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Digital Readiness: Nearly one-third of Americans lack the skills to use next-generation "Internet of things" applications

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Executive Summary

Accelerating technological change is placing a new premium on people's abilities to navigate the digital landscape. As the "Internet of things" ushers in powerful new applications in health care, education, government service delivery, and commerce, Americans are asked to share personal data with service providers in ways unforeseen a decade ago. They also have to muster the technical know-how to make Internet-connected devices function.

Yet nearly one-third of Americans are not ready to meet the twin challenges of trust and skills in a society in which digital applications are extending to more corners of our lives. Based on a 2013 national survey of Americans, this report finds that:

- **29% of adult Americans have low levels of digital readiness**, as measured by respondents' understanding of terms about the Internet and self-reported confidence in using computers or finding information online.
- **Digital readiness is a bigger problem than the digital divide**. Some 18% of Americans lack "advanced Internet access," that is, either broadband at home or a smartphone; 15% are not Internet users at all. Put differently, 70 million Americans are not "digitally ready" for robust online use, nearly twice the number (36 million) of people with no online access.
- **Lack of digital readiness afflicts one in five Americans who have advanced online access.** Although non-Internet users necessarily lack digital readiness, 18% of people who have broadband or a smartphone register low levels of digital readiness. These Americans – possessing the tools but deficient in skills – exhibit far lower levels of Internet use.

The report also makes policy recommendations for improving Americans' level of digital readiness. The proposals aim at building the capacity to help Americans use digital applications that will increasingly shape how governments serve citizens. Specifically:

- Governments should make complementary investments in digital readiness as they roll out new applications.
- Investments in digital readiness should build on existing programs that promote digital inclusion, such as those funded by the Commerce Department's Broadband Technology Opportunity Program, as well as other public-private initiatives.
- The philanthropic sector should direct investments to digital readiness for all segments of the community, as well as invest in measurement of how digital readiness impacts outcomes.
- Cities should create "community tech champions" as advocates for digital readiness. Such champions would highlight the need for promoting digital skills for new "Internet of things" applications that the public and private sectors develop.
- Libraries, who are already the primary curator on programs to encourage digital readiness in many communities, should embrace and expand that role.

Each of these recommendations expands of mission for different parties, and this will require new funding – from the public, private, and non-profit sectors. The returns to such investments, however, could be significant, with faster uptake of "Internet of things" applications, more efficient delivery of health care, education, and other government services. It would also contribute to a more skilled workforce as more job training migrates to the Internet. Resources to bolster digital readiness will foster a greater sense of inclusiveness in society where the expectation of universal broadband access and use is growing.

Introduction

When the U.S. Department of Commerce in the 1990s first started measuring how many people in the United States used the Internet, Larry Irving, head of the Department's National Telecommunications and Information Administration (NTIA), invoked the term "digital divide" to describe the Internet's "haves" and "have nots." At a time when one in seven Americans used the Internet, that binary notion of access shaped policy.

This proved to be a powerful way to frame policy discourse pertaining to digital equity. It motivated the creation of the Department of Commerce's Technology Opportunities Program in 1994, which provided grant funds for programs in areas such as education and health care to put new telecommunications technologies to work in those fields. As the 2000s unfolded, a number of non-profit organizations, such as Zero Divide, One Economy, and Computers for Youth, arose to draw people to broadband use. The American Recovery and Reinvestment Act of 2009 provided $450 million in funds for NTIA to expand public computing capacity at libraries and community colleges, as well as programs to encourage the adoption of broadband service. At each policy juncture along the way, the term "digital divide" was a common denominator.

Yet I want to argue that, as a tool to motivate policymakers, the term "digital divide" has outlived its usefulness for two reasons:

1) The problem itself has diminished in size.
2) Continued focus on the digital divide obscures a larger and more important problem in the arena of digital equity – digital readiness.

Digital readiness is the capacity for people to engage with online resources with full information about service attributes and use of personal and household data. Millions of people who have the tools to access the Internet – computers, tablets, smartphones, and home broadband subscriptions – do not have a sufficient level of "digital readiness" to use online applications. Notwithstanding our society's rising expectations that everyone will easily grasp the latest digital innovations, many Americans lack skills to use the newest and most useful applications. This will deprive them of the many benefits of a digital society, such as the health, educational, or other applications that the "Internet of things" will enable. It will also limit the size of the market for companies developing these applications.

This paper will argue for the term "digital readiness" as the proper way to frame policy with respect to digital equity by:

1. Presenting new research that shows the size of the population that is not digitally ready;
2. Recommending ways to tackle the digital readiness problem, and;
3. Examining the payoffs to solving the digital readiness problem.

I. Shrinking Gaps: Trends in Technology Adoption

To say that a lot has changed in the technology world since the 1990s is an understatement. In 1995, not very many people imagined a smartphone and even in 2009, few people would have predicted smartphones would become so popular so fast among so many Americans. As Table 1 shows, the extent and quality of technology adoption has changed dramatically since the 1990s.

Table 1

	Cell Phone	Internet Use	Broad-band at home	Smart-phone	Tablet computer
1998	37%	36%	n/a	n/a	
2000	53	50	3	n/a	
2003	65	61	16	n/a	
2006	73	70	42	n/a	
2009	82	74	63	17	10
2012	88	81	72^	45	25
2013	91	85	70	56	34

Source: Pew Research Center surveys except where noted.
^ National Telecommunications & Information Administration

More people have more tools to get online than ever before. It is not just that 70% of Americans have broadband at home. When looking across various means of online access – broadband, smartphones, or tablet computers, a majority of Americans, some 57%, have two of those three tools for getting online. Some 19% of Americans do not have access to any of those three tools. To put these figures in the context of the general population, in 2009 about 108 million Americans (or 83 million adults) lived in homes without a broadband subscription. By the end of 2012, if we expand the definition of broadband access to include powerful tools such as smartphones, 63 million Americans lack means to get online. For adults, that number is approximately 48 million.[1]

II. Americans Digital Skills & Literacy

The other side of the adoption coin is use. Once people have broadband at home, and the associated devices that give the service value, do they have the skills to use online applications? For some applications, like email or browsing for news, the answer is simple. People embrace them quickly. However, there is ample evidence that large numbers of Americans lack the skills to confidently negotiate the Internet. This has been true since the early days of the Internet. Northwestern University's Eszter Hargittai pioneered the notion that people have various levels of digital skills in

[1] Some digitally excluded Americans may live in areas that lack broadband infrastructure; 6% of households, mostly in remote rural areas, do not have a wireline broadband provider nearby.

her 2002 paper called "Second Level Digital Divide: Differences in People's Online Skills."[2] At a time when half of Americans used the Internet and very few had high-speed at home, Hargittai found a great deal of variation in people's ability to find content online, with older Americans particularly challenged in online skills.

As to the size of those who are, for whatever reason, less engaged with the Internet, research consistently shows that roughly one-third of Americans are heavily engaged with the Internet, while close to 40% are not. The Pew Research Center's Internet & American Life Project's typology of online users found in 2006 that 41% of Americans were light or reluctant online users, with 15% lacking any tech gadgets at all (computers, cell phones, or online access).[3] A 2010 FCC study, done in conjunction with the National Broadband Plan, measured people's levels of digital skills by asking Internet users how well they understood various Internet or technology terms. Among broadband users, nearly one-third (29%) rated low on digital skills, while 24% were highly skilled.[4]

This paper uses a 2013 survey, conducted by the author for the Joint Center for the Political and Economic Studies, to examine the digital skills of *all* Americans. The survey measured respondents' awareness of tech terms and self-reported confidence with computers and finding content online.[5] Using the answers to these questions, a statistical technique called cluster analysis classified respondents according to the similarity of their answers. One can imagine, at one end of the spectrum, people with low levels of knowledge of tech terms and little confidence with computers. At the other end, some people are very sophisticated when it comes to technology – they know the lingo and what they are doing.

But how large are the different groups of respondents who fall into identifiable categories according to their skill levels? Cluster analysis demonstrates the relative sizes of groups with different levels of digital skills. The analysis shows three categories of Americans according to their digital skills:

- 29% of Americans have ***low*** levels of digital skills;
- 42% of Americans have ***moderately*** good levels of digital skills;
- 29% of Americans have ***high*** levels of digital skills.

Demographically, those with low levels of digital skills tend to be older, less educated, and have lower incomes than those with moderate or high levels of digital skills. Those with low levels of

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[2] Eszter Hargittai, "Second Level Digital Divide: Differences in People's Online Skills." First Monday, Volume 7, Number 4, April 2002. Available online at: http://firstmonday.org/article/view/942/864#h5.

[3] John B. Horrigan, "A Typology of Information and Communications Technology Users." Pew Internet & mericna Life Project, May 2007. Available online at: http://www.pewinternet.org/~/media//Files/Reports/2007/PIP_ICT_Typology.pdf.pdf.

[4] John B. Horrigan, "Broadband Adoption and Use in America." OBI Working Paper No. 1, Federal Communications Commission, February 2010, p. 18. Available online at: http://hraunfoss.fcc.gov/edocs_public/attachmatch/DOC-296442A1.pdf.

[5] Respondents were asked how well they understood the following tech terms: an Internet browser cookie, spyware/malware, app, refresh/reload, WiFi, QR code. They were also asked how easily they could find information using a desktop or laptop and (separately) using a mobile device. Finally, they were asked how comfortable they felt using a computer. Respondents could score the answers on a four point scale.

digital skills are three times more likely than those with high level digital skills to be age 65 or older and three times more likely to be poor. Collectively, the low digital skills group has graduated from college at one-third the rate of the group with high skill levels. The appendix contains greater detail on the demographic differences across the three groups.

The 2013 survey also looked at outcome variables, that is, the association between levels of digital skills and online behaviors such as job search, visiting government websites, and taking a class online. As the table below shows, different levels of digital skills have significant consequences when it comes to online behavior.

Table 2: All Americans

	Low Digital Skills (29% of population)	Medium Digital Skills (42% of population)	High Digital Skills (29% of population)
Visit a state or federal government website	49%	78%	89%
The Internet was "very" or "somewhat" important to job search	14%	40%	54%
Used the Internet during most recent job search	8%	35%	52%
Take a class online	1%	16%	26%

The key point from the table is that, among the general adult population in the United States, nearly one-third (29%) have low digital skills, and they are far less likely to say the Internet plays a role when they look for work, whether they take a class online, or they visit government websites.

The same patterns holds true for people with "advanced online access," which are people with either broadband at home *or* smartphones. In the Joint Center survey, 67% of people had broadband at home, 53% had a smartphone, and 78% had *either* a smartphone or broadband at home. Those with access to at least one of those means of online access have "advanced online access." Put differently, the survey found that 67% of people had broadband at home and 11% had *only* smartphones as their means of online access (and not broadband at home). Table 3 shows results for those users.

Table 3: Advanced online access (those with broadband <u>or</u> smartphones)

	Low Digital Skills (18% of advanced users)	Medium Digital Skills (46% of advanced users)	High Digital Skills (36% of advanced users)
Visit a state or federal government website	62%	79%	89%
The Internet was "very" or "somewhat" important to job search	16%	40%	54%
Used the Internet during most recent job search	10%	38%	52%
Take a class online	2%	17%	26%

For those with advanced online access, nearly one-fifth (18%) are low-skilled in using the Internet – and the impact shows up clearly when looking at how they use online resources for something as consequential as job search, taking classes online, and visiting government websites.

It is important to point out that digital skills do not explain the entirety of people's online behavior. Younger people may be more likely to take online classes than older ones. High income people (who are presumably employed) are less likely to use the Internet for job search than low-income people. Statistical techniques allow such factors to be held constant in order to compare the magnitude of the "digital skills effect" to age, income, or a respondent's educational level.

That analysis shows that respondents' levels of digital skill have *the largest* impact on predicting the scope of a series of online activities or the probability of doing any particular one. To focus on one online activity, it is true that older people are less likely to take a class online than others. However, holding age and other factors constant, low levels of digital skills exerts almost *three times* the negative influence on taking a class online than being a senior citizen. The findings do not establish causation, i.e., that low digital readiness drives online behavior. But the negative correlation between skills and online engagement is both strong and suggestive.

Looking at these numbers in the context of the overall adult population demonstrates the magnitude of the problem. Table 4 provides estimates of the millions of adult Americans who fall into different categories of online access and online skill levels, using 2012 Census population figures.

