Cost of Regulatory Risk for

Wireless Spectrum Values

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I. EXECUTIVE SUMMARY

Radio spectrum is a scarce resource and care must be taken to ensure it is put to its highest valued uses. This goal is facilitated through transfers of spectrum licenses to firms willing to invest in building wireless networks. The current value of spectrum licenses—either at auction or in secondary markets—is driven by the expected value from its future use. Ensuring that spectrum licenses receive their highest value, both at auction and on the secondary market, requires that spectrum licenses meet at least two criteria: (1) that they are easily transferable and (2) that the bundle of rights associated with a spectrum license do not face contingent impairment from future changes in regulatory policy. For this reason, maintaining regulatory transparency and minimizing regulatory risk is crucial to preserving the substantial value of radio spectrum licenses.

If the FCC were to follow the GPS industry requests to prevent LightSquared from ever deploying a terrestrial network in the L-Band, it would effectively be signaling a new level of uncertainty in FCC policy. That increased uncertainty will be seen as caused by the political process preventing spectrum from being reallocated to its highest valued use. Due to interference with GPS devices that do not filter spectrum outside of the GPS allocation, the GPS industry has called for the FCC to revoke LightSquared's authority to build a terrestrial network in the L-Band and to move LightSquared out of the L-Band entirely. LightSquared has already made substantial investments to integrate its existing satellite services with a nationwide 4G LTE network in the L-Band—a plan that is integral to meeting the goals identified in the National Broadband Plan. By revoking LightSquared's authority, the FCC would introduce the possibility that future license allocations may also be revoked, regardless of investment or the benefits of the anticipated services.

This paper uses a simple cash flow model similar to one that might be employed by a firm evaluating the costs and benefits of investing in a wireless broadband network to illustrate how the value of any spectrum license might change if regulatory uncertainty is introduced. The additional regulatory risk of having an allocation revoked reduces the present value of that spectrum allocation in two ways. First, the possibility that cash

flows might fall to zero if a spectrum license is revoked decreases the *expected* cash flow by about the same percentage as the risk of having a license revoked. Second, the risk of losing the license further increases the cost of debt and, thereby, decreases the present value of future cash flows.

Results suggest that an added 5% probability that the FCC would revoke a license and stop the deployment of licensed spectrum after 2 years decreases the value of the spectrum by 10%. The direct effect from the change in expected cash flows alone reduces the value of the spectrum license by 6%. The indirect impact of increased risk on the discount rate used to calculate the present value of cash flows accounts for the additional 4% reduction in value. These findings prove robust to adjustments in various model assumptions. Factors that largely determine the impact of regulatory risk on spectrum value are the actual change in risk of regulatory action, and the extent to which the purchase of a spectrum asset is financed by debt.

The impact of this regulatory uncertainty could be significant for the wireless broadband industry and U.S. economy more broadly. By reducing the expected returns from wireless broadband radio spectrum licenses, uncertainty could result in reduced FCC spectrum auction receipts, delayed and cancelled wireless broadband investment projects, reduced consumer welfare, and lower economic growth. Inevitably, many spectrum based wireless broadband investment projects that currently seem profitable would no longer appear so as a result of lower expected returns and higher financing costs. Even for projects that would still be profitable in the face of added uncertainty, reduced expected returns and higher risks will make these projects less attractive. This could result in financing delays and temporarily stalled projects. Reduced and delayed network investments would have ripple effects throughout the economy. In fact, by former Treasury Secretary Lawrence Summers estimation, a dollar of investment in wireless broadband results in up to $7 to $10 of higher GDP, implying that losses from reduced investments would be substantial.

The impact of these costs on FCC spectrum auction receipts could also be significant. If the 500 MHz of spectrum identified in the National Broadband Plan for wireless

broadband allocation is worth as much as $100 billion, then a 5% increase in the risk of losing an allocation could reduce expected spectrum receipts by over 10% or $10 billion.

II.   INTRODUCTION

Radio spectrum is a scarce resource and care must be taken to ensure that it is put to its highest valued uses.[1] Wireless broadband service is currently one of these highest valued uses—both in terms of economic value and social welfare. This implies that transferring spectrum licenses to firms and investors interested in building wireless networks maximizes both social welfare and economic value.   Secondary market trades of previously assigned spectrum licenses ensure that spectrum continues to be put to its highest valued uses even as resource requirements and demand for services that utilize spectrum shift. The actual value of spectrum licenses—either at auction or in secondary markets—is driven by the expected value derived from its future use.

