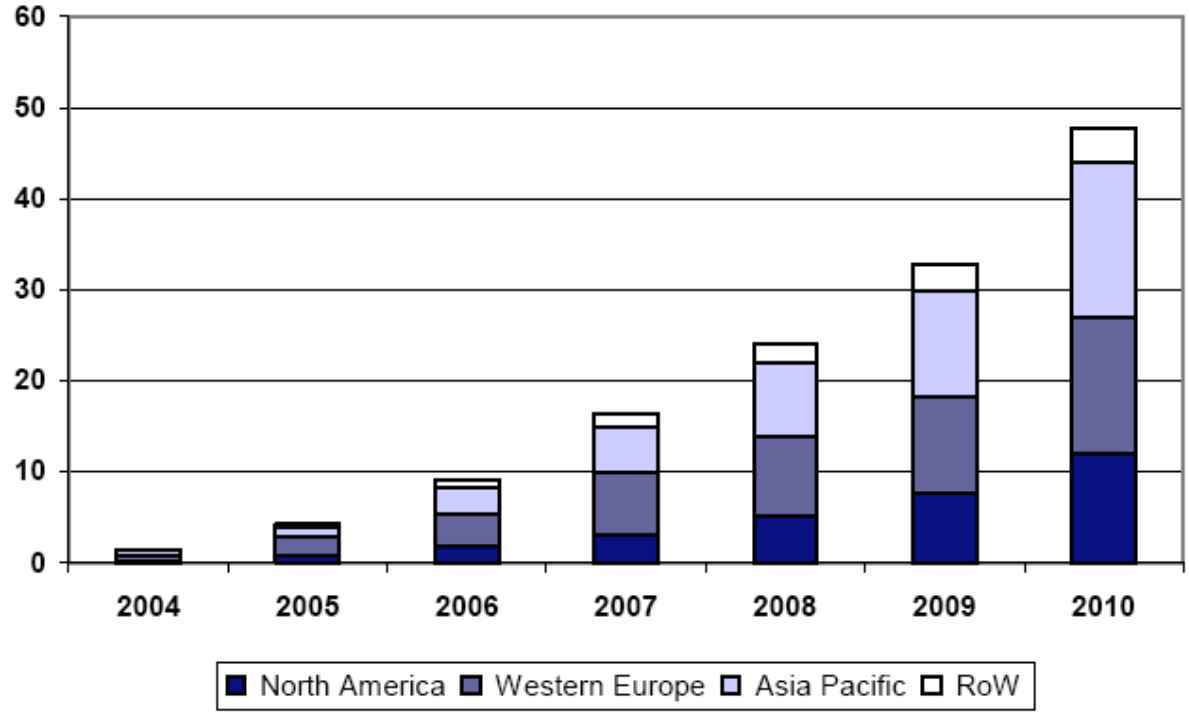
The M2M market is relatively new, so it is difficult to know precisely how large it is. ABI Research estimates that North America had approximately 22.3 million M2M connections in 2008, and expects that number to increase to 88.3 million by 2014.[22] Estimates vary but seem to put M2M revenues collected by cellular operators in North America at about $2 billion in 2006 and $3.5 billion worldwide in 2009. Expenditures on M2M hardware and services by end-user firms is probably somewhere between $30-$40 billion. Table 1 shows estimates in different years from a variety of sources. Figure 1 shows one estimate of projected M2M revenue growth around the world.

[22] ABI Research Service, April 2009 (personal communication with Sam Lucero April 14, 2009).

**Table 1**
**Estimates of M2M Market Size**

| Year | Units (millions) | Cellular carrier revenues ($ billions) | Total M2M revenues ($ billions) |
|---|---|---|---|
| 2004 | | 2.5 [e] | $34 |
| 2005 | 9.6 [a] | | 42 [f] |
| 2006 | 14.6 [a] | 2 [b] | |
| 2007 | 20 (modules shipped) [b] | | |
| 2008 | 22.3 (North America) [c] | | |
| 2009 | | 3.5 [d] | |
| 2011 | 27 (EU + US) [d] | | 40 [g] |
| 2014 | 88.3 (North America) | | 57 [g] |
| | | | |
| [a] Gartner | | | |
| [b] ABI Research | | | |
| [c] ABI Research, April 2009 | | | |
| [d] Berg Analytics | | | |
| [e] FocalPoint, reported in Business Week | | | |
| http://www.businessweek.com/magazine/content/04_17/b3880607.htm | | | |
| [f] IBM report cited here: | | | |
| http://www.zdnetasia.com/news/hardware/0,39042972,39280429,00.htm | | | |
| [g] Strategy Analytics, March 2008 | | | |
| Also Mobile Data Association presentation February 2008 | | | |