Table 4: Access, skills, and the general population

Nature of skills and access (adults)	Millions of adult Americans
Americans who do not use the Internet (15%)^	36 million
Americans without advanced online access (18%)^^	43 million
Americans with low levels of digital skills **AND** advanced online access (14%)	33 million
Americans with low levels of digital skills (29%)	70 million

^ Pew Research Center places overall online use at 85% of adults.
^^ Combines NTIA data on broadband adoption (72%) with Pew Research Center data on "smartphone only" use (10%).

Let's compare the size of the digital divide (those who lack advanced online access) to those with low levels of digital readiness/skills. Among adults Americans, 43 million is the upper end estimate of the number of people who are on the wrong side of the digital divide; about one-fifth (about 7 million) may use the Internet at a library or at work, but none have the means of advanced online access four-fifths of the country has. The skills problem is a different story. Overall, some 70 million Americans have low level of digital skills and *nearly half in this group* has advanced Internet access.

There are three things to take away from this analysis:

- **<u>Digital readiness is a bigger problem than the digital divide</u>**. Some 36 million people do not use the Internet at all, but 70 million are not digitally ready. Among those with advanced online access, 33 million are not digitally ready, on par with the number who are digitally excluded.

- **The digital divide will diminish in size but the digital skills problem will remain sizable for some time**. Among the 70 million Americans who are not digitally ready, half lack online access altogether. If history is any guide, two things will happen. First, some people with online access and low digital readiness will graduate to a level of higher digital competence. Second, those without access will come online, but will low levels of digital skills. This will replenish the pool of those with low levels of digital readiness.
- **Digital readiness is strongly linked to low levels of online behavior.** There is a strong negative correlation between low levels of digital readiness and online behavior. Even among people with advanced online access (either a smartphone or broadband at home), those with low levels of digital skills engage in online activities such as job search or educational applications at a fraction of the rate of others.

III. What to do about it?

Even if digital readiness is a problem, it may not be a problem that necessarily warrants intervention. After all, one could argue that the research cited above shows snapshots of the adoption paths during different time periods. There are always late adopters who are less sophisticated. They eventually figure out how to use technology, even if they may have to go through that process repeatedly in the face of innovation.

This line of reasoning misses two important contemporary developments:

1. **Many next-generation applications are in the public sector**: Whether in health care, renewing licenses, or educational, public officials are rolling out applications that promise better outcomes and new efficiencies. To take one example, as of January 2014 a general education degree (GED) test can only be taken online.
2. **Applications driven by the "Internet of things" will require entirely new levels of data-sharing and trust among consumers**: When objects have the capacity to connect to the Internet, new applications will change how we manage our homes, health care, education, and more. This will require fundamentally new levels of trust in the entities with which people will share personal data.

The Internet of things and the penetration of digital applications into realms that impact people as citizens (and not just people as consumers) raise the stakes for Americans' understanding of the attributes of digital goods and services. This gives stakeholders in the public and private sectors ample reason to worry about digital readiness. Here are a few suggestions on how to tackle the problem of digital readiness:

- **Complementary investments in digital readiness by government agencies:** Whether our leaders know it or not, they are on the brink of a massive technology transfer effort as they tout and roll out next-generation service delivery. That means expenditures on training users. If reform of the E-Rate program and the president's ConnectEd initiative are the means for information technology to improve schools, the investments in hardware will only go so far if educators do not how to use them to meet educational goals. Similarly, broadband will improve public housing or social service delivery only if people can use it for desired purposes. The U.S. Department of Veterans Affairs has a "blue button" program to let veterans download and share data on their health; this can help health care providers only if veterans have the skills and trust to access and share the data. The same applies for the Energy Department's Green Button for data on consumers' energy usage.

- **Leverage existing programs**: The past four years has seen the emergence of a broadband adoption infrastructure. The 2009 American Recovery and Reinvestment Act was the initial impetus through NTIA's Sustainable Broadband Adoption and Public Computing Center programs. Since then, Comcast's Internet Essentials and Connect to Compete (C2C) have both started programs to get more people online. As established and trusted places for people who want to become broadband users, their missions can expand to help anyone interested in taking steps to improve their digital readiness.
- **Make sure communities have "tech champions" to advocate for digital readiness:** Many communities have bicycle coordinators, that is, officials that make sure cities are doing things to make sure a city is "bicycle friendly" or avoiding actions that would make a place less "bicycle friendly." Communities that have been at the forefront in advancing digital access typically have gotten there through strong community leadership. Such leadership is not widely distributed. Investing in a "community tech champion" for digital readiness is the next step in ensuring that *all* communities are ready for next generation applications.
- **Use libraries:** Some 54% of Americans age 16 or over have use libraries in a given year, whether that is going physically to a library to a public library website.[6] Libraries already serve as a source for access for those without the Internet at home, and librarians often take on "tech support" roles by default. Libraries could also serve as curators for trusted information on how to acquire digital skills and understand the ins-and-outs of emerging applications.
- **Engage the philanthropic sector on digital readiness:** For national and community foundations, this means supporting the development of strategies that can help all online users acquire the skills and information to be engaged online users. It also means investing in measurement to:
    - Understand the role of digital skills and literacy in engaging Americans in emerging socially consequential online applications.
    - Tracking progress in digital skills development.
    - Assessing the returns to programs that promote digital skills and literacy.

Each of these suggestions requires existing entities to expand their missions, for the most part in incremental ways. This will require new funding at a time when tight government budgets subject new investments to close scrutiny. How can we assess *ex ante* whether these investments will pay off? There is no clear answer to that question.

[6] Pew Research Center, "How Americans Value Public Libraries in Their Communities," December 2013. Available online at: http://libraries.pewinternet.org/2013/12/11/libraries-in-communities/.

At the same time, though, these investments would not unfold in a vacuum. Since 2009, a community of practice has arisen that provides a blueprint on how to reach underserved populations with digital connectivity. Many of these have been funded by the Commerce Department's Broadband Technology Opportunities Program and effective strategies are available in the Broadband Adoption Toolkit.[7] Those lessons have clear relevance for thinking about digital readiness. Additionally, public-private initiatives, such as Connect to Compete and Comcast's Internet Essentials program are sources for additional insights on digital readiness.

IV. What happens if we get this right?

The other part of assessing whether investments in digital readiness are worthwhile is potential payoffs. Those payoffs are easier to talk about than quantify, but they include:

- **Faster uptake of the "Internet of things."** All the kinks in "Internet of things" applications will not be solved upon rollout, and one-third of the population will not tolerate hiccups well. With an estimated trillion dollar-plus market size, even modestly faster uptake rates could have significant revenue impacts – something a more digitally ready population would yield.
- **A faster IP transition:** The current debate on the rate at which telecom carriers can retire legacy networks involves, in part, whether some classes of users will be left behind. Will everyone be able and willing to forgo the traditional dial-tone for new services that operate using the Internet protocol? The answer to that question depends on consumer acceptance of new things – or digital readiness.
- **Better government services:** Governments at every level have invested in e-delivery of services only to find reluctance to use those methods among significant portions of the population. A more digitally ready population would improve the return to those investments for government, while expanding the pool of beneficiaries of services that promise better results.
- **A higher caliber workforce:** Digital readiness extends beyond the household. Increasingly a wider range of jobs require the ability to use digital applications to run machinery. Job training resources are increasingly online, meaning only the digitally ready can use them.
- **Economic leadership**: By investing in a population that can take full advantage of next generation, the United States positions itself in a virtuous cycle for economic advancement. A high share of "lead demanders" in the general population using new innovations can spur feedback loops to the innovation system that fuels additional innovation and productivity growth. Though hard to predict, much less quantify, the potential here is real.

V. Conclusion

Digital readiness takes on special urgency not only because one-third of the population is lacking, but because we are on the brink of a new wave of innovation that the "Internet of things" is driving. Make no mistake about it – the advent of the "Internet of things" is a game changer when thinking

[7] "Broadband Adoption Toolkit." National Telecommunications and Information Administration, May 2013. Available online at: http://www2.ntia.doc.gov/files/toolkit_042913.pdf.

about digital readiness. The first wave of digital innovation – from companies such as Google, Amazon, eBay, and Apple (through iTunes) – went after transactional inefficiencies in established markets and used communications networks to upend established business institutions.

The "Internet of things" aims at the transactional inefficiencies of humans and their homes, such as how we learn, how we manage our health, how we consume energy at home, and more. As intrusive as tweets, texts, and Facebook notifications can sometimes be, myriad IP-connected objects takes things to an entirely different level. The possible benefits are clear, but to think that the path to them will be smooth flies in the face of what research tells us.

This makes digital readiness significant enough to warrant attention and justify intervention. Developing ways to increase Americans' digital readiness will not solve any single problem, but it is an important ingredient to helping all Americans realize the benefits of faster networks and more powerful applications. Should stakeholders choose to devote effort to addressing digital readiness, here are three final bits of advice:

- **A "one size fits all" solution will not work**. A "national digital readiness program" does not make sense when digital readiness intrudes into so many different spheres of people's lives. Investments in digital readiness will have to complement other activities (such as helping senior citizens get health care information, introducing students to online educational resources, or teaching people how to log onto their home manage energy usage). Actors in different sectors will have to make these complementary investments.
- **The solution is not about "cracking the code" or finding the "killer app" but rather about building capacity.** It is common for communications policy to invoke images from the tech world. If we could only discover the "killer app" or "crack the code" of a stubborn problem, then we can "unleash" all sorts of digital bounty. This kind of imagery suggests that developing a single solution – a piece of software – is the answer for getting people to do something they have always done in a new way (such as write letters on a computer, not on a typewriter). Digital readiness is a different problem. It is about encouraging people to learn something new and learn how to stay current.
- **Use information and communications technology to enhance digital readiness:** The things that create the challenge of digital readiness – pervasive connectivity and huge data sharing and flows – have within them the seeds to address digital readiness. Innovators can – and should – create applications in ways that direct users to resources that are tailored to a user's particular needs for raising their levels of digital readiness.

Addressing digital readiness requires capacity, the same kind of capacity companies have with tech support to help employees when they have a tech problem. As a nation, we need to make the investments so that communities and government have similar capacity to help citizens be digitally ready. Those who develop new technologies are adept at raising expectations about the affordances of new gadgets and services. As the "Internet of things" deepens the reach of technology in our lives, it is in everyone's interest to take steps to ensure *all* Americans can take advantage of its benefits.

APPENDIX

Demographic detail on respondents by levels of Digital Readiness

All respondents

	Low Digital Readiness	Medium Digital Readiness	High Digital Readiness
Gender			
Male	47%	47%	52%
Female	53	53	48
Race/Ethnicity			
White	73%	69%	77%
African American	13	15	11
Latino	14	17	12
Age			
18-24	11%	10%	9%
25-44	26	35	29
45-64	25	37	49
65+	34	16	11
Income			
Under $15K	27%	18%	9%
$15K to $35K	14	7	4
$35 to $60K	42	26	13
$60K to $90K	5	14	32
Over $90K	10	16	19
Education			
High school grads or less	59%	44%	3%
Some college	19	25	50
College +	15	26	44
Number of cases	466	669	469

Those with Advanced Internet Access (either broadband-at-home or smartphone)

	Low Digital Readiness	Medium Digital Readiness	High Digital Readiness
Gender			
Male	50%	47%	53%
Female	50	53	47
Race/Ethnicity			
White	77%	69%	77%
African American	12	15	10
Latino	11	17	12
Age			
18-24	12%	10%	8%
25-44	28	36	29
45-64	26	36	49
65+	33	16	11
Income			
Under $15K	29%	17%	9%
$15K to $35K	10	5	4
$35 to $60K	39	23	13
$60K to $90K	6	16	33
Over $90K	11	17	19
Education			
High school grads or less	53%	42%	25%
Some college	24	26	28
College +	18	27	45
Number of cases	223	580	453

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U.S. INVESTMENT HEROES OF 2013: The Companies Betting on America's Future

BY DIANA G. CAREW AND MICHAEL MANDEL SEPTEMBER 2013

For too long, U.S. policymakers have focused narrowly on boosting consumers' buying power, assuming that the productive end of the economy will take care of itself. Yet the last decade of slow growth shows that debt-driven consumption is not a sustainable strategy for expanding economic opportunity or lifting U.S. living standards. In contrast, a high-growth strategy requires strong investment—private and public—in our nation's productive and knowledge capacities.