Ensuring that spectrum licenses receive their highest value requires that spectrum licenses meet at least two criteria: (1) that they are easily transferable and (2) that the bundle of rights tied to a spectrum license is not diminished. Similar to any asset, if the value of the spectrum license can not be traded and its usefulness diminishes over time, then the asset loses value. For this reason, maintaining regulatory transparency and minimizing regulatory risk is crucial to preserving the substantial value of radio spectrum licenses.

If the FCC were to follow the GPS industry requests to prevent LightSquared from ever deploying a terrestrial network in the L-Band, it would increase regulatory uncertainty regarding the security of rights tied to FCC licenses. This regulatory uncertainty would, in turn, increase the attendant costs and reduce the value of holding radio spectrum licenses. As a result, these added costs would decrease the potential receipts from spectrum auctions, as well as the value of spectrum traded on the secondary market.

Furthermore, by relenting to GPS industry requests and rescinding LightSquared's license despite the substantial value it is expected to create, the FCC might create—or

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[1]   See the Principle of Spectrum Reallocation as discussed in "Oral Testimony of Coleman Bazelon," *The Brattle Group, Inc.* U.S. House of Representatives, Committee on Energy and Commerce Subcommittee on Communication and Technology (April 12, 2011). Found at: http://democrats.energycommerce.house.gov/sites/default/files/image_uploads/Testimony_04.12. 11_Bazelon.pdf (last visited June 20, 2011).

reinforce—an expectation that the political process could be used to influence policy and prevent spectrum from being reallocated to its highest valued use. The FCC should operate in a fair-minded way by focusing on policies that benefit the consumer, while also ensuring that spectrum is used for its highest valued use whenever possible. The FCC's review process is typically understood to be a way for the FCC to gather information on the costs and benefits of a particular policy, and then make an informed decision, presumably on the facts. By allowing political interests to influence allocation decisions well outside the normal deliberative process, the FCC could create even more uncertainty and exacerbate the element of political strategy into what should otherwise be a fact driven process.

Since the expected value of radio spectrum licenses is driven by the present value of future expected cash flows from the services enabled, any factor that decreases the value of those expected cash flows has a negative effect on spectrum value. For instance, license restrictions imposed by the FCC and various other encumbrances to the spectrum can have a substantial impact on the value of spectrum by increasing deployment costs, and decreasing capacity and revenues. Similarly, any factor that increases the risk or uncertainty related to deploying spectrum or receiving revenue will reduce its expected revenue and cash flow and, in turn, decrease its value.[2]

One potential source of uncertainty for the expected revenues of a spectrum license is regulatory risk. In addition to the conventional sources of risks related to the telecom industry and wireless broadband spectrum business overall—such as uncertainty about future demand and technology—government regulation can be a serious source of added uncertainty and reduced revenue expectations. In fact, regulatory risk is not unique to the telecom industry, and is likely to decrease values in a variety of regulated industries. For

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[2]   Other factors that either increase costs or decrease expected revenues include the quality and physical characteristics of the spectrum, the cost of clearing incumbent users from the spectrum, and the cost of network build-out. For further discussion of factors that impact spectrum value, see Coleman Bazelon, "The Economic Basis of Spectrum Value: Pairing AWS-3 with the 1755 MHz Band is More Valuable than Pairing it with Frequencies from the 1690 MHz Band," The Brattle Group (April 11, 2011). (Herein "Bazelon, "Economic Basis of Spectrum Value," 2011"). Found at: http://www.brattle.com/NewsEvents/NewsDetail.asp?RecordID=945 (last visited July 17, 2011).

instance, regulatory risk is cited as a problem for natural gas pipelines, energy utilities, and various other regulated industries.[3]

Although the FCC has not taken this authority to revoke licenses lightly,[4] based on the rules of FCC licenses, the risk that the FCC might revoke a license has always existed. For example, most licenses auctioned come with 'a high expectancy of renewal,' even though the licenses are based on a fixed term and the FCC is not obliged to renew them. This 'expectancy' was created by the FCC in an attempt to reduce uncertainty about what would happen at the end of a license term and, thereby, increase the value to bidders of licenses at auction. Such long-term certainty also created the incentives for licensees to continue to invest in their networks even as the license expiration approaches. Nevertheless, spectrum license holders do not hold property rights in their licenses, and would have few remedies against a revoked license.