**Figure 1**
**M2M Revenues, Billions of Euros**




Source: IDATE (2005)[23]

A large number of firms provide M2M services to end users.[24] These firms typically use specialized hardware designed to work with one or more of the different cellular technologies.[25] M2M providers fall intro three groups. The first group includes MVNOs, which aggregate spectrum and network use from the facilities-based carriers and then resell specialized services using those networks.[26] The second group includes so-called M2M network operators, or MMOs, which purchase spectrum and network use wholesale like MVNOs but also deploy

[23] shop.idate.fr/pages/download.php?id=252&rub=news_telech&nom=IDATE%20News%20352%20M2M.pdf
[24] Many of these firms are listed here: http://m2mzone.com/Sponsors.asp.
[25] See, for example, http://www.motorola.com/Business/US-EN/Business+Product+and+Services/M2M+Wireless+Modules, http://inthinc.com/our-products.html, or http://www.numerexdna.com/m2m-device.
[26] Examples of these firms include Kore Telematics, Jasper Wireless, and Numerex. General information about M2M is available at these websites: http://www.m2mmag.com/ and http://m2mzone.com/Default.asp.

specialized infrastructure equipment.[27] The earliest companies classified as MMOs were Jasper Wireless and Aeris Communications. The final group is the cellular operators themselves, which have about are the leading M2M providers.[28]

It is not simple to translate this breakdown into secondary versus primary markets. MVNOs and MMOs clearly represent secondary market transactions, since those firms buy service wholesale from other carriers and then sell it to end users. But, as discussed earlier, the line between wholesale and secondary market is not clear. When a cellular carrier sells M2M services directly it is not obvious whether the service is more appropriately considered an input into the purchaser's production process or a secondary market sale of wireless services to an end user. For example, Amazon purchases service wholesale from Sprint for what it calls its "Whispernet" to deliver content to Kindle devices. Consumers purchase both the book and the network use necessary to transmit that book from Amazon. Sprint, though it operates the network, never interacts with the consumer. So is the consumer engaging in a secondary market transaction, or is the wireless service merely a necessary input in the same way paper is to produce a traditional book? Similarly, GM's OnStar system works with mobile carriers, but customers purchase OnStar service directly from GM, not from the cellular carriers.

Finally, we observe that the MVNO and the M2M markets overlap in the sense that some M2M providers are also MVNOs, as the figure below illustrates. Accordingly, some people will consider MVNOs and parts of the M2M market to be wholesale rather than secondary market transactions.[29] We remain agnostic on this point, but note that all are important components of

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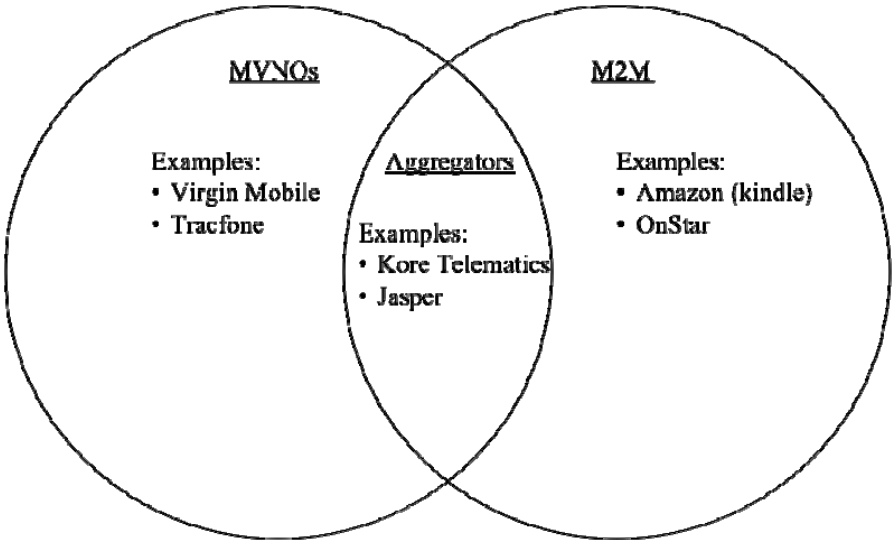
[27] http://www.abiresearch.com/abiprdisplay.jsp?pressid=916