Total domestic investment fell drastically during the recession and has yet to fully recover.

It's time for progressives to rebalance the consumption-investment equation. Total domestic investment fell drastically during the recession and has yet to fully recover. A big part of the problem is the public sector. With gridlock in Washington and financial troubles at the state and local level, government real spending on productive assets from highways and bridges to computer equipment, net of depreciation, is down by half compared to the average level of the 2000s.

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Investment by the private sector is doing better, but taken as a whole still falls way short of what the country needs to generate jobs and growth. As shown in Figure 1, business investment, outside of housing, is still 20 percent below its long-term trend. There are several reasons why private business investment is failing to reach its potential. Globalization, weak demand, deleveraging and a shortage of workers with technical skills all contributed to the investment fall-out and subsequent investment gap. And as PPI has documented elsewhere, the sheer accumulation of regulations over time can discourage capital investment and innovation.[1]

> The top five U.S. Investment Heroes of 2013 are AT&T, Verizon, Exxon-Mobil, Chevron, and Intel.

Within this gloomy picture, however, are some bright spots—companies that continue to place big bets on America's future, creating jobs and raising productivity in the process. Surprisingly, in a world of information overload, identifying these major contributors to the U.S. economy is not an easy task, since most companies do not break out their domestic capital spending. That's why we undertook our second annual report on "U.S. Investment Heroes," making a systematic analysis of publicly available information to rank nonfinancial companies by their capital spending in the U.S.

PPI's ranking of U.S. Investment Heroes for 2013 is once again led by AT&T, which invested almost $20 billion in the U.S. in 2012. The list then follows with Verizon, Exxon, Chevron, Intel and Walmart.[2] Together, we estimate these companies invested almost $75 billion in the U.S. in 2012, an astonishing total almost twice the GDP of Wyoming.[3] Over the last year, these companies have poured capital investment into the deployment of high-speed broadband, oil and natural gas production, and new corporate and retail facilities.

As a general principle such spending provides both direct and indirect benefits to Americans. For example, a variety of studies suggest that investment in fixed and mobile broadband creates jobs. In fact, PPI Chief Economic Strategist Michael Mandel estimates that since Apple introduced the iPhone in 2007, the economy has created over 750,000 jobs related to mobile apps.[4]

Indeed, telecommunications and cable companies are a major driver of U.S. investment today, sparking the rise of what we call "the data-driven economy." The digital transformation of the U.S. economy would not be possible if high-speed fixed and mobile broadband networks were not in place. That's why encouraging private investment in our nation's broadband infrastructure is rightly a major priority for the Obama administration.[5] Beyond that, robust private investment in smart devices, sensors, and "big data" analytics is sparking the emergence of the "Internet of Everything," which could boost productivity and job creation in 'physical' industries such as manufacturing and transportation.[6]

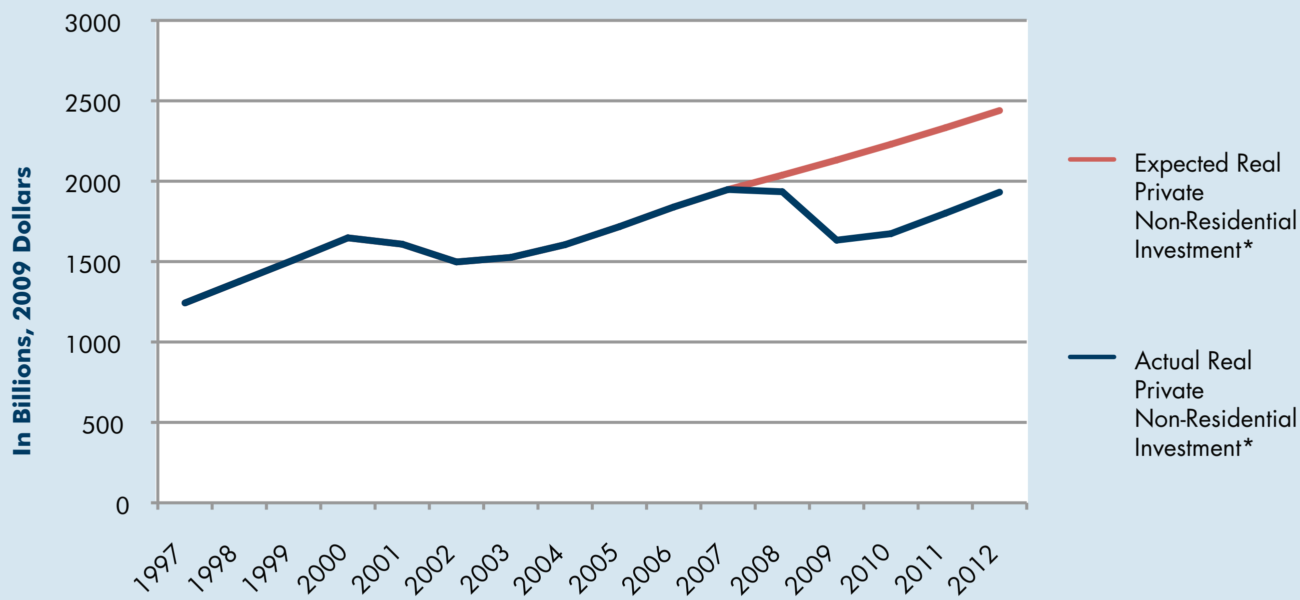
Our ranking of U.S. companies investing in America also shows the tremendous role energy—oil and natural gas production and power generation—has on U.S. economic growth. The shale oil and gas boom has turned old assumptions about energy scarcity on their head. It is lowering input costs for U.S. chemical companies and helping to revive U.S. manufacturing. It may also turn the United States into a major energy exporter, while creating jobs at home.

This report is the third in PPI's "Investment Heroes: Who's Betting on America's Future" research series. That so many companies are choosing to invest elsewhere—or not at all—makes it all the more important to recognize those that are placing their bets on America's future.

IMPORTANT NOTES ABOUT THE RANKING

As with last year's ranking,[7] in this paper we present two lists of "U.S. Investment Heroes": one that includes energy companies and one that does

FIGURE 1: THE U.S. PRIVATE FIXED INVESTMENT DROUGHT CONTINUES



**Assumes real investment grew over 2008-12 at average annual rate over 1997-07*
Source: BEA, PPI

not (our "Non-Energy U.S. Investment Heroes" ranking can be found at the end of this paper). We include a non-energy list to tell the story of what U.S. industries are investing in America outside of the sector that provides a necessary input to them all.

Most companies do not report their U.S. capital expenditures separately from their global (gross) capital expenditures. Therefore, we designed a novel methodology to calculate what share of their global capital expenditures were in the United States. This methodology incorporates certain assumptions, which we detail in the complete methodology found at the end of this paper, and incorporates publicly available annual reports and financial statements. In many cases, no other estimates of U.S. capital expenditures currently exist outside of our calculations.

Our U.S. Investment Heroes ranking for 2013 followed a similar methodology to last year. We started with the 2013 Fortune 150 list as our universe of companies. We removed all financial and insurance companies, since their reporting of capital expenditures is not consistent with our interpretation of plants, property, and equipment. We then estimated the amount of gross capital expenditures in the United States, and finally ranked the companies on our list in order of their total estimated U.S. capital expenditures. For these rankings, we used each company's most recent fiscal year statements. In most cases, the fiscal year is the calendar, in which case we used 2012. For a handful of companies, the fiscal year did not match up with the calendar year, but the most recent fiscal year statement did capture a large portion of calendar year 2012.[8]

We note that the companies in these rankings are all based in the United States. Non-U.S. based companies were not included in this list because of data comparability issues, but certainly there are non-U.S. companies that invest in America. In fact, our recently released report "Non-U.S. Investment Heroes: Foreign Companies Betting on America" highlights those foreign companies that are investing in America's plants, properties, and equipment.[9]

We would also like to offer several caveats associated with these rankings. First, some of the companies on our list have been criticized for a wide variety of issues, including broadband pricing, environmental impacts, privacy concerns, and low tax payments. Without minimizing these potential problems, we don't want to discount the positive impact these companies are having in terms of creating U.S. jobs and generating economic growth through their U.S. investments.

Second, a company's absence from the list does not mean they did not invest domestically in 2012. We cut the list at the top 25 companies for both our energy and non-energy rankings. Mainstay U.S. companies like UPS, Dow Chemical, and Google are investing domestically, just not as much as the other companies on the list.

Finally, we note that if our universe was expanded to include companies in the Fortune 200, additional energy and power companies would have made the list. For example, we estimate Apache invested $5.2 billion in 2012, while Southern Power invested $4.8 billion and PG&E invested $4.6 billion. We do not discount this investment, and certainly the investment in our nation's power infrastructure by these companies is essential. Rather, we decided to stay in the Fortune 150 to make our findings comparable with last year's results.

U.S. INVESTMENT HEROES

This year's ranking of "U.S. Investment Heroes" tells a clear story about which types of companies are investing in America's future. Our 2013 list is comprised significantly of three types of companies: cable and telecommunications, technology, and energy. In fact, companies in these three categories make up 18 out of the 25 on our list.

The top five U.S. Investment Heroes of 2013 are AT&T, Verizon, Exxon-Mobil, Chevron, and Intel. Together, these five companies invested over $66 billion in 2012 on U.S. plants, property, and equipment according to our estimates. The complete list of PPI's top 25 U.S. Investment Heroes for 2013 is below.

Telecom giants AT&T and Verizon again lead this year's ranking. Exponential growth in demand for mobile data, video streaming, and other high-speed broadband services makes investing in fixed and wireless broadband infrastructure essential.[10] Together, we estimate these two companies invested $34.5 billion in building out their high-speed national broadband networks in 2012.

Similarly, Sprint and CenturyLink also invested in the deployment of the latest generation high-speed broadband network. For example, Sprint spent much of its 2012 capital expenditures on the transition from the now legacy Nextel platform to its newer, high-speed Network Vision platform.

The demand for mobile internet connections is also being met in part by the cable companies on our list. In 2012, both Comcast and Time Warner Cable invested in a joint network of 150,000 "wi-fi hotspots" nationwide, as part of the CableWiFi Alliance.[11] These cable providers also spent much of their investment on updating equipment and expanding existing network capacity, according to their annual reports.

Building off the availability of high-speed internet connections, the technology companies on our list spent 2012 investing in the hardware and software that goes into smart devices. According to press reports, Intel announced it was expanding its D1X research facility in Hillsboro, Ore. by an additional 2.5 million square feet.[12] In

U.S. INVESTMENT HEROES: TOP 25 NONFINANCIAL COMPANIES BY ESTIMATED U.S. CAPITAL EXPENDITURE[1]

Rank	Company	Estimated 2012 US Capital Expenditure[2] (in $ mns)	Rank	Company	Estimated 2012 US Capital Expenditure[2] (in $ mns)
1	AT&T[3]	19,465	14	Union Pacific[3]	3,738
2	Verizon Communications[4]	15,000	15	General Motors	3,650
3	Exxon Mobil	12,157	16	Enterprise Products Partners[3]	3,622
4	Chevron	10,738	17	Time Warner Cable[3]	3,095
5	Intel	8,769	18	Microsoft	3,044
6	Walmart Stores	8,257	19	Amazon[6]	2,945
7	Occidental Petroleum	7,592	20	CenturyLink[3]	2,919
8	ConocoPhillips[5]	6,079	21	Ford Motor[7]	2,693
9	Exelon[3]	5,789	22	Walt Disney	2,671
10	Comcast[3]	5,714	23	FedEx	2,575
11	Duke Energy	5,407	24	Apple	2,553
12	Hess	4,740	25	Target	2,345
13	Sprint Nextel[3]	4,261	**Total**		**149,817**

Source: PPI estimates based on 2012 and 2013 company financial reports & filings. Totals do not include R&D, only capital expenditures in plants, property, and equipment.

1. Universe includes nonfinancial Fortune 150 companies from 2013
2. For all but six companies, fiscal year 2012 was calendar year 2012. For Walmart, Microsoft, Walt Disney, FedEx, Apple, and Target, we used the most recent fiscal year statement as of August 2013
3. Predominately U.S. Operations
4. Reduced total capital expenditures by the share of international employment, to adjust for global investment activities
5. May include a small amount of investment in Latin America
6. Includes Canadian investment, but our assessment finds this amount was minimal
7. Adjusted for net investment in operating leases by removing it from long-lived assets in proportion to the country share

2012, Microsoft expanded its U.S. retail presence with the launch of Microsoft Surface and Windows RT, and in July the company opened a new corporate office in Silicon Valley.[13] Apple also invested its U.S. capital expenditures in retail stores, new corporate facilities, and updates to its information systems hardware and software.