Until now, license holders have not anticipated the FCC revoking licenses as a concern, as they do in some industries. License holders rely on the certainty that if they purchase a spectrum license and invest in the infrastructure required to transmit services, the rights associated with their license will be maintained. Further, buyers on the secondary market have had the same assurance that the rights associated with any license they purchase will be maintained once the license is transferred. This certainty has likely resulted in relatively lower costs of borrowing for license holders, increased the expected cash flow from licenses, and allowed for greater transparency in the secondary market—all of which likely increased the value of spectrum licenses.

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[3]   For further discussion on regulatory risk, see Laurence A. Kolbe, William B. Tye, and Stewart Myers. *Regulatory Risk: Economic Principles and Applications to Natural Gas Pipelines and Other Industries.* Kluwer Academic Publishers. Massachusetts: 1993.
For a European perspective, see Burkhard Pedell, *Regulatory Risk and the Cost of Capital*, Springer 2006.

[4]   There are cases of FCC licenses revoked for failing to meet the criteria of a license. For instance, in September 2010 MSS, satellite provider Globalstar lost its ATC authority for failing to meet gating criteria for ATC deployment in a timely manner. See Paul Weiss LLC, "Globastar ATC Authority Suspended by FCC," *Current Telecom Developments* (September 17, 2010). Found at: http://www.paulweiss.com/files/Publication/9e5df7a7-cdae-4655-916e-3488c387b129/Presentation/PublicationAttachment/d0ff24b6-9f9a-4a9c-8b09-3601ea9715f0/CTD9-17-10.pdf (last visited July 14, 2011).

Recently, however, the GPS industry has called for the FCC to revoke LightSquared's authority to build a terrestrial network in the L-Band and to move LightSquared out of the L-Band entirely.[5] According to the GPS industry, tests of LightSquared's terrestrial base stations have shown that these transmissions can cause interference issues for GPS receivers. These interference issues are not the result of LightSquared signals intruding into GPS spectrum, but rather due to existing GPS devices that do not filter spectrum beyond the GPS allocated spectrum bands.[6] Part of the solution to this problem will be for future GPS devices to be embedded with a filter to block spectrum signals beyond the border of the GPS transmissions. It appears that technology exists to adequately fix the interference problem from LightSquared's Ancillary Terrestrial Component (ATC) signals discussed above, but there has previously been no need for GPS devices to incur the expense of using filters that can block radio waves in the adjacent L-Band.[7]

Further, LightSquared has already made substantial investments in infrastructure to integrate its existing satellite services with a nationwide 4G LTE network in the L-Band.[8]

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[5] See press release from the Members of the Coalition to Save Our GPS that calls for LightSquared "to move completely out of band adjacent to GPS." "FCC-Mandated Working Group Report Documents Pervasive Harmful Interference with GPS," *Coalition to Save Our GPS Press Release*, (June 30, 2011). Found at: http://www.saveourgps.org/related-articles.aspx (last visited July 30, 2011).

[6] LightSquared has ensured that their spectrum will not interfere with GPS frequencies by developing base station filters that effectively cut off all signals above 1559 MHz. GPS users acknowledge there is no problem with out-of-band emissions. See Coleman Bazelon, "GPS Interference: Implicit Subsidy to the GPS Industry and Cost to LightSquared of Accommodation," *The Brattle Group White Paper* (June 22, 2011). Found at http://www.lightsquared.com/wp-content/uploads/2011/06/LightSquared625pm.pdf (last visited July 30, 2011). (Herein "Bazelon, "GPS Interference," 2011"), which cites Tim Farrar, "Fixing the GPS interference problems," TMF Associates MSS blog (April 6, 2011). (Herein "TMF Associates, April 6, 2011"). Found at: http://tmfassociates.com/blog/2011/04/06/fixing-the-gps-interference-problems/ (last visited June 20, 2011). According to John Deere, "[out of band emissions] is not a problem in the GPS band if LightSquared filters their signals as they have committed." See John Deere Presentation to FCC, attached to Electronic Filing regarding Notice of Ex Parte Presentation in LightSquared Subsidiary LLC Request for Modification of its Authority for an Ancillary Terrestrial Component. IBFS File No. SAT-MOD-20101118-00239 (March 21, 2011).

[7] See, for example, Qualcomm's comments on their discussion with the FCC regarding their plans to remedy similar problems in their cellular devices. Comments filed by Qualcomm at the FCC regarding "Ex Parte Notification – IB File No. SAT-MOD-20101118-00239," (January 21, 2011). Searchable at: http://licensing.fcc.gov/cgi-bin/ws.exe/prod/ib/forms/reports/related_filing.hts?f_key=-216679&f_number=SATMOD2010111800239 (last visited June 20, 2011).