[28] ABI Research, April 2009. Personal communication.
ABI Research. http://findarticles.com/p/articles/mi_m0EIN/is_2008_Oct_23/ai_n30930389. Verizon Wireless, an operator which claims to support more than 7 million devices (http://www.verizonwireless.com/pdfs/mvno_brochure.pdf).

[29] Some have argued that even use by license holders' end users (e.g., direct customers of facilities-based cellular providers like AT&T, Verizon, Sprint, and T-Mobile) should be considered part of a secondary market. While one

the general picture of how spectrum is used by entities other than those that purchased spectrum licenses directly from the FCC.

**Figure 2**




## IV. The Emergence and Growth of "Direct" Secondary Spectrum Markets

One precondition for a well-functioning secondary market is the ability to learn who owns the good in question.[30] In this regard, data on all changes to spectrum licenses are recorded in the FCC's Universal Licensing System (ULS).[31] Unfortunately, this information is extremely difficult to use. While a motivated prospective participant in the market likely has the incentive to decode the database and its interface, the opaqueness of the system constitutes one

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could make a credible case for including that group in an expansive definition, we believe this transaction is better described as a primary retail market in which consumers purchase directly from the owner (or, in this case, lease-holder) of the spectrum.

[30] With radio spectrum rights we are not discussing ownership *per se* but, insofar as all licenses have a set expiration, something more like a lease; going forward we ignore this quibble to avoid confusion with the distinct and more interesting "leasing" in the secondary market.

[31] http://wireless.fcc.gov/uls/index.htm?job=home

barrier to a well-functioning market.[32] Nevertheless, the data allow us to begin to understand how much trading actually occurs in this secondary market.

The ULS records two general types of transactions: 1) assignments of authorization and transfers of control, and 2) leases. The distinction here is mainly one of duration: agreements of the first group are "permanent" in that the license is transferred or reassigned for the remainder of its lifetime, whereas those of second group (the leases) represent more temporary and limited bestowals of right. Table below presents a broad overview of how many licenses have changed hands under the pair of more lasting procedures.

The first three columns, labeled "notification track," tally licenses that changed hands because a license-holder was acquired by, or merged with, another firm, or that moved between affiliates. In other words, these occur within a given organization and are not market transactions. The set of columns titled "approval track" (so labeled because they require FCC approval), largely represent market transactions between third parties. Table 3 shows the number of transfers categorized by "service code"—the service the FCC authorized for the license being traded.

[32] The Appendix provides detailed information on how we assembled information from the many components of the ULS.

## Table 2

**Completed Assignments of Authorization and Transfers of Control by ULS Procedure[a]**

| Receipt Year | Notification-Track[b] | | | Approval-Track[c] | | |
|---|---|---|---|---|---|---|
| | Total | Assignment | Transfer | Total | Assignment | Transfer |
| Pre-1994 [d] | 28 | 12 | 16 | 2,754 | 1,115 | 1,639 |
| 1994 | 130 | 51 | 79 | 371 | 116 | 255 |
| 1995 | 2 | 1 | 1 | 14 | 11 | 3 |
| 1996 | 115 | 49 | 66 | 62 | 42 | 20 |
| 1997 | 457 | 219 | 238 | 395 | 214 | 181 |
| 1998 | 365 | 88 | 277 | 558 | 236 | 322 |
| 1999 | 346 | 209 | 137 | 906 | 416 | 490 |
| 2000 | 514 | 311 | 203 | 2,136 | 1,557 | 579 |
| 2001 | 559 | 308 | 251 | 3,285 | 2,888 | 397 |
| 2002 | 287 | 217 | 70 | 3,181 | 2,646 | 535 |
| 2003 | 166 | 100 | 66 | 2,322 | 1,946 | 376 |
| 2004 | 308 | 158 | 150 | 2,151 | 1,677 | 474 |
| 2005 | 358 | 269 | 89 | 2,558 | 2,102 | 456 |
| 2006 | 327 | 243 | 84 | 2,671 | 2,020 | 651 |
| 2007 | 211 | 139 | 72 | 2,301 | 1,579 | 722 |
| 2008 | 325 | 130 | 195 | 1,994 | 1,515 | 479 |
| 2009 | 96 | 26 | 70 | 215 | 178 | 37 |
| Unkown | 474 | 447 | 27 | 31 | 19 | 12 |
| Total | 5,068 | 2,977 | 2,091 | 27,905 | 20,277 | 7,628 |