The eight energy companies on this year's list invested a combined $56 billion in 2012. The oil and natural gas companies in our ranking all invested in expanding their oil and gas exploration, production, and refining in 2012. For example, according to company reports, Occidental Petroleum's average U.S. operated-rig activity increased 25 percent in 2012 over 2011, from 51 rigs to 64 rigs in California and the Permian Basin in Texas. ConocoPhillips spent its estimated $6.1 billion U.S. investment in 2012 on oil and natural gas development in Texas, New Mexico, North

Dakota, Oklahoma, Montana, Colorado, Wyoming, Alaska, and the Gulf of Mexico. The power companies on our list, Exelon and Duke Energy, invested primarily in expanding their capacity to generate and distribute power.

Ford and General Motors, two major U.S. motor vehicle manufacturers, were also on last year's list. As was the case last year, annual reports show much of the capital expenditures from these companies were focused on their existing automobile and light truck product lines. Moreover, in addition to expanding its Texas production footprint, in September 2012 General Motors announced the creation of its first "IT Innovation Center" in Austin where it intends to hire up to 500 IT professionals to "drive breakthough ideas into GM vehicles."[14]

This year's list also includes several retailers, all of which have an expansive internet presence. Two retailers on the list, Walmart and Target, also have a major brick and mortar presence that is integrated with their online services. Walmart, sixth on our 2013 ranking, spent much of its $8.3 billion U.S. investment in building out new stores and remodels, information systems, and eCommerce capabilities.

Though most of the companies on this year's list were also U.S. Investment Heroes in 2012, there are several new additions to the list worth noting. Amazon, the giant Internet-based retailer, substantially increased its U.S. investment in 2012. According to company records, Amazon is significantly expanding its network of local "fulfillment" centers across the country, in addition to spending on software enhancements and website development. Moreover, in 2012 the company invested $1.4 billion to purchase three square blocks in Seattle, Wash. for its office headquarters.

Union Pacific, a railroad company, is also new to this year's list. The company, whose railroads cover 23 states in the Western U.S., invested $3.7 billion in updating 1,051 miles of railroad track infrastructure, adding 139 miles of new rail lines, and on new locomotives and freight cars.

POLICY IMPLICATIONS

Given the importance of investment as a path to sustainable growth, it is essential that our economic policies make domestic business investment a priority. Investment in the key sectors highlighted in this report—telecommunications and cable, technology, and energy—generates very positive spillover effects for the rest of the economy.

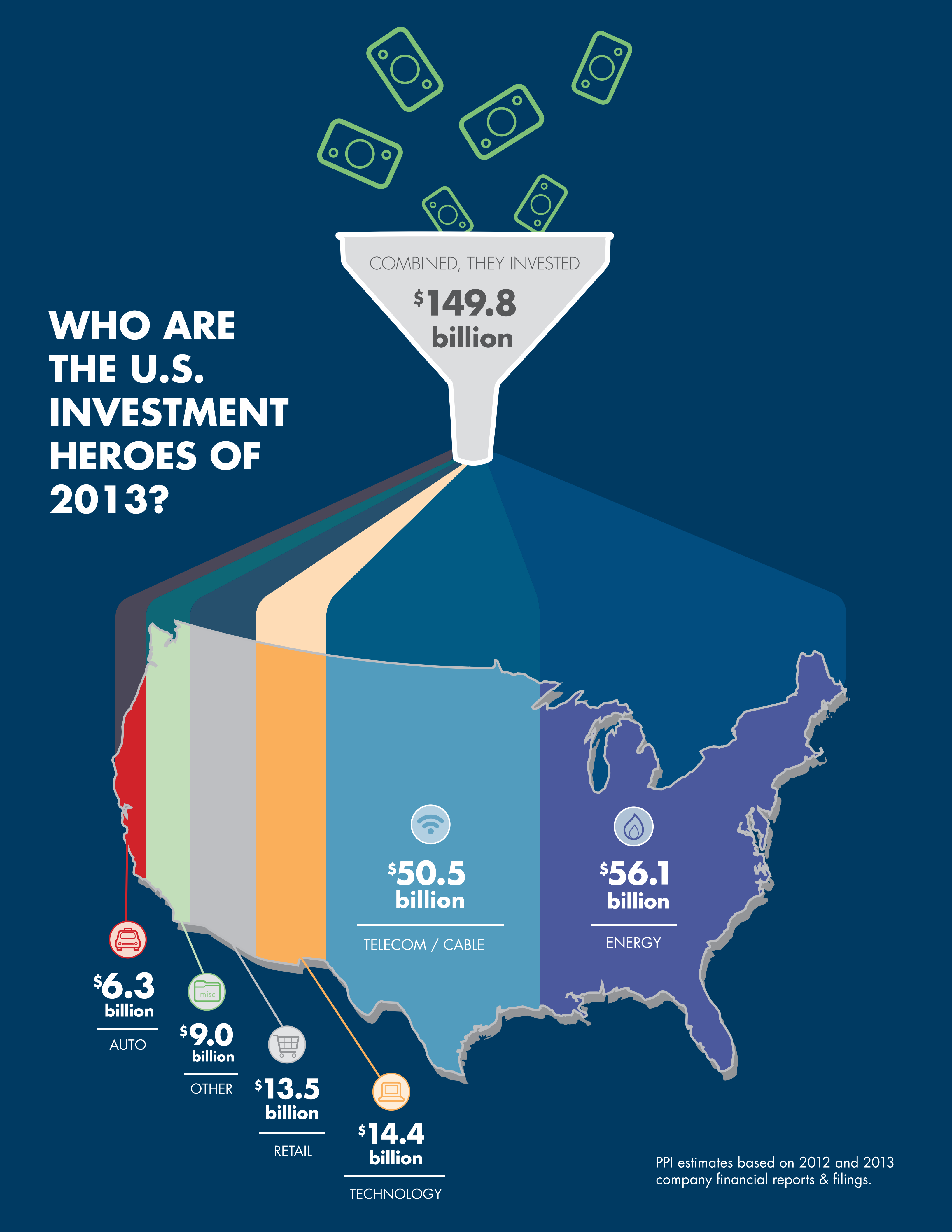
We can see the impact of the data-driven economy in our rankings with the rise of Amazon's investment over the last year. Amazon's rapid expansion—and the growth in all eCommerce[15]—would likely not be possible if it wasn't for the ongoing investment by telecommunications and cable providers in ever faster fixed and mobile broadband networks.

That means it is essential to have policies that facilitate continued investment in cable and telecommunications, technology, and energy, while simultaneously encouraging more investment from other sectors not heavily represented in our rankings.

The eight energy companies on this year's list invested a combined $56 billion in 2012.

The last year has seen some progress to this end. The American Tax Payer Relief Act of 2012, passed in January 2013, allows for a 50 percent deduction in capital expenditure-related depreciation that was retroactive to January 2012. Several companies on our list highlighted this measure in their discussion of 2012 capital investments.

In June 2013, President Obama issued an Executive Order directing all federal agencies to review spectrum needs within 6 months.[16] The intention of this order is to reallocate or repurpose unused and unneeded spectrum held by the government to telecommunications companies that need more spectrum to meet growing consumer



WHO ARE THE U.S. INVESTMENT HEROES OF 2013?
COMBINED, THEY INVESTED
$149.8 billion
$50.5 billion
TELECOM / CABLE
$56.1 billion
ENERGY
$6.3 billion
AUTO
misc
$9.0 billion
OTHER
$13.5 billion
RETAIL
$14.4 billion
TECHNOLOGY
PPI estimates based on 2012 and 2013 company financial reports & filings.

FOUR WAYS TO ENCOURAGE MORE INVESTMENT:

Simplify the
CORPORATE TAX SYSTEM

Invest in
WORKFORCE TRAINING

Don't over regulate
INNOVATIVE INDUSTRIES

Free up more
SPECTRUM

demand for wireless communication. A finite resource, current spectrum constraints threaten the mobile revolution from reaching its potential.

Also in 2013, the Obama administration announced a new "ConnectEd" initiative that will accelerate broadband access and technology adoption at schools,[17] and the government implemented FirstNet, the first nation-wide wireless emergency response network.[18] On the manufacturing front, a February 2013 evaluation of the Obama administration's grant-making program for "regional innovation clusters", designed to boost U.S. production, showed the initial funding is having a positive economic impact.[19]

But more needs to be done. We are still a long way from meeting the spectrum goals outlined in the 2010 Broadband Agenda.[20] And the effectiveness of upcoming voluntary spectrum auctions, remains uncertain, as many of the terms are still undecided. Recent PPI research on the auction concluded that picking and choosing which providers can participate may come at a social and economic cost.[21] That means it is essential to open these auctions to all companies that need spectrum, in order to effectively spur continued broadband investment.

> It is essential our economic policies make domestic business investment a priority.

In energy, the debate over natural gas fracking, along with territorial disputes over interstate and oil and natural gas pipelines, could eventually hinder investment if issues remain unresolved. It is important that U.S. energy policy embrace the potential of low-cost natural gas, while encouraging producers to adopt "best practice" drilling and production techniques that minimize health risks and environmental damage. Our research has shown both U.S. and non-U.S. energy companies are among the largest investors in America's plants, properties, and equipment.

Policy makers also can encourage more companies across all sectors to invest domestically. Through responsible regulatory reform, we can clear bureaucratic red tape by removing or improving the many outdated and duplicative regulations imposed on U.S. businesses at the federal, state, and local levels. PPI has proposed Congress authorize a Regulatory Improvement Commission (RIC) that would accomplish this task in a politically viable way.[22] Indeed legislation called for the establishment of a RIC was recently introduced in the Senate as the *Regulatory Improvement Act of 2013*.[23] Should such legislation move forward at the federal level, there is great potential for the RIC to be replicated by both state and local governments.

Simplifying the corporate tax system is another way to encourage businesses to invest in America. Our tax system should reward companies that produce domestically. And a simpler, streamlined tax code for small businesses could go a long way toward enabling entrepreneurs to grow their business for the first time. Moreover, U.S. businesses of all shapes and sizes are spending millions each year on patent litigation. Patent reform could free up funding for these companies to expand and innovate without having to worry about getting hit by frivolous lawsuits.

Encouraging private investment also means ensuring there is a qualified workforce whose skills meet employer needs. It is well-documented that for today's fast-growing data-driven jobs, there is a skill mismatch that is forcing too many Americans—especially young college graduates—into lower-paying jobs they are overqualified for.[24] The *Workforce Investment Act of 1998*, having just cleared the Senate HELP Committee for reauthorization,[25] could provide a powerful opportunity to bridge the skills gap by targeting recent college graduates that lack the skills they need to get a high-paying job.

Finally, to invest effectively in U.S. manufacturing, PPI proposes Congress fund a global "Competitiveness Audit."[26] The global Competitiveness Audit would tell us in which sectors the U.S. is at or near competitive in terms of pricing by comparing U.S. production costs to the cost of comparable goods imported from overseas. For example, we think the U.S. has a competitive edge in hi-tech manufacturing, such as 3-D printing, but we don't actually have any official statistics to tell us in which areas we are and are not internationally competitive. Having a formal measure of competitiveness could help target private investment funding more effectively.

CONCLUSION

U.S. economic policy is strongly biased toward stimulating consumption, not investment. This is wrongheaded, because investment in America's capacity to produce both tangible and intangible goods and services is the surest way to put our economy back on a high-growth trajectory. Such investment not only boosts output, but also creates the high-skill, high-wage jobs we need to lift the middle class and reverse today's troubling trend toward greater inequality.

> Telecom and cable, technology, and energy currently dominate the sectors betting on America's future.

Our analysis shows that private domestic investment continues to be well below where it could have been had it not fallen during the recession. Only now is real private non-residential fixed investment reaching its pre-crisis levels. And public investment, constrained by pressures to reduce the federal deficit, will not be able to counteract this missing private investment. In fact, real public investment has been falling, and is currently at 2002 levels, adjusted for inflation.