[8] For a complete discussion of LightSquared, its plan to build-out a terrestrial network, and the interference issues related to GPS, see Bazelon, "GPS Interference," 2011.

Until recently, there was no reason to believe this interference would be an impediment to LightSquared's LTE network plans. LightSquared has had ATC authority for several years. Through a series of secondary market trades, LightSquared has accumulated the license rights to 46 MHz of spectrum in the L-Band.[9] Additionally, the company has invested $1.1 billion to build and launch a next-generation satellite system for integrated satellite and 4G terrestrial LTE network,[10] and invested heavily in developing and deploying a terrestrial network as part of an integrated, nationwide network.[11] Without authority to provide terrestrial and satellite service in the L-Band, however, LightSquared's plans will be halted and its investments will be lost.

Beyond the loss of all future revenues to LightSquared, however, if the FCC revokes LightSquared's ATC authority in the L-Band they would be effectively signaling a new level of uncertainty in FCC policy. Such action by the FCC would introduce the possibility that other current and future license allocations may also be revoked. Even more, such revocation would result not by actions that the licensee has taken, or even could take, but rather by other users who arguably are not living within the boundaries of licenses. And by revoking LightSquared's authority and license the FCC would be suggesting that there is potential for such action regardless of investments made, or consumer and social benefits of a project.

If the FCC were to signal a willingness to revoke spectrum licenses, this new uncertainty could reduce the expected value of all spectrum licenses in two important ways. First, given the risk that the FCC could revoke a license there would be some probability that any project could be stopped. Without a license, services that relied on that spectrum

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[9]   See TMF Associates, April 6, 2011. See, also, "Order and Authorization in the Matter of LighSquared Subsidiary LLC Request for Modification of its Authority for an Ancillary Terrestrial Component," *FCC*. Docket DA 11-133 (January 26, 2011), p. 2. Found at: http://transition.fcc.gov/Daily_Releases/Daily_Business/2011/db0126/DA-11-133A1.pdf (last visited July 30, 2011). (Herein "Order and Authorization for LightSquared, January 26, 2011").

[10] See "LightSquared Announces the Successful Launch of Next-Generation Satellite," *LightSquared Press Release*, (November 15, 2010).
Found at: http://www.lightsquared.com/press-room/press-releases/lightsquared-announces-the-successful-launch-of-next-generation-satellite/ (last visited June 20, 2011).

[11] In addition to covering 100% of the U.S. population with satellite services, LightSquared has committed to build-out 4G terrestrial LTE based service to at least 36% of the population (100 million people) by the end of 2012 and at least 92% of the U.S. population (260 million people) by 2015. See Order and Authorization for LightSquared, January 26, 2011, p. 4.

would have to be halted, and future revenues and cash flows would be lost. Second, the possibility that cash flow might be zero increases the probability that, with zero cash flow, the license holder will default on its debt obligations.[12] A higher likelihood of default, in turn, could increase the cost of debt.

The next section discusses the costs associated with the added regulatory uncertainty that might be imposed if the possibility of license revocation increases. Section IV then addresses how these costs would be likely to affect the value of spectrum and the implications of lower spectrum values.

III. THE COST OF REGULATORY RISK

If the FCC were to revoke LightSquared's ATC authority and L-Band spectrum licenses, it would effectively be signaling a willingness—absent licensee malfeasance—to revoke spectrum licenses even after capital investments had been made on projects that had substantial consumer and societal benefit. The analysis below assumes that by revoking a wireless broadband license the FCC increases the perceived probability that it will take such measures on any wireless spectrum license. It is very difficult, and largely speculative, to estimate the exact change in perceived risk that would result if the FCC increases market uncertainty by revoking a spectrum license. To illustrate that even a small increase in the probability of losing a license has significant impact, this analysis assumes a 5% increase in risk of license revocation. I perform a sensitivity analysis to understand how these results change with different levels of risk of license loss.

In order to illustrate how the value of any spectrum license might change under these conditions I employ a simple cash flow model similar to one that might be used to evaluate the costs and benefits of investing in a wireless broadband network. The results suggest that an added 5% probability that the FCC revokes a spectrum license and stops the project after 2 years decreases the value of the project by just over 10%. As this

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[12] There is a third potential impact of increased risks on spectrum value—the potential to change the 'beta' of a company and, therefore, its cost of equity. It is unclear if this channel would be applicable here, or even the direction of the impact if there was one, so it will not be considered in what remains.

model illustrates, because the value of a wireless broadband spectrum license is equal to the present value of future expected cash flows, an additional 5% chance that the services will be stopped and net revenue will fall to zero results in a lower present value. The direct effect from the change in expected cash flows alone reduces the value of the spectrum license by 6%.[13] The additional impact of increased risk on the discount rate used to calculate the present value of cash flows accounts for the additional 4% reduction in value.