[a] Current as of March 1, 2009 database update. The "general procedure" distinction is not directly native to the ULS but is useful as a broad categorization of the assignment or transfer process.

[b] Applications recorded as "accepted" or "granted," depending on ULS procedure at the time. Many of these are *pro forma* transactions between telecom companies which qualified for forbearance. Some may take place before paperwork is filed with the FCC.

[c] Applications recorded as "consummated" or "consented" (if consummation has not yet occurred). These are, at least in theory, more closely scrutinized by the Commission and must be approved before the trade is carried out.

[d] Applications from this period are incomplete and certainly contain errors: e.g., 23 are recorded as received in 1911, immediately followed by 25 in 1987.

Source: FCC ULS Assignments and Transfers database.

# Table 3

**Completed Approval-Track Assignments of Authorization and Transfers of Control[a]**
**by Service Code Category,[b] 1994-2009[c]**

| Receipt year | Cellular | PCS | Industrial/ Business | Land Mobile | | Broadband radio | Educational broadband | Public safety | Microwave | Paging | Coast & Ground | Other[d] | Unknown[e] | Total[f] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Commercial | Private | | | | | | | | | |
| 1994 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 370 | 371 |
| 1995 | 0 | 13 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 14 |
| 1996 | 0 | 54 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 7 | 62 |
| 1997 | 0 | 392 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 395 |
| 1998 | 136 | 177 | 0 | 14 | 0 | 0 | 0 | 0 | 81 | 135 | 0 | 8 | 16 | 558 |
| 1999 | 238 | 267 | 2 | 39 | 0 | 3 | 0 | 0 | 340 | 87 | 0 | 3 | 5 | 906 |
| 2000 | 234 | 295 | 534 | 489 | 12 | 0 | 0 | 5 | 584 | 95 | 0 | 94 | 1 | 2,136 |
| 2001 | 23 | 278 | 1,600 | 1,082 | 71 | 1 | 0 | 67 | 303 | 56 | 37 | 44 | 2 | 3,285 |
| 2002 | 38 | 188 | 2,017 | 589 | 47 | 0 | 0 | 217 | 325 | 68 | 93 | 10 | 7 | 3,181 |
| 2003 | 33 | 294 | 1,419 | 272 | 80 | 0 | 0 | 166 | 252 | 63 | 50 | 20 | 4 | 2,322 |
| 2004 | 98 | 235 | 1,431 | 173 | 50 | 0 | 0 | 94 | 260 | 57 | 58 | 10 | 0 | 2,151 |
| 2005 | 31 | 237 | 1,560 | 455 | 47 | 90 | 23 | 109 | 220 | 78 | 67 | 15 | 8 | 2,558 |
| 2006 | 100 | 220 | 1,500 | 373 | 75 | 70 | 27 | 302 | 264 | 76 | 43 | 9 | 5 | 2,671 |
| 2007 | 120 | 191 | 1,370 | 166 | 62 | 81 | 24 | 204 | 361 | 47 | 52 | 4 | 2 | 2,301 |
| 2008 | 103 | 182 | 1,075 | 93 | 57 | 189 | 43 | 163 | 308 | 31 | 50 | 5 | 2 | 1,994 |
| 2009 | 0 | 10 | 133 | 9 | 6 | 0 | 0 | 45 | 21 | 6 | 5 | 0 | 0 | 215 |
| Totals | 1,154 | 3,034 | 12,641 | 3,756 | 507 | 434 | 117 | 1,372 | 3,319 | 801 | 455 | 222 | 3,215 [g] | 27,905 [g] |