Our research suggests that while there are some policies in place to facilitate private U.S. investment, more can be done. This year's rankings highlight the very important fact that telecom and cable, technology, and energy currently dominate the sectors betting on America's future. At the same time, our research indicates very few U.S. and foreign based manufacturers outside of motor vehicles are actively investing in America. This suggests policies that aimed at increasing investment in U.S. industrial capacity could have a sizable impact on creating new sources of sustainable economic growth.

NON-ENERGY U.S. INVESTMENT HEROES

As a complement to our complete U.S. Investment Heroes ranking, PPI also created a ranking of the top U.S. companies investing in the United States that are both non-financial and non-energy. Below is PPI's 2013 ranking of non-energy U.S. Investment Heroes according to our estimates. In addition to the non-energy U.S. companies contained in our initial ranking, this list of non-energy U.S. Investment Heroes includes two U.S.

TOP 25 NONFINANCIAL NON-ENERGY COMPANIES BY ESTIMATED U.S. CAPITAL EXPENDITURE[1]

Rank	Company	Estimated 2012 US Capital Expenditure[2] (in $ mns)	Rank	Company	Estimated 2012 US Capital Expenditure[2] (in $ mns)
1	AT&T[3]	19,465	14	Walt Disney	2,671
2	Verizon Communications4	15,000	15	FedEx	2,575
3	Intel	8,769	16	Apple	2,553
4	Walmart Stores	8,257	17	Target	2,345
5	Comcast[3]	5,714	18	IBM	2,146
6	Sprint Nextel[3]	4,261	19	Kroger[3]	2,062
7	Union Pacific[3]	3,738	20	United Airlines[3]	2,016
8	General Motors	3,650	21	CVS Caremark[3]	2,000
9	Time Warner Cable3	3,095	22	Delta Airlines[3]	1,968
10	Microsoft	3,044	23	HP	1,798
11	Amazon[5]	2,945	24	DirecTV	1,741
12	CenturyLink[3]	2,919	25	Boeing[3]	1,703
13	Ford Motor[6]	2,693	**Total**		**109,126**

Source: PPI estimates based on 2012 and 2013 company financial reports & filings. Totals do not include R&D, only capital expenditures in plants, property, and equipment.

1. Universe includes nonfinancial Fortune 150 companies from 2013
2. For all but eight companies, fiscal year 2012 was calendar year 2012. For Walmart, Microsoft, Walt Disney, FedEx, Apple, Target, Kroger, and HP we used the most recent fiscal year statement as of August 2013.
3. Predominately U.S. Operations
4. Reduced total capital expenditures by the share of international employment, to adjust for global investment activities
5. Includes Canadian investment, but our assessment finds this amount was minimal
6. Adjusted for net investment in operating leases by removing it from long-lived assets in proportion to the country share

airlines, United Continental and Delta, which both reported investing in a new fleet of Boeing airplanes in 2012 while refurbishing aircraft in thier existing fleets. Boeing, which also makes this ranking, spent most of its capital expenditures on the production of commercial airplanes, military aircraft, and network and space systems.

Other non-energy U.S. Investment Heroes include technology giants IBM and HP, which invested heavily in new software and systems technologies. DirecTV, a satellite communications and cable provider, spent $1.7 billion in 2012 on new at-home equipment and satellite upgrades in an effort to retain its customers.

Finally, major U.S. grocery chain Kroger, and pharmacy chain CVS, spent most of their 2012 investment on new stores and maintaining existing operations.

METHODOLOGY

To develop this year's list of "Investment Heroes," we started with the 2013 list of Fortune 150 companies, ranked by revenue.[27] We omitted financial companies, because their reporting of capital expenditures is not consistent with our definition of U.S. plants, property, and equipment. For each company, we then looked at their most recent publicly available financial data, including their 2012 annual 10-K filing with the SEC, and used this information to estimate their U.S. expenditures on additions to plants, property, and equipment (but not R&D) over the last fiscal year.

To rank the remaining Fortune 150 companies by U.S. capital spending, we estimated the appropriate share of gross capital expenditures to investment in the U.S. using several different procedures, as appropriate.

In some cases, including many of the energy companies on our list, the amount of U.S. investment was given explicitly in the filing. In those cases that estimate was used.

In other cases, the company did not break out non-U.S. operations separately, suggesting that they were relatively small (non-material). In those cases, we allocated all of the capital expenditures as U.S. expenditures, and indicated that on the table.

We paid special attention to AT&T and Verizon, the top two companies on our list. In its statement, AT&T reported its assets were "predominately in the United States." For Verizon, no international distribution of assets were reported, even though there are some international operations. We adjusted our estimate for their international operations using the share of international employees as a proxy. We would like to note that based on our analysis, both companies would retain their top spots under any reasonable set of assumptions.

For companies that did significant business internationally, we used the geographic distribution of long-lived assets—plant, property, and equipment—for their two most recent fiscal years. In all but six cases, or eight cases in the non-energy ranking, the fiscal year was the calendar year, so we used fiscal year 2011 and 2012 statements. For the remaining six companies, or eight on the non-energy list, we used the two most recent fiscal years available. Once we had the latest two years of data, we added back reported depreciation for the latest fiscal year to estimate domestic capital expenditures.

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NOTES

About the Progressive Policy Institute

The Progressive Policy Institute (PPI) is an independent research institution that seeks to define and promote a new progressive politics in the 21st century. Through research, policy analysis and dialogue, PPI challenges the status quo and advocates for radical policy solutions.

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The Impact of High-speed Broadband Availability on Real Estate Values: Evidence from United States Property Markets[1]

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Work in progress: preliminary results

Abstract

This working paper presents a study to show the possible impact of fiber-based broadband service availability on real estate values. The research goal is to find out whether people are willing to pay more for real estate located in areas where fiber is available than for a property that does not offer this amenity. Using information from the National Broadband Map and county assessors' data for residential single-family houses from three Metropolitan Statistical Areas in the State of New York, we apply a hedonic pricing model to test the hypothesis. Early results suggest that fiber availability may indeed have a positive impact on real constant-quality house prices. Initial findings also urge additional research efforts to test the impact more thoroughly and to address issues due to potential endogeneity.

Key words: broadband, Internet, real estate, welfare

JEL Classification: R21, L96, L98

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1. INTRODUCTION

An extensive literature on broadband adoption is available. However, empirical studies related to the economic impact of fiber technology are fewer in number. This paper explores whether people are willing to pay more for real estate located in areas where fiber broadband access is available than for a property that does not offer this amenity.

Numerous factors influence the value of residential real estate, including the energy efficiency of buildings, the proximity of good schools, or the amount of crime in neighborhoods. For some people, an important consideration when buying a home might be the availability of fiber-based broadband services to the property. To test this, we aim to evaluate empirically whether access to fiber broadband is associated with any measurable effect on property values. Using a hedonic price framework and data from the National Broadband Map (NBM) the research goal is to investigate how constant-quality real estate prices vary, where constant-quality real estate is defined as a property where structural, land, and community attributes are all held constant. The focus of this investigation is the hypothesized impact of variations in fiber service availability on residential single-family house prices. The paper adds to the existing literature by conducting an empirical analysis of the assumed neighborhood effect of fiber availability.

The existing literature has examined the economic impact of broadband penetration, but not that of fiber-based Internet access. Using 2011 June data from the NBM, the recent Broadband Brief by the Department of Commerce's National Telecommunications & Information Administration and the Economics and Statistics Administration confirmed that "broadband is less available in rural areas than in urban areas" (NTIA-ESA, 2013, p. 11). The NTIA-ESA analysis also showed that proximity to central cities within a Metropolitan

Statistical Area (MSA) is likely to be "more strongly associated with the availability of the highest speed levels of broadband service than population density" (p. 10). The broadband brief, however, leaves the question open whether the location within a MSA is simply associated with increased broadband availability or whether it is a contributing factor to increased broadband availability.

Real estate economists often quantify the impact of variables that are specific to neighborhoods by applying the hedonic method outlined in the seminal paper of Rosen (1974).[1] These hedonic valuation models assume that the main considerations of property values, such as structural characteristics, neighborhood characteristics, and relative location of the property, are known.

The first models focused on the structural characteristics of the property, including the size of the building, the number of bedrooms and bathrooms, and other lot characteristics. Later, other area amenities, such as air pollution (Rosen, 1979), local climate (Haurin, 1980), and crowding (Roback, 1980) were added. Roback (1982) also considered labor markets in her approach. The empirical studies of Beeson and Eberts (1989), Peek and Wilcox (1991), Blomquist and Berger (1992), and Potepan (1994) found that crime, recreational opportunities, and population demographics should also be considered for real estate valuation models.

Despite recent advances in real estate economics, spatial econometrics, and the increasing number of studies that support the existence of neighborhood effects, the impact of fiber-based broadband on property prices is still not a well-researched area. Academic research regarding this topic has been limited by a lack of good quality data on fiber

[1] Hedonic valuation models are regressions of real estate value against property characteristics that determine this value.

broadband access availability. Although a recent research by RVA LLC found that “a fiber connection adds between $5,300 and $6,450 to the value of a home” (RVA, 2013, p. 31), their study was based on surveying homebuyers and developers (*stated preferences*), and it was not an empirical analysis of transactional data (*revealed preferences*).

The NBM has data to allow for investigation of this research question (NBM, 2011). The NBM shows where broadband is available, the technology used to provide the service, the maximum speeds, and the name of the service providers. Created from collaboration between the National Telecommunications and Information Administration, the Federal Communications Commission (FCC), and all states of the US and territories and the District of Columbia, the NBM is an online tool that provides semi-annual information on the availability, technology, speed, and location of broadband Internet access at the census block level. Matching fiber broadband availability information from the NBM with factual information on real estate sales transactions and property characteristics will not only make it possible to investigate the economic impact of superior broadband, but it also provides another approach to measure the value of fiber broadband in monetary terms.

This study and the model used in this paper were following Haurin and Brasington (1996). Using two variants of a random coefficients model and testing transactional data from six MSAs in Ohio, Haurin and Brasington studied the impact of school quality on real estate prices. They found that public school quality positively influences real constant-quality house prices. For simplicity, we decided to follow their hedonic model for this paper.

Using information from the NBM and county assessors’ data for residential single family houses, we tested 2011 transactions from nine counties of three MSAs in the State of New York. We found that the presence of fiber-based broadband is associated with a positive effect on property values. Results suggest that the availability of fiber broadband might be as important in explaining spatial variations in real constant-quality house prices as the presence of cooling capability/air conditioning, fireplaces, or a pool.

The next section overviews the real estate valuation techniques. The empirical model is described in Section three and Section four details the data. The preliminary results are presented in Section five. Section six concludes and describes future work.

2. REAL ESTATE VALUATION TECHNIQUES

Malpezzi (2002) divides real estate valuation model into three main groups: hedonic valuation techniques, repeat sales methodologies, and hybrid models. Hedonic valuation models are essentially regressions of real estate value against property characteristics that determine this value. Hedonic valuation models assume that the main considerations of property values, such as structural characteristics, neighborhood characteristics, and relative location of the property are known. Hedonic price models are derived from Lancaster's (1966) consumer theory, Rosen's (1974) trading model, and Maclennan's (1977) theoretical works. Lancaster suggests that consumer utility is generated not by goods but instead by the characteristics of the goods. Rosen modeled how suppliers and consumers interact assuming a framework of bids and offers for product characteristics. Maclennan's model recognized that observed real estate transaction prices cannot be equilibrium prices and laid down the theoretical foundation for the hedonic models.

Repeat sales methods are based on data that directly measure property price appreciation over different periods. Prices from these known time periods are combined to create matched pairs, providing observations of actual transactions on the same property.

Repeat sales models have the advantage of controlling for unobserved characteristics of a given property (no omitted variable bias). Bailey, Muth, and Nourse (1963) were the first to propose repeat sales regressions, simply using ordinary least squares (OLS). Case and Shiller (1989) pointed out the disadvantages of using OLS and suggested using another regression technique, generalized least squares (GLS).[2]

There are two disadvantages of the repeat sales methods. First, frequently traded properties are not necessarily a random sample of all real estate available. Second, the methods often do not consider improvements to properties; the property sold at t_1 may not be identical to the property sold at t_0.

Hybrid valuation models combine hedonic and repeat sales models. They estimate the two models as imposing a constraint that price changes over time are equal in both models. According to Malpezzi (2002), the basis for the hybrid valuation theory is contained in the influential works of Case and Quigley (1991), Quigley (1995), Hill, Knight and Sirmans (1997), and Knight, Dombrow and Sirmans (1995). The primary disadvantage of the hybrid method is that it requires careful matching of time-series and cross-section observations.