This additional risk works through the firm's ability to borrow money to finance its activities. If the project is halted and net revenue is then zero, the debtors are at risk of not being repaid. This risk may be particularly acute if the current license holder received the asset through a secondary market trade. That is, even if there is a possibility that the FCC would repay a winning bidder its license payments after an auction, it is less likely that it will reimburse a party that purchased the license on the secondary market.[14] In this case, the value of the spectrum license is diminished by 10%. Results are reasonably robust to the risk induced by any FCC action and various other parameters of our model.

A.   VALUE OF A SPECTRUM LICENSE

As with any capital investment, the net return of investing in a band of spectrum will be realized over time. The upfront capital investment in a spectrum license is expected to result in a stream of annual cash flows (revenue, minus capital expenditures and operating costs) over time. The value of the investment and expected stream of profits depends critically on the timing of this stream of returns. The present value of any future payment is equal to the amount you would need to invest today to receive that future return. For instance, given an interest rate of 5%, the present value of $105 next year is $100 today. The value today of this stream of costs and revenues is captured by the net present value (NPV) of an asset.

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[13]   As discussed below, this loss is a little over 5% because there is a 100% probability of negative cash flows due to infrastructure investments in the first two years.

[14]   The legal issue of 'regulatory takings' and any constitutional requirement for compensation is complicated and well beyond the scope of the current analysis. There is no way to know how the FCC would behave in this situation. If the FCC did repay the license, the risk to debtors and resulting increase in the cost of debt would likely be lower.

The NPV of a capital investment represents the cash value today of the expected stream of net returns (revenues minus costs) that an investment is expected to yield over its lifetime. The present value of any investment is equal to the sum of the present value of each annual net return or cash flow (CF), discounted by the rate of return for that year.[15]

$$NPV = \sum_{t=0}^{n} \frac{CF_t}{(1+R_t)^t}$$

Investments that have higher levels of risk must have higher expected rates of return (R) or, equivalently, higher discount rates. As a result, if the rate of return on an investment is higher, the NPV of each anticipated cash flow is more heavily discounted, and therefore lower, today.

For instance, if regulatory uncertainty results in a higher risk that there will be no future cash flows there will be two effects. First, expected cash flow (CF) from that project will be lower due to the probability that there are no net revenues after year 2. Second, the present value will be more heavily discounted through the use of a higher discount rate.

B. IMPACT OF REGULATORY UNCERTAINTY

The effects of decreased expected cash flow and added uncertainty from the possibility that the FCC might revoke the license are estimated through a simple cash flow model. The assumptions in this model are based on observed cash flows of wireless broadband providers, as reported in company Annual Reports and other filings.[16] The essential features of the model include an initial capital investment in network build-out that is estimated to take 4 years. The cost of this initial investment per year is equal to one third of the expected revenues in year-5 when the entire network is operational and a customer

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[15] Aswath Damodaran, *Investment Valuation 2nd Edition*, New York, NY: John Wiley and Sons (2001).

[16] In particular, I reviewed the 2008 through 2010 Annual Reports of Verizon Wireless, U.S. Cellular, and Sprint.

base has been established.[17] During this initial period, cash flows are expected to be negative and operating costs are ramping up annually with service and build-out.[18]

Beginning in year-5, the network is expected to be in full operation, receiving full revenues and incurring operating expenses equal to 63% of capital investment.[19] After year-5, revenues are expected to grow at 5% annually. I assume there are no further capital investments in infrastructure. In contrast to a typical balance sheet, but consistent with the typical cash flow of capital investments, the model assumes the cash outlay for capital investments is incurred in the first 4 years. Since we are modeling the possibility that the entire project is shut-down half-way through build-out, this assumption is a critical feature of the model. Finally, we assume that, unless the project is canceled after 2 years due to a revoked license, the project will generate revenue through year-30. Because costs are tied to revenue, and revenue is assumed to grow at a constant rate, each annual cost and cash flow are essentially a multiple of year-5 revenues. With no loss in generality, I consider the case in which revenue in year-5 is equal to 1.[20]