[a] That is, assignment of authorization and transfer or control applications (and amendments and corrections thereof) marked "consented" or "consummated" by the FCC.
[b] Grouping details available at http://wireless.fcc.gov/uls/index.htm?job=radio_services.
[c] As of March 1, 2009 ULS database update. "Total" column includes applications outside of the named timeframe (see note [g]).
[d] Applications which are marked by a radio service code outside the categories named. They are: BC, CA, CB, CG, CO, CR, MM, and ZV.
[e] Applications without radio service details recorded (more precisely, without call sign information, which is required to link to license radio service).
[f] Equal to less than the sum of the other columns. Applications may be for rights to spectrum from under several of the assignor's licenses. Each license falls under certain radio service. Thus a given application may invoke several differing radio services, which would result in double-counting if not ignored in these totals.
[g] Totals beneath the "Unknown" and "Total" columns include applications marked with one of the relevant statuses but containing insufficient information to warrant display elsewhere in the table.
We observe 2,754 applications received prior to 1994, none with radio service details. In addition, 31 applications show neither radio service nor receipt dates recorded.

Source: FCC ULS Assignments and Transfers database.

Leases appear to be less common than outright trades, but they do occur. They are somewhat difficult to examine in part because the way firms were required to report information changed in 2006. The two tables below—one for leases that occurred before the change and one for leases that occurred after the change—show the extent of leasing.

**Table 4**
**Completed Spectrum Leases**
**2004 - August 27, 2006**

| Receipt year | Leases and Subleases | | | Lease Assignments & Transfers |
|---|---|---|---|---|
| | Spectrum Manager | *De facto* Transfer | Total | |
| 2004 | 50 | 70 | 120 | 2 |
| 2005 | 96 | 229 | 325 | 13 |
| 2006 | 54 | 301 | 355 | 38 |

Notes: Leases granted under Form 603-T for applications received through August 27, 2006.
Under a "spectrum manager lease," the licensee retains *de jure* and *de facto* control over the spectrum.

Under a "*de facto* transfer lease," the "retains *de jure* control of the license while transferring de facto control of the leased spectrum and the associated rights to the spectrum lessee for a defined period of time" http://wireless.fcc.gov/licensing/index.htm?job=spectrum_leasing

"Lease assignments and transfers" refer to assignments of authorization of leased spectrum by the lessee to another entity, or the purchase of a lessee firm by a third party (transfer of control).

## Table 5

**Completed Spectrum Leases, Application Form 608**
**New Leases and Subleases[a] by Service Code Category,[b] and Term Length,[c] 2006-2009[d]**

| Receipt Year | Lease Term | Cellular | PCS | Industrial/Business | Land Mobile Commercial | Broadband Radio | Educational Broadband | Microwave | Paging | Coast & Ground | Other[e] | Unknown[f] | Total[g] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2006 | Short | 1 | 4 | - | 1 | - | - | 5 | 1 | - | - | 1 | 10 |
| | Long | - | 10 | 5 | 3 | 9 | 128 | 6 | - | - | - | - | 161 |
| 2007 | Short | 8 | 44 | 1 | 6 | 6 | 6 | 7 | 3 | - | - | - | 79 |
| | Long | - | 61 | 20 | 18 | 14 | 403 | 24 | 2 | - | 1 | - | 541 |
| 2008 | Short | 29 | 106 | - | 11 | 14 | 6 | 46 | 5 | - | 1 | 1 | 202 |
| | Long | 2 | 51 | 4 | 16 | 13 | 219 | 55 | 1 | 13 | - | - | 372 |
| 2009 | Short | 1 | 3 | - | 3 | 5 | - | 2 | 1 | - | - | - | 15 |
| | Long | - | 7 | - | 1 | 2 | 14 | 6 | - | 1 | - | - | 31 |
| Total | | 41 | 286 | 30 | 59 | 63 | 776 | 151 | 13 | 14 | 2 | 2 | 1411 |

[a] Also includes "spectrum commons" transactions.
[b] Grouping details available at http://wireless.fcc.gov/uls/index.htm?job=radio_services.
[c] Under the Form 608 rules short-term leases are for a year or less, long-term is anything greater (not exceeding the length of the license).
[d] As of the March 1, 2009 database update. This form was introduced on August 28, 2006.
[e] Applications which are marked by a radio service code outside the categories named. They are: BC, CA, CB, CG, CO, CR, MM, and ZV.
[f] Applications without radio service details recorded (more precisely, without call sign information, which is required to link to license radio service).
[g] Equal to less than the sum of the other columns. A lease may be for rights to spectrum from several of the assignor's licenses. Each license falls under certain radio service. Thus a given application may invoke several differing radio services, which would result in double-counting if not ignored in these totals.