Due to the importance of location and neighborhood characteristics in explaining house price variations, more recent developments in house price models are leveraging advances in spatial econometrics. Dubin (1988), Laakso (1997), Karakozova (2005), Kiel and Zabel (2007) all found empirically that characteristics of the vicinity significantly affect real estate prices. According to LeSage and Pace (2009), there is sound justification to use spatial econometric models in all of the valuation methods described above, as the omitted location and neighborhood variables are considered to be autocorrelated.

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[2] GLS is a statistical technique for estimating the unknown parameters in a regression model. This is typically applied in the case of heteroskedasticity or when there is a certain degree of correlation between the observations.

3. EMPIRICAL MODEL

Following Haurin and Brasington (1996), this paper tests a simple hedonic price equation.

$$\ln V_{ij} = X_{ij}\beta + J_j\delta_j^{'} + \varepsilon_{ij} \qquad (1)$$

where i is a transacted house, j is the geographic area, and ε is the random error. X_{ij} is a set of structural and land characteristics, and J_j is a set of dummy variables indicating the jurisdiction (census block group) of an observation. In this equation, the coefficient $\delta_j^{'}$ represents percentage deviation of an average house price in district j from the price of a constant-quality property.

The capitalization test for the community and MSA variables is as follows:

$$\delta_j^{'} = Z_j\gamma^{'} + \mu_j^{'} \qquad (2)$$

In equation (2), $\delta_j^{'}$ is related to the community and MSA level variables Z_j. Equations (1) and (2) test for an impact through changes in the lot price. Depending on the land size, the impact varies amongst properties within a given census block group.

Combining equation (2) with (1), the hedonic price equation can be written as:

$$\ln V_{ij} = X_{ij}\beta + Z_j\gamma^{'} + \mu_j^{'} + \varepsilon_{ij} \qquad (3)$$

Equation (3) relates the natural log of the real transaction prices for houses ($\ln V_{ij}$) to a set of structural and land characteristics X_{ij}. Using GLS is appropriate because we test for CBG-specific mean zero random errors in house prices (Garman & Richards, 1990; Haurin & Brasington, 1996).

The parameter of interest in equation (3) is $\partial \ln V_{ij}/\partial FIBER\_D = \gamma_f^{'}$. The coefficient $\gamma_f^{'}$ indicates the percentage deviation of an average house price in CBG j, where fiber broadband is available, from the price of a constant-quality property. Failure to reject the null hypothesis $\gamma'_f = 0$ provides evidence that the presence of fiber in the census block group may have an impact on real estate value.

4. DATA AND VARIABLES

The primary source of the property information is a dataset containing real estate transactional data and property characteristics for single-family detached houses in three MSAs in the State of New York.[3] The data set was obtained from DataQuick (2013), a property information service provider. The master dataset included property characteristics and assessor data for a total of 24,784 sale transactions for single-family detached houses in 2011. Fiber broadband availability data were obtained using the June 2011 version of the NBM. *Other explanatory variables* in (3) are drawn from various sources, including data from US Census (2011), ACS (2011), and Geolytics (2012).

4.1 Variables

As described in the third section, our test relates the natural log of the real estate transaction prices to a set of structural and neighborhood characteristics and several jurisdictional amenities. Detailed definitions of all variables are listed in Table 2.

Measures of the *house and lot characteristics* included the age of the house (AGE10, measured in ten years), lot size (LOTSIZE10k, measured in 10,000 square feet), house size (HOUSESIZE1k, measured in 1,000 square feet), garage size (GARAGESIZE1k, measured in 1,000 square feet), and number of bathrooms (NBRBATH). We used dummy variables to

[3] The three MSAs are: Buffalo-Cheektowaga-Tonawanda, Poughkeepsie-Newburgh-Middletown, and Rochester. Table 1 shows key characteristics of the nine counties in these three MSAs.

indicate the presence of a patio and/or a porch (PATIOPORCH_D), a pool (POOL_D), air conditioning or some cooling solution (COOLCODE_D), and a fireplace (FIREPLACE_D).

Measures of *neighborhood characteristics* included average income per capita (INCOME1k_CBG), expected county population growth (POPGR_CNTY), tax rate (TAX_CNTY, measured in percentage), and the number of serious crimes per capita in the MSA (CRIME_MSA). INCOME1k_CNTY is defined as the 2011 per-capita income in the county, measured in thousands dollars. We measured expected county population growth by the ratio of 2010 to 2000. TAX_CNTY is a public sector variable, and it is the nominal tax rate used in the county. The MSA-level measure of crime is the number of serious crimes per capita.

For *neighborhood amenities*, we adopted recreational and arts opportunities (ARTREC_CNTY), accessibility (ACCESS_CNTY), and the distance of the real estate to the central business district (DISTANCE_CBD, measured in miles). ARTREC_CNTY is a variable we used to proxy the recreational and arts opportunities. We defined ARTREC_CNTY as the percentage of employees in the county who work in the arts, entertainment, and recreation sector. We measured accessibility by the average time in minutes to get to the workplace by those who commute to work. The distance to the central business district was defined as the geographic distance between the geocoded location of the property and the latitude and longitude coordinates for the central business district of the principal city in each MSA.[4]

The focus of this paper is the impact of *fiber availability* on real constant-quality house prices. We used information from the NBM (2011) to identify census block groups where fiber technology was present. FIBER_D is the dummy variable indicating the presence

[4] The location of each MSA's CBD was obtained from the research of Holian and Kahn (2012)

of fiber in a census block group.[5] Since our analysis is at the census block group level, we considered fiber available in a census block group if the technology was reported in at least one of the census blocks.[6]

Other *jurisdictional variables* in the estimation are the percentage of non-white households (NONWHITE) and the percentage of people who lived in the same county twelve month ago (TURNOVER_CNTY). The former is used to capture variations in house price resulting from discrimination, and the latter is a measure to proxy community stability.

4.2 Summary statistics

Table 3 presents summary statistics for all the variables used in our empirical analysis. Because some of the properties in our dataset have missing or incomplete data, our final dataset is comprised of 20,521 real estate transactions in the three MSAs of our study.

The average house price is $155,036. The average lot size is 16,322 square feet, and average building size is 1,630 square feet. The average garage size is 343 square feet. On average, 74% of the properties have a patio or porch, 44% have fireplace, 39% have a cooling solution installed, and 8% have a pool. A typical house has two bathrooms and is 50.6 years old.

5. RESULTS

[5] Census block groups are small statistical subdivisions of census tracts. Census tracts typically coincide with the limits of cities, towns or other administrative areas. They contain 1,500 to 8,000 people; on average, they made up approximately four census block groups. There are 217,740 block groups nationwide, as of the 2010 census.

[6] Previous market structure studies have used census tract, county, local telephone exchange and zip-code boundaries to define the geographical market for broadband Internet (Gillett and Lehr, 1999; Prieger, 2003; Wallsten and Mallahan, 2010; Xiao and Orazem, 2011; Nardotto et. al., 2012). Because ISP decisions to roll out and promote new services are usually made for smaller geographical footprints, we define the market for fiber broadband to be a census block group, which generally contains between 600 and 3,000 people.

Table 4 reports the results based on the 20,521 observations located across 2,180 census block groups in the nine counties of the three selected MSAs in New York State.

5.1 Ordinary Least Square Regression

The house and lot characteristics have the expected signs, and most of them are significant. Increasing age (AGE10) reduces house value. The positive coefficient for AGE10_SQ suggests that housing depreciates at an increasing rate, but the result is not significant. The OLS regression shows that increased square footage of the house (HOUSESIZE10k) and square footage of the lot (LOTSIZE10k) both increase the price of the property at a decreasing rate. The presence of a fireplace (FIREPLACE_D), cooling solution (COOLING_D), pool (POOL_D), patio and/or porch (PATIOPORCH_D), and bathrooms (NBRBATH) all increase the value of the house.

The coefficients of the *jurisdictional variables* generally also have the expected sign. Increasing non-white population (NWHITE_CBG), county tax rates (TAX_CNTY), and crime (CRIME_MSA) were associated with decreasing property prices. Increasing per-capita income (INCOME_CBG) and population stability (TURNOV_CNTY) were both associated with greater house value. Positive population growth (POPGR_CNTY) were associated with increased real estate value. Geographic distance from the central business district (Distance_CBD) and better accessibility (ACCESS_CNTY), as expected, were negatively correlated with price. The positive coefficient of *FIBER_D* (γ_1 = 0.026) implies that the presence of fiber increases the property value in the neighborhood. With a mean house price of $155k, this is a change in value of $4.061. The coefficient is significant at the one percent level.

5.2 Random-effects GLS Regression

Generally, results of the random effects model are very similar to those of the OLS model. The house and lot characteristics have the expected signs, and are most of them are significant. Increasing age (AGE10) was associated with reduced house value, and the positive coefficients for AGE10_SQ suggest that housing depreciates at an increasing rate. We were able to confirm that the increased square footage of the house (HOUSESIZE10k) and the square footage of the lot (LOTSIZE10k) were both associated with an increase in the price of the property at a decreasing rate. The presence of a fireplace (FIREPLACE_D), cooling solution (COOLING_D), pool (POOL_D), and bathrooms (NBRBATH) were all associated with increased value of the house. The coefficient to show the impact of the presence of a patio and/or a porch was also positively correlated, but it was not significant in the GLS model.

The coefficients of *jurisdictional variables* generally also have the anticipated sign. An increasing non-white population (NWHITE_CBG), county tax rates (TAX_CNTY), and crime (CRIME_MSA) were associated with decreasing property prices. Increasing per-capita income (INCOME_CBG) and population stability (TURNOV_CNTY) were both associated with greater house value. Better accessibility (ACCESS_CNTY) and positive population growth (POPGR_CNTY) were both found to be associated with increased real estate value. Distance from the central business district, as expected, was found to be negatively correlated with the price, but the result was not significant. The positive coefficients of *FIBER_D* (γ'_1 = 0.051) implies that the presence of fiber in the neighborhood increases property value. With a mean house price of $155k, this is a change in value of $7.905. The coefficient is significant at the five percent level.

6. SUMMARY AND CONCLUSIONS

This paper presented an empirical study of the impact of access to fiber-delivered Internet on real estate values. The research goal was to determine if people are willing to pay more money for real estate located in areas where fiber broadband access is available than for a property that does not offer this amenity. Using information from the NBM and county assessors' data for residential single-family houses from three MSAs in New York State, we applied a hedonic pricing model used in real estate economics. The random-effects GLS model signified that the presence of fiber-based broadband was associated with a positive effect on property values in the neighborhood.

However, caution is warranted in drawing conclusions at this point for two reasons. First, correlation does not necessarily equal causation. Fiber availability may drive real estate prices upwards. An unobserved variable may jointly determine both real estate prices and fiber presence. Alternatively, both might be correct. Residential properties in markets with high-speed broadband access would be expected to have greater value. However, good quality broadband infrastructure is also expected to be rolled out first in high-income areas with high-valued real estate. Estimating the value of high-speed internet availability through property markets creates challenges in addressing this potential endogeneity. Second, this proof-of-concept study was using data from three MSAs only. The selection of the MSAs was arbitrary, and the real estate dataset is unrepresentative. In addition, our exposure time was rather short; the analysis focused on 2011 data alone.

Regardless of these limitations, we believe that these early results are strong enough to justify further research. Based on a larger data set, the objective of our future work is to measure the value of broadband Internet throughout real estate markets across the United States. The semi-annually updated NBM data on fiber broadband availability makes it feasible to test our hypothesis on a larger set of real estate transactional data and use a wider array of geographies. To address endogeneity, future work will control for the unobserved consumer demand effects that are jointly positively correlated with residential real estate prices and high speed Internet roll out and use the advances of spatial econometrics to acquire results that are more robust. A future version of this research will also test the impact of ultra high-speed broadband (i.e., 100Mbps or greater) on property prices and run a technology agnostic study.