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[17] Linking the amount of capital expenditure to the value of full service revenue ensures that capital investment for build-out is related to the revenue of the full capacity network. Assuming annual capital investment for the first 4 years is one-third of year-5 revenues implies that, based on the assumptions here, total capital expenditure is 40% of the total spectrum value with no regulatory uncertainty. This assumption is validated by LightSquared's own experience. LightSquared signed a deal with Nokia Siemens to build its LTE network for $7 billion. See Stacey Higginbotham, "Nokia Siemens Networks Wins $7B Contract to Build Harbinger's LTE Network," *Gigaom* (July 20, 2010). Found at http://gigaom.com/2010/07/20/nokia-siemens-networks-wins-7b-contract-to-build-harbingers-lte-network/ (last visited July 30, 2011). It is likely that $5 billion of this investment is upfront capital expenditures, which represents 42% of the total $12 billion value of the L-Band spectrum available to LightSquared for network build-out. See Bazelon, "GPS Interference," 2011.

[18] In year-1, revenues and operating costs are equal to $0. In year-2, gross revenues and operating costs are 25% of year-5 revenues. In year-3 gross revenues and operating costs are 50% of year-5. Finally, in year-4, gross revenues and costs are assumed to be 75% of year-5. Operating expenses are 63% of total revenue per year, starting in year-2.

[19] This assumption allows me to model various expenses, such as consumer equipment subsidies, as a fixed share of revenues, thus significantly simplifying the calculations. Cash flow and operating cost assumptions based on observations from public income statements of three wireless carriers' (*i.e.*, Verizon, Cellco, Sprint and U.S. Cellular) for 2007 through 2009. I made similar modeling assumptions in a previous paper released in April 2011. See Bazelon, "Economic Basis of Spectrum Value," 2011.

[20] The model can be scaled appropriately by multiplying revenues in year 5 by any estimate of revenues for a fully operational wireless network.

Based on these assumptions, there are two cash flow scenarios to consider. First, in the absence of regulatory uncertainty (*i.e.*, assuming there is no increased chance the FCC will revoke the license), the expected cash flow for any year is simply the expected revenue, less capital investment and operating expenditure. Second, if the FCC were to revoke the license, however, cash flows would be equal to the cash flows in absence of uncertainty in years 1 and 2, but thereafter cash flows are equal to zero. Based on the capital investment costs, cash flows in the first 2 years are negative, but although cash flows would continue to be negative in year 3 if the project continues, no costs are incurred once the project is halted.[21] Assuming regulatory uncertainty creates a 5% chance the FCC will revoke any license, the expected cash flow under regulatory uncertainty is equal to the sum of a 95% chance of business as usual cash flows and a 5% chance of no cash flows after year 2. As a result, after year 2 the expected cash flows under uncertainty are 5% lower than the expected cash flows were in absence of this uncertainty. Total cash flows for all 30 years are a little more than 5% lower under regulatory uncertainty.[22] These calculations result in a stream of expected annual cash flows for 30 years.

In the absence of regulatory uncertainty, the only risks incurred should be associated with existing business related factors. Certainly, every enterprise incurs some risk of doing business. Some portion of this risk is inherent to the entire economy, while the rest is unique to the industry or sector. Sector specific risks often include market failures, technological uncertainties related to research and development, and the possibility of accidents. These general market and sector specific risks and uncertainties are reflected in the industry cost of capital, defined as the weighted average return from debt and equity by firms in the sector. The cost of capital, therefore, reflects general economic risks and sector specific business risks.[23]

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[21] This assumption is conservative to the extent operators have signed development contracts with cancelation penalties.

[22] A little more than 5% because the first 2 years of negative cash flows occur with 100% probability.

[23] This includes any existing regulatory risks associated with spectrum licenses.

For the purposes of this analysis, I use the weighted average cost of capital (WACC) for companies in the wireless networking sector of 8.8% to calculate the present value of 30 years of cash flows.[24] Based on our initial assumptions, if year-5 revenue is $1 billion, for instance, the total value of a spectrum license is $3.3 billion with no increased regulatory uncertainty. Using the existing industry discount rate, but assuming the expected cash flow is based on a 5% probability the FCC might revoke a license, the present value of spectrum is 6% lower, or $3.2 billion. See Table 1 below.

Because long-lived assets such as spectrum licenses are typically financed with debt, I assume that the average debt to equity ratio is 75/25, as opposed to 15/85 estimated more generally for the wireless networking sector. Assuming that the WACC remains 8.8%, I recalculate the cost of debt and equity to be 5.4% and 21.0%.[25] I use this cost of debt and debt to equity ratio to calculate the total debt payments associated with investing in a spectrum license.