Source: FCC ULS Form 608 Spectrum Leasing database

The tables show that spectrum licenses do change hands, and that trades are hardly uncommon. These tables, however, provide no evidence on the thickness of the market or the magnitude of the trades. Trades can be as large as an entire market or as small as a single cell site. Even determining the size of trades at a market level is not simple because licenses can be partitioned (divided into smaller geographic areas) and disaggregated (divided into smaller frequency blocks) or both, creating license trades that resemble multi-dimensional blocks of Swiss cheese.

**Magnitude of Spectrum Trades**

Ideally, we could track spectrum value if we know how much buyers paid sellers for their spectrum. Unfortunately, because these are private transactions that information is generally not available. We can, however, calculate how much spectrum is traded in various frequencies and service codes. The typical way of defining magnitudes in spectrum is to estimate "MHz-pops," or the amount of bandwidth in megahertz times the population covered by the license. Table 6 shows the amount of spectrum that traded hands as market-based trades. That is, it excludes leases and also site-based trades.[33] The table shows that since 2003 about 10 billion MHz-pops of PCS spectrum have changed hands annually. By comparison, the 700 MHz auction in 2008 released about 18 billion MHz-pops into the market.

[33] The magnitudes as presented are derived by calculating the MHz-Pops of market-based licenses since these are relatively convenient to calculate. The FCC provides files listing the populations of the market areas under such licenses, as well as the frequencies to which the licenses give "ownership." These allow for the calculation of MHz-Pops values which may then be tied to assignments and transfers. Site-based licenses are more opaque. They are defined around specific geographic points and lack straightforward metrics for populations served or bandwidth implicated, making them difficult to evaluate with anything beyond a simple transaction count.