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TABLE 1
COUNTY POPULATION, AREA SIZE, AND HOUSING UNITS

MSA/COUNTY	Total Population	Area Size	Pop. Density	Housing Units
Buffalo-Cheektowaga-Tonawanda, NY				
Niagara County	216,469	1139.7	414.4	99,120
Erie County	919,040	1226.9	881.4	419,974
Poughkeepsie-Newburgh-Middletown, NY				
Orange County	372,813	838.6	459.3	137,025
Dutchess County	297,488	825.3	373.9	118,638
Rochester, NY				
Livingston County	65,393	640.3	103.5	27,123
Monroe County	744,344	1366.7	1132.6	320,593
Ontario County	107,931	662.5	167.6	48,193
Orleans County	42,883	817.4	109.6	18,431
Wayne County	93,772	1383.1	155.3	41,057
9 County Average	317,792	988.94	421.9	136,684
US Average (3143 counties)	98,232	1208.0	259.3	41,904

Source. US Census (2013).

TABLE 2
VARIABLE DESCRIPTIONS

Variable	Description and data source
logHOUSEPRICE	Log of transaction amount for residential single family house (deflated). Source: DataQuick (2013)
AGE10	Age of house in ten years. Source: DataQuick (2013)
LOT SIZE10k	Lot size in ten thousand square feet. Source: DataQuick (2013)
HOUSESIZE1k	House size in thousand square feet. Source: DataQuick (2013)
GARAGESIZE1k	Garage size in thousand square feet. Source: DataQuick (2013)
NBRBATH	Number of bathrooms. Source: DataQuick (2013)
PATIOPORCH_D	Patio & porch dummy. Source: DataQuick (2013)
FIREPLACE_D	Fireplace dummy. Source: DataQuick (2013)
COOLING_D	Cooling solution dummy. Source: DataQuick (2013)
POOL_D	Pool dummy. Source: DataQuick (2013)
NBRBATH	Number of bathrooms. Source: DataQuick (2013)
Q1SALE	Dummy variable to indicate Quarter 1 sales. Source: DataQuick (2013)
Q2SALE	Dummy variable to indicate Quarter 2 sales. Source: DataQuick (2013)
Q3SALE	Dummy variable to indicate Quarter 3 sales. Source: DataQuick (2013)
FIBER_D	Availability of fiber-based Internet access technology in the CBG in 2011. Source: NBM (2011)
TAX_CNTY	Nominal property tax rate. Source: The Tax Foundation (2013)
INCOME1k_CBG	Per capita income in the CBG (in thousands). Source: ACS (2011)
NWHITE_CBG	The percentage of nonwhite households in the CBG. Source: ACS (2011)
DISTANCE_CBD	Calculated distance from the property to the MSA's center (in miles). Source of MSA center geocodes: Holian and Kahn (2012)
TURNOVER_CNTY	Percentage of households who lived in the same house or in the same county 12 month ago. ACS (2011)
ACCESS_CNTY	Weighted average of the average commuting time to work. Source: ACS (2011)
ARTREC_CNTY	Percentage of employees in the art & recreation sector. This is a measure of art & recreation opportunities. Source: CBP (2011)
POPGR_CNTY	2010 county population divided by 2000 county population. Source: Geolytics (2012)
CRIME_MSA	Serious crimes including murder, robbery, etc. This is a MSA-level variable. Source: FBI (2011)

TABLE 3
SUMMARY STATISTICS

Variable	Obs.	Mean	s.d.	Min	Max
HOUSEPRICE	20521	155036.7	128501.7	4200	2250000
lnHOUSEPRICE	20521	11.65183	0.810398	8.336308	14.59855
AGE10	20521	5.062516	3.231351	0	292
LOTSIZE10k	20521	1.632267	1.630365	0.04356	8.712
HOUSESIZE1k	20521	1.63024	0.638391	0.384	9.146
GARAGESIZE1k	20521	0.343415	0.248996	0	12.324
PATIOPORCH_D	20521	0.744359	0.436231	0	1
FIREPLACE_D	20521	0.44145	0.496572	0	1
COOLING_D	20521	0.392232	0.48826	0	1
POOL_D	20521	0.078944	0.269657	0	1
NBRBATH	20521	1.971395	0.862973	0	8
Q1SALE	20521	0.186687	0.389669	0	1
Q2SALE	20521	0.26295	0.440246	0	1
Q3SALE	20521	0.297987	0.457385	0	1
Q4SALE	20521	0.252376	0.434386	0	1
TAX_CNTY	20521	2.676215	0.360779	1.77	3.02
FIBER_D	20521	0.680181	0.466418	0	1
INCOME1k_CBG	20521	63.96973	26.28247	8.466	175.481
NWHITE_CBG	20521	0.148656	0.200824	0	1
DISTANCE_CBD	20521	11.90923	9.044666	0.238185	46.71218
TURNOV_CNTY	20521	0.958216	0.008421	0.921552	0.965054
ACCESS_CNTY	20521	23.70592	4.07874	20.92004	33.88074
ARTREC_CNTY	20521	1.599454	0.353301	1.209812	2.04769
POPGR_CNTY	20521	0.66925	4.000225	-3.28593	9.211786
CRIME_MSA	20521	3.44403	0.816763	2.41	4.392

NOTES. Obs. is number of observations. s.d. is standard deviation..

TABLE 4
OLS AND RANDOM EFFECTS GLS REGRESSION

	OLS			GLS		
	Coefficient	Estimate	s.e.	Coefficient	Estimate	s.e.
Structural & lot characteristics						
CONSTANT	β_0	4.970973***	0.739063	β_0	4.403418***	1.505939
AGE10	β_1	-0.05123***	0.004068	β_1	-0.05893***	0.003388
AGE_SQ	β_2	0.000359	0.000311	β_2	0.001254***	0.000222
LOTSIZE10k	β_3	0.054200***	0.007175	β_3	0.055347***	0.007637
LOT10k_SQ	β_4	-0.00673***	0.000958	β_4	-0.00584***	0.000946
HOUSESIZE1k	β_5	0.360486***	0.026554	β_5	0.340801***	0.019275
HOUSE1k_SQ	β_6	-0.02408***	0.005681	β_6	-0.02256***	0.003803
GARAGESIZE1k	β_7	0.206576***	0.022258	β_7	0.212733***	0.01779
GARAGE1k_SQ	β_8	-0.02024***	0.003890	β_8	-0.01982***	0.003316
PATIOPORCH_D	β_9	-0.03091***	0.008492	β_9	0.008238	0.007844
FIREPLACE_D	β_{10}	0.165179***	0.007679	β_{10}	0.111224***	0.007886
COOLING_D	β_{11}	0.100019***	0.007091	β_{11}	0.091769***	0.007713
POOL_D	β_{12}	0.042865***	0.009826	β_{12}	0.059502***	0.011901
NBRBATH	β_{13}	0.116733***	0.006908	β_{13}	0.089419***	0.00584
Q1SALE	β_{14}	-0.02819*	0.011083	β_{14}	-0.01762*	0.009486
Q2SALE	β_{15}	0.035359***	0.009762	β_{15}	0.033495***	0.008614
Q3SALE	β_{16}	0.057077***	0.009094	β_{16}	0.043895***	0.008359
Neighbourhood/MSA characteristics						
FIBER_D	γ_1	0.026222***	0.009206	γ'_1	0.050989**	0.02216
TAX_CNTY	γ_2	-0.44253***	0.033004	γ'_2	-0.49567**	0.067664
INCOME1k_CBG	γ_3	0.004054***	0.000166	γ'_3	0.005615***	0.000387
NWHITE_CBG	γ_4	-0.94814***	0.028945	γ'_4	-1.04032***	0.040944
DISTANCE_CBD	γ_5	-0.00212***	0.000799	γ'_5	-0.00215	0.001543
TURNOV_CNTY	γ_6	9.084472***	0.776347	γ'_6	10.33109***	1.60284
ACCESS_CNTY	γ_7	-0.01922***	0.004656	γ'_7	-0.03023***	0.009796
ARTREC_CNTY	γ_8	-0.29152***	0.034443	γ'_8	-0.31609***	0.068766
POPGR_CNTY	γ_9	0.0186***	0.00341	γ'_9	0.01427**	0.007157
CRIME_MSA	γ_{10}	-0.22429***	0.017977	γ'_{10}	-0.28885***	0.037398
R-squared		0.6209			0.6153	

NOTES. Dependent variable is 2011 Log Real Transaction House Price. Sample size is 20,521 transactions in nine counties. s.e. denotes robust standard errors in parenthesis. ***significant at the 0.01 level; **significant at the 0.05 level; *significant at the 0.1 level.

DRAFT

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The Reality of Reality: Judges' Trouble with True TV

Amy Gajda

NOTE: The following is an excerpt from the fifth chapter in my forthcoming book, *The First Amendment Bubble: How Privacy and Paparazzi Threaten a Free Press* (Harvard University Press 2014). In the book, I argue that courts are limiting First Amendment protections for all media more often today because of certain push-the-envelope media practices. The manuscript is still in draft form, as is the following excerpt, so I welcome all comments and suggestions.

The Rise, and Lows, of Quasi-Journalism

If developments in mainstream media have the potential to push the protective First Amendment bubble even closer to the breaking point, then emerging practices of quasi-journalism seem determined to break it. In some ways, they already have.

Quasi-journalism is a term meant here to describe the publication of truthful information outside the context of traditional mainstream journalism. Traditionally, journalism's qualities are said to be "impact, immediacy, proximity, prominence, novelty, conflict, and emotion."[1] Some experts add "mystery, drama, adventure, celebration, [and] self-improvement."[2] As noted previously, in making news decisions, traditional journalists also exercise ethics-related judgments beyond those qualities, including the story's "truth, its importance, its public value or utility,"[3] and its potential harm. If it is true that the "mystique of the editorial process" is based upon "intuitive judgment and competitive strategy,"[4] then many with the intuition today make judgments far different from those in the mainstream press.

Though there is no perfect way to draw the line, many quasi-journalists do not seem to follow an established mainstream ethics code and some would not consider themselves journalists, even though they publish what many readers consider truth.[5] Here, a tabloid like the *National Enquirer* is a form of quasi-journalism because of its highly sensational stories that at times push the envelope of propriety and truth, even though its reporters work under some editorial control and ethics principles, perhaps closest to mainstream journalism here. Websites like *Gawker*, blogs that operate more as free-form thoughts or diaries, or those that more clearly lack an ethics foundation in the traditional sense, and many reality television programs also fall into this category. Those sorts of publications contrast with New York's daily tabloids, for example, because the latter report traditional news including crime and political news in addition to more sensational articles and seem more restricted by ethics. This quasi-journalism category, in contrast, includes publishers that mostly publish outside the traditionally mainstream.

In other words, both mainstream and quasi-journalism publish truth-based information but quasi-journalism 1) often excludes what we might consider traditional news in favor of sensational news items more likely to inflict the emotional harm and 2) often seemingly fails to consider traditional journalistic ethics principles when doing so.

This chapter collects numerous examples of push-the-envelope quasi-journalism and courts' negative responses. Today, protection based upon First Amendment principles is not as robust as it once was and quasi-journalism is at least partly responsible.

. . . .

The Law and Girls Gone Wild

Long before The Dirty and Gawker and other websites with a mission to expose, in 1997, there was Girls Gone Wild. The videotape series was "[c]reated by entrepreneur Joe Francis," one court explained, and "feature[d] young, and sometimes underage, women in states of partial or total nudity."[6] Girls Gone Wild's focus was helped along by the women themselves: They "commonly consent[ed] to be photographed and videotaped in various stages of undress," one court explained, "for a nominal gift in the form of costume jewelry, usually consisting of brightly-colored plastic beads and trinkets."[7] Each videotape in the series consists of carefully edited clips of girls and young women lifting their shirts to expose their breasts, sometimes interspersed with far more graphic clips of girls and women engaged in sexual activity.

The facts as described by the plaintiffs in the cases that made their way to court were often heinous. Some claimed that producers had taken advantage of their intoxication[8] or had provided them with drugs and/or liquor,[9] pressuring them to perform while promising that their images would not appear on the Girls Gone Wild series.[10] Most of the girls who brought claims in reported cases against Francis and his production company were underage: 17, 16, 15, 14, and even 13 years old.[11] Some were stopped by a photographer on the street, others were brought to a party and allegedly plied with alcohol. Some knew that a photographer was present but others insisted they did not or did not fully understand what the photographer was up to.

In other words, the series seemed designed to give courts good reason to extend privacy law to protect these plaintiffs whose mistakes had life-altering privacy implications: these momentary lapses of discretion by apparently trusting underage girls had been immortalized forever as part of a tawdry series of videotapes.