This particular regulatory risk associated with the FCC revoking an existing spectrum license is different from normal business cycle related risks, in that it is asymmetric. That is, this uncertainty introduces the possibility that, if a license is revoked, there will be zero return on investment, without increasing the possibility that cash flows and profits will be higher.

The regulatory uncertainty likely induced by the FCC if it revokes LightSquared's ATC authority in the L-Band could increase the cost of debt by introducing the probability of default in year-3 if the FCC revokes the license. The cost of debt must ensure that debtors are indifferent between lending under no uncertainty and lending in the presence of regulatory risk. Assuming a 5% regulatory risk and a 75/25 debt to equity ratio, the

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[24] Cost of equity is 9.56% and cost of debt is equal to 5.29%, or 4.48% after tax. These costs are based on 48 telecommunications companies in the wireless networking sector. For detailed cost of capital information on a variety of sectors, and the companies included in the wireless networking sector see Aswath Damodaran, "Cost of Capital by Sector," webpage on Damodaran Online. Updated as of January 2011. Found at: <http://pages.stern.nyu.edu/~adamodar/New_Home_Page/ datafile/wacc.htm> (last visited July 29, 2011). (Herein "Damodaran Online").

[25] Calculations based on unleveraged beta of 1.08, a risk free rate of 4.2% and a risk premium of 4.3%. See Damodaran Online.

cost of debt (before taxes) increases to 5.84%, nearly 8% higher than under regulatory certainty.[26] See Table 1 for a summary of results.

Table 1. Impact of Regulatory Risk on Spectrum Value
Assuming 5% Increase in Probability License is Revoked

	Cost of Debt *(Percent)* [1]	WACC *(Percent)* [2]	Present Value of Spectrum Cash Flow *($Billions)* [3]	Discount on Present Value of Spectrum Cash Flow Due to Regulatory Risk *(Percent)* [4]
[A] No Regulatory Risk	5.29%	8.80%	$3.35	
[B] Regulatory Risk of License Revocation Increased by 5% in Cash Flow with No Change in WACC	5.29%	8.80%	$3.15	6%
[C] Regulatory Risk of License Revocation Increased by 5%	5.84%	9.08%	$3.01	10%

Sources & Notes:
[1][A], [1][B]: Cost of Capital for Wireless Networking sector found at Damodaran Online,
<http://pages.stern.nyu.edu/~adamodar/New_Home_Page/ datafile/wacc.htm>.
[1][C]: The Brattle Group Calculation.
[2]: [1]*75% + Cost of Equity*25%, where cost of equity (9.02%) is found on Damodaran Online,
<http://pages.stern.nyu.edu/~adamodar/New_Home_Page/ datafile/wacc.htm>.
[3]: The Bratle Group Calculation.
[4]: 1 - [3] / [3][A], for the respective case.

C. SENSITIVITY OF RESULTS

The analysis above assumes that if the FCC revokes LightSquared's license, the probability that the FCC will revoke a license in the future will increase by 5%. This magnitude of the increase in risk is largely speculative; that some increase in risk will result, however, is not speculative. It would likely be difficult to determine what the impact would be until it occurs. The results of the model above remain reasonably consistent to a range of potential risks.

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[26] In order to calculate the updated costs of debt, I assume that the debt is a lump sum equal to 75% of the present value of the spectrum license over 30 years, as calculated with the no additional uncertainty WACC (8.8%). I apply the original cost of debt (5.29%) to the expected payment streams in the case of no regulatory uncertainty.   This yields a stream of annual payments such that the entire debt and interest is repaid at the end of 30 years. Next, using the total payment to debtors from this stream of payments under no added regulatory risk, I calculate the cost of debt and expected stream of payments under each risky scenario that will yield the same expected total sum of payments to the debtor.

As Table 2 illustrates, for any increase in the probability of a revoked spectrum license, the percent change in spectrum value is close to double that probability or added risk. For instance, a 1% increase in the probability that the FCC will revoke a license results in just over a 2% decrease in the present value of spectrum. For a 20% increase in the probability of a license being revoked, the present value decreases by 39%.

Table 2. Sensitivity of Spectrum Value to Regulatory Risk

Regulatory Risk	Change in Present Value
1%	2%
2%	4%
3%	6%
4%	8%
5%	10%
10%	20%
15%	30%
20%	39%

Source: The Brattle Group Analysis.

The model remains robust to similar sensitivity tests of a range of debt to equity ratios, and costs of debt and equity. For instance, by changing the debt to equity ratio from 75/25 to 25/75, the change in present value drops from 10% to 7%. This impact is largely due to the fact that a lower proportion of spectrum asset value would be financed by debt if the debt to equity ratio were lower.[27] Increasing the revenue growth rate from 5% to 8% decreases the change in present value by less than 1%. Finally, adjusting the year that the license is revoked also has little effect on the results.