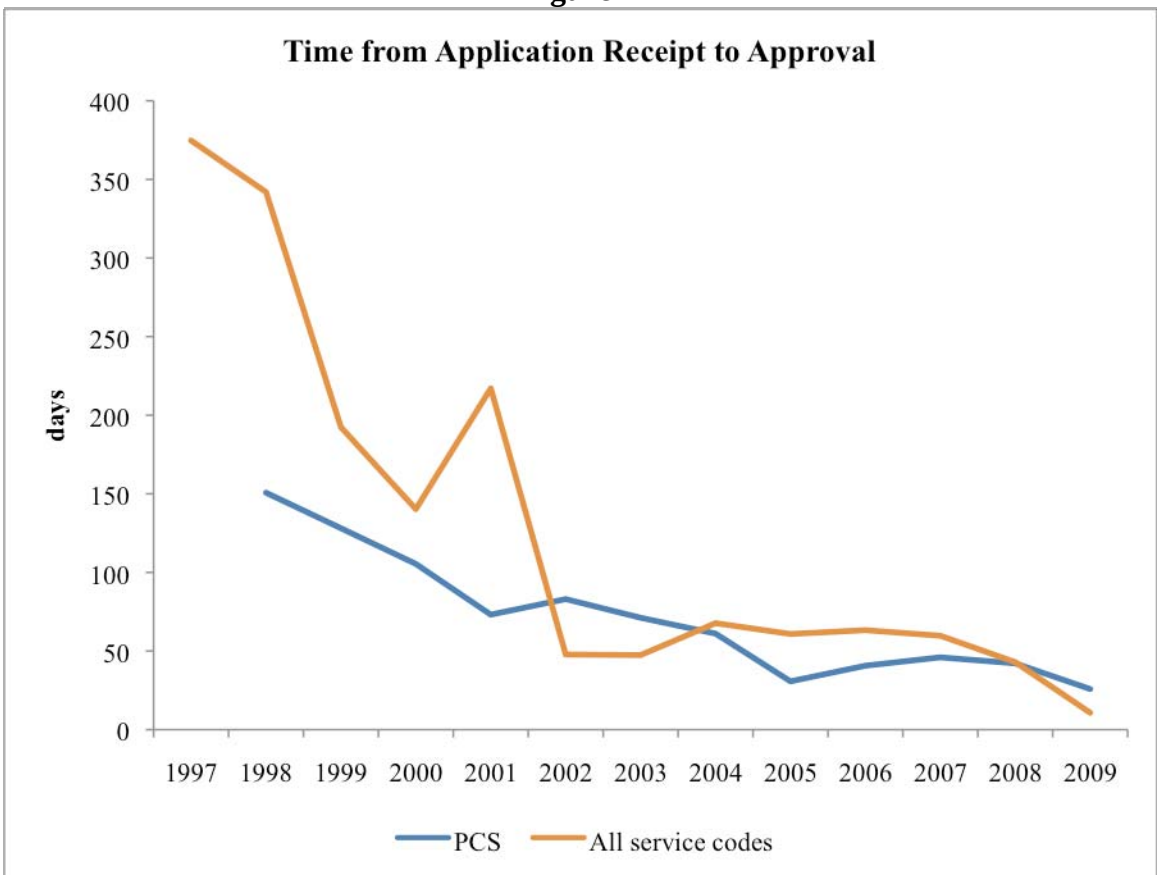
**Table 6**

| Spectrum Traded in Voluntary, Non-Pro Forma Transfers and Full Assignments of Market-Based Licenses by Service Code Category in billions of MHz-Pops | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Year** | **PCS** | **Land Mobile Commercial** | **Broadband Radio** | **Microwave** | **Paging** | **Coast & Ground** | **Total** |
| 1997 | 0.307 | 0.004 | | | | | 0.311 |
| 1998 | 3.051 | 0.013 | | 10.576 | | | 13.640 |
| 1999 | 12.106 | 2.530 | | 170.974 | | | 185.610 |
| 2000 | 13.436 | 0.716 | | 9.035 | 0.004 | | 23.191 |
| 2001 | 9.175 | 0.468 | | 87.200 | 0.005 | | 96.848 |
| 2002 | 5.390 | 0.354 | | 577.000 | 0.012 | 0.014 | 582.770 |
| 2003 | 12.613 | 0.121 | | 49.100 | 0.016 | 0.001 | 61.851 |
| 2004 | 14.575 | 0.188 | | 14.674 | 0.056 | 0.015 | 29.509 |
| 2005 | 7.659 | 7.510 | 12.600 | 56.200 | 0.030 | 0.035 | 84.034 |
| 2006 | 8.918 | 1.100 | 1.030 | 133.000 | 0.052 | 0.093 | 144.192 |
| 2007 | 9.143 | 2.200 | 2.400 | 37.899 | 0.027 | 0.043 | 51.712 |
| 2008 | 12.581 | 0.326 | 18.699 | 10.052 | 0.009 | 0.087 | 41.754 |
| 2009 | 0.613 | 0.034 | 0.014 | 1.130 | 0.006 | | 1.797 |

Source: FCC ULS Assignments and Transfers, License databases.

As discussed earlier, the FCC has undertaken concerted efforts to facilitate secondary market trading. One important policy objective was to reduce the time the FCC would take to approve transactions. Some transactions, such as ones that are merely transfers between firm affiliates, are more akin to notifications. These "pro forma" trades are approved almost instantly. Other trades still require approval, but unless they violate certain conditions, they are also approved quickly. Figure 2 shows the average length of time, in days, the FCC took to approve transfers of license control. The figure shows that, for example, in 1998 it took the FCC 151 days, on average to approve PCS license transfers once it had received the application, but only about 30-40 days from 2005-2009.

**Figure 2**



## V. Conclusion

While the the use of markets to make new spectrum allocation decisions is becoming increasingly common in policy circles, such initial allocations are only that—*initial* allocations. The ability of market mechanisms to ensure that resources remain in their most highly valued use requires not only that these initial allocations be properly conducted, but also that secondary markets be well functioning. And though this is well understood in principle, the practice of secondary spectrum markets has been less well studied. In this paper, we have made an initial effort to understand the underlying principles of such secondary markets and the evolving policies toward secondary spectrum markets. We have also taken first steps toward quantifying important dimensions of the secondary spectrum markets. With this initial effort in hand, it is perhaps possible to begin to fashion policies that better enable the growth and development of these markets, and, more generally, the use ability of wireless technologies that rely upon this spectrum.

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