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[27] I note that the probability of revoking the license only affects the cost of debt, so the WACC will differ across capital structures.

**Table 3. Sensitivity of Spectrum Value to Various Costs of Borrowing
Assuming 5% Increase in Probability License is Revoked**

	Change in Present Value
Debt/Equity at 75/25	10.2%
Debt/Equity at 50/50	8.8%
Debt/Equity at 25/75	7.3%
Debt/Equity at 75/25	
Growth Rate at 5%	10.2%
Growth Rate at 8%	10.2%
Year License Revoked	
1	9.9%
3	10.2%
5	10.2%

Source: The Brattle Group Analysis.

As the results in Table 2 and Table 3 indicate, the major factors that largely determine the impact of regulatory risk on spectrum value are the actual change in risk of regulatory action, and the extent to which the purchase of a spectrum asset is financed by debt. The base cost of debt and equity, as well as the revenue and cash flow assumptions of the stream of payments are much less influential.

IV. IMPLICATIONS OF LOWER SPECTRUM VALUES

Clearly, any factor that reduces the value of licensed spectrum will impact future investments in the wireless industry in a number of ways. For instance, lower spectrum values would result in lower FCC auction receipts. If the expected value of the NBP's suggested 500 MHz of spectrum was worth $100 billion,[28] a 5% increase in license revocation risk could reduce the value of that spectrum by as much as 10% or $10 billion. Perhaps more important than the direct impacts on federal auction receipts, however, is the impact of lower expected returns on private sector investment in wireless broadband.

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[28] See, for example, Coleman Bazelon, "Expected Receipts From Proposed Spectrum Auctions," *The Brattle Group* (July 28, 2011). Found at:
http://www.brattle.com/_documents/UploadLibrary/Upload964.pdf (last visited August 9, 2011).

Any investment project, either deploying wireless networks or some alternative, is a balance of revenues and costs. If the expected revenues exceed the expected costs, then an investment is profitable and worth undertaking. Higher expected cash flows imply greater expected profits and more attractive investment opportunities. Investment projects often compete across sectors, regions, or economies for investors. Potential wireless broadband projects in the U.S. are likely to compete for investors with a variety of other investment opportunities in the U.S. and abroad. Even for projects that continue to be profitable under such uncertainty, lower returns will make investing less attractive than alternative investments not impaired by increased license revocation risk and, in turn, finding investors will be more difficult. This all may result in it taking longer to get projects underway.

The increased regulatory uncertainty analyzed here is likely to reduce cash flows and result in less attractive investment opportunities in two ways. As illustrated above, increased risk of license revocation first reduces the expected gross revenues of services. Added uncertainty also indirectly reduces cash flows by increasing the cost of financing the project. With returns diminishing and the cost of financing increasing, the expected profits of every wireless broadband project will be lower.

While some projects will still be profitable enough to attract investors, some projects that would have been profitable in the face of regulatory certainty could be less attractive to investors, or even unprofitable. These decreased profits could affect either an entire project or a portion of a project. For example, a new network deployment that could otherwise be undertaken will no longer be an attractive investment. Alternatively, added uncertainty could make expansion, such as deploying an existing network further into rural areas, less attractive. This could result in either delayed or canceled expansion.

The reduced network investments that would result from less profitable spectrum deployment opportunities would have ripple effects throughout the economy. It is well known that wireless broadband investments have significant economic multipliers. For example, former Treasury Secretary Lawrence Summers has stated, "[e]ach dollar invested in wireless deployment is estimated to result in as much as $7 to $10 higher

GDP."[29] It is difficult to estimate exactly the reduced investment that would result, but with a multiplier of $7 to $10, it does not take much lost investment for serious economic harm to result. Added uncertainty about the security of license rights could make many wireless broadband investments less attractive to investors than they would otherwise be. Furthermore, some wireless investments that would have otherwise been undertaken will now be unattractive, resulting in delays and canceled opportunities. Consequently, these negative economic impacts on wireless industry growth would be amplified throughout the economy.

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[29] Remarks of Lawrence H. Summers, New America Foundation, *Technological Opportunities, Job Creation, and Economic Growth* (June 28, 2010). Found at: http://www.whitehouse.gov/administration/eop/nec/speeches/technological-opportunities-job-creation-economic-growth (last visited July 30, 2011).