Nonetheless, Francis had the First Amendment and decades of privacy law jurisprudence on his side. First, he argued that he was simply covering a newsworthy part of American culture -- the phenomenon of females willing to disrobe for an item of little value – making the same argument as would a journalist who had covered a riot on the streets. "[T]he defendant [Girls Gone Wild] suggests it merely used videotape of the crowd at Mardi Gras," one court wrote, "as part of a true and accurate depiction of a newsworthy event – much as CBS might cover a presidential speech or Fox might cover the Super Bowl."[12]

Moreover, the defendant producers noted, the girls had exposed themselves in public, either at the beach or at parties, and, therefore, privacy law would not apply. One young woman, for example, was on "a public part of the lake, stood on top of a boat and removed her bikini bathing suit top"[13] and another was “at a ‘party’ on the second floor of a Bourbon Street bar” in New Orleans.[14] Their “flashing,” Francis argued, was a newsworthy, public event[15] and he was but the documentarian.

One court sided with Francis in a case involving a 17-year-old who had argued that she would not have exposed herself had she known of the cameraman’s plan. The court rejected her privacy claim, finding that the Girls Gone Wild series was “an expressive work created solely for entertainment purposes” in which the girl had “voluntarily participated.”[16] The videotape, like any television news story, the judge wrote, was a “truthful and accurate description of [the plaintiff] voluntarily exposing her breasts to a camera just as she did on Labor Day Weekend in Panama City Beach, Florida” in a public place “while several pedestrians were in the general vicinity,” even though the cameraman was a complete stranger.

That decision stood alone, however. From the first reported case brought against Girls Gone Wild in 2002, in which the court wrote that “[t]he First Amendment provides no right to make an unconsenting individual the poster-person for a commercial product,”[17] to one of the last, decided in 2013, and involving a 14-year-old girl, in which the court reasoned that “[t]he men to whom [the plaintiff] exposed her breasts never indicated to [the plaintiff] that they worked for, had any connection with, or had any intention of giving [the plaintiff’s] image to” Girls Gone Wild producers,[18] the decisions are uniformly in favor of the plaintiffs’ claims, which mostly sounded in privacy and intentional infliction of emotional distress.

The remaining courts in reported cases rejected the Girls Gone Wild producers’ newsworthiness arguments either implicitly or explicitly. “Since plaintiff is not a public figure,” one such court wrote, the producers are “not participating in a public dialogue about the condition of American society in general.”[19]

Two courts also rejected the defendants’ argument that they were protected because what had happened with the young women had happened in public. One court held that someone at a party attended by others could, in fact, be in private even though the bar in question was on Bourbon Street in New Orleans and even though the establishment was open to the public and strangers were in attendance.[20] Another flatly rejected the idea that by taking off one’s top in public puts the person in the public eye.[21]

And one federal appeals court worried openly about what might happen to these girls and young women in the age of the internet where visual depictions of their indiscretion might remain forever. It warned that Girls Gone Wild girls “faced the very real danger of becoming internet sensations” and it pointed to the example of the 17-year-old who had failed to convince the judge to rule in her favor.[22] That plaintiff was now “permanently identified in the IMDB.com database for one of the Girls Gone Wild movies,” the court wrote, by name and with the title of “17-year-old public breast-flasher.” For that reason, over First Amendment-based objections by Girls Gone Wild producers, the court held that the plaintiffs in the case could remain anonymous throughout the duration of the lawsuit.[23]

The legacy of quasi-journalist Joe Francis and his Girls Gone Wild series, then, can be seen as three-fold. First, people who are at a public gathering may, in fact, be considered in a private space for purposes of invasion of privacy; second, newsworthiness’s sweep is more limited and presumably does not include a news item with video of young women who flash for beads in public; and, third, courts can restrict media from learning lawsuit parties' names if there is a danger that privacy will be forever wiped away by internet mentions.

Mainstream news media organizations recognized the implications these cases had for traditional news gathering and reporting and filed First Amendment amici briefs in at least one of the cases.[24] But, not surprisingly, those arguments, too, were drowned out by privacy claims of girls who found themselves more exposed than they thought possible.

The Law and Borat

"Borat" was a 2006 Hollywood film starring Sacha Baron Cohen, subtitled "Cultural Learnings of America for Make Benefit Glorious Nation of Kazakhstan." On the Internet Movie Database, it is described this way: "Kazakh TV talking head Borat is dispatched to the United States to report on the greatest country in the world. With a documentary crew in tow, Borat becomes more interested in locating and marrying [television star] Pamela Anderson." In the real-life making of the film, Baron Cohen traveled across the United States pretending to be a foreign journalist and interacting with very real people who had no idea they were being tricked: What they thought was a Kazakhstan-produced documentary would later appear in theaters across the United States. The film, then, was very real in that real businesspeople, real etiquette experts, and real fraternity brothers were featured in non-scripted ways, but also quite fictionalized in that Borat, the journalist, was a figment of Baron Cohen's imagination, as was the general script.

After the film's release, multiple people featured in the film sued for privacy-related reasons. Some argued that they had been made to appear silly, others that their anti-social behavior had been revealed. The trouble was that many of them had signed releases that, upon reflection, should have raised red flags. In exchange for up to $350, the participants had agreed to appear in the film which was described as one "meant to reach a young adult audience by using entertaining content and formats" and those signing a participation contract had promised not to sue for invasion of privacy or intentional infliction of emotional distress.[25] The releases mostly protected the producers. In one case, for example, the court analyzed the news value of the film as a trump to the plaintiff's privacy claims, finding it to be a newsworthy "ironic commentary of modern American culture, contrasting the backwardness of its protagonist with the social ills [that] afflict supposedly sophisticated society."[26]

But Borat's travels had led him to a Pentecostal church camp meeting, one attended by a deeply religious woman named Ellen Johnson. As a court would explain, in the film "Borat . . . seeks redemption at the camp meeting during which he acts as if he is converted by the minister and begins speaking in tongues along with other Pentecostals doing the same."[27] Johnson appears in the film for three seconds. "While Borat appears to be experiencing this religious conversion," the court explained, "several members of the camp meeting, including the plaintiff, are shown in the film raising their arms to praise God for Borat's conversion."

There was no conversion, of course, and, after seeing the film, Johnson felt that she was made to look as if she did not take her religion seriously. She sued the filmmakers for invasion of privacy and intentional infliction of emotional distress in a federal trial court in Mississippi. They had, she argued, filmed her without her consent, had portrayed her in a way that suggested that she knowingly mocked her church, had released the film without her signed waiver, had tricked her into believing that the film was a documentary on American religion to be shown in a foreign country, and had not told her that Borat was not real. The defendants, in turn, argued that they were protected by the First Amendment.

The court that would hear the case called it "a battle between the defendants' assertion of their free speech rights and the plaintiff's right to privacy."[28] And here, privacy won out.

The decision is remarkable in that the court found two separate privacy-related torts actionable even though case law supported the opposite conclusion. First, the court agreed with the plaintiff that she had a valid false light claim even though the court found that Mississippi had never before explicitly recognized false light as a valid cause of action. The producers had argued that the three seconds of hand-raising had truthfully occurred and that, therefore, there could be no false light claim, but the court ruled that the issue was whether viewers of the movie might believe that Johnson had knowingly mocked her religion. The court reasoned that the film could well be misunderstood: "There are indeed many reasonable Americans," the court wrote, "especially those who are of an older generation, who are not familiar with the type of humor/satire that is depicted in the film Borat."

Even more remarkable, however, was the court's decision to allow the plaintiff's privacy-related misappropriation claim to continue as well, even though it was based solely on a three-second image of the plaintiff in an 84-minute film. The court reasoned that those three seconds could support misappropriation because the film itself was a commercial enterprise, because producers had not received her explicit permission, and because producers had misled church leaders. Multiple courts had previously decided that a small focus within a considerably larger project would not support such a claim, but the court's focus was on the film's commercial nature.

As for the defendants' First Amendment claims, the court ruled that Supreme Court precedent that protected fictionalized motion pictures did not apply to one involving "an invasion of privacy claim by a private citizen":

> [T]he nature of the film Borat is different from a purely fictional work since, although the viewer is aware that the plot itself is fictional and that the characters of Borat and his producer are fictional, the viewer is also aware that the vast majority, if not all, of the other people featured in the movie are non-public figures who are not actors and are likely unaware that Borat is not a Kazakhstani reporter filming a documentary for Kazakhstan.

As in the previous examples in this chapter, the actions of the pretend journalist Borat and the court's reaction to his shenanigans, therefore, have implications for mainstream journalists. First, the court officially recognized the false light privacy tort in the jurisdiction in order to protect citizens from mischief-making media, here a quasi-journalist. Second, misappropriation was extended to include what many would consider incidental use – three seconds within a much longer film –simply because the end product had a commercial nature. And finally, and perhaps most importantly, the defendants' calls for First Amendment protection went unheard because the court's very strong focus was not on freedom of expression but on the protection of the plaintiff's privacy interests.

. . .

The Law and Reality Television

It cannot be good for all journalism that, at a time when courts have moved to restrict police records like mug shots and accident reports on privacy grounds, a series titled "Panic 9-1-1" exists. "Panic 9-1-1" is a cable television show described as one that

> take[s] 911 calls to a whole new level never seen or heard before on television. Unlike emergency shows of the past, viewers will live inside the calls and experience every harrowing and terrifying moment along with the caller. Every second is real.[29]

The premiere episode made clear that "harrowing" and "terrifying" are apt descriptors: viewers listened to a real 911 tape and watched a reenactment as "9-1-1 dispatchers receive[d] a frantic call from a Colorado mother who [had] barricade[d] herself and her teenage son inside an upstairs closet with no lock as an unknown intruder searche[d] for their hiding place." One clip on the program's website is titled, "Don't Let Me Die." Such sensationalized real-life moments of agonizing terror could make even media-sympathetic courts think twice about releasing 911 tapes to media generally, lest the recorded calls end up as voiceover for a television program more about horror than news.

Most lawsuits brought against reality television programs, however, are those based upon newsgathering and the push-the-envelope production behavior at places like hospitals or with police at crime scenes. Contrary to James O'Keefe's interpretation of constitutional law, most courts have found no First Amendment protection for newsgathering itself, despite the newsworthiness of the underlying story. Even in intrusion-into-seclusion tort cases in which courts could easily decide that the offensiveness of any intrusion should be offset by the value of the underlying news story, most courts refuse to allow newsworthiness to enter the intrusion determination at all.

Most of the intrusion decisions, however, stem not from *60 Minutes* or some other well-respected investigative journalism, but from reality television programming and O'Keefe-like behavior. A California appeals court in 2002, for example, reiterated what the *Shulman* court had held four years before:

> [N]o constitutional precedent or principle of which we are aware gives a reporter general license to intrude in an objectively offensive manner into private places, conversations or matters merely because the reporter thinks he or she may thereby find something that will warrant publication or broadcast.[30]

In that case, the plaintiffs had alleged that reporters had disguised themselves as hospital workers in order to get video for the reality television program "Trauma: Life in the ER" and had featured within the program itself a man who had ingested a drug known as Blue Nitro. Despite the fact that the court recognized the newsworthiness of the dangers of so-called "rave" drugs, it allowed the lawsuit to continue over the producers' First Amendment arguments.

Even though these programs have had a negative impact on mainstream journalism, they often do not seem to follow the same ethics restrictions. In a lawsuit brought against the reality television program "Inside American Jail," for example, the complaint noted that the show's producers had donated money to the sheriff's reelection campaign, reasoning that since the sheriff had agreed to the filming, the producers would help with his reelection.[31] In contrast, mainstream news reporters are strongly encouraged to be apolitical lest their reporting be perceived as biased and subjective. Many mainstream journalists do not campaign for any candidate and some refuse to vote in primary elections in which they would be forced to reveal their political allegiance. Indeed, reporters have been fired for covering political rallies while wearing political paraphernalia[32] or for revealing their political beliefs in some other fashion.[33]

Even so, when a California court holds that newsgathering itself has no constitutional protection, as did the California court in the Blue Nitro reality television case, the holding applies to all journalism. And when a federal appeals court in California decides that the identity of a police informant is not newsworthy in a case springing from a reality television program's alleged failure to digitize the man's face, the holding can be applied more generally; the court had noted that others' faces had been digitized and reasoned that, therefore, there was little news value in the person's precise identity.[34]

Troubling, too, are those times in which a reality television program aligns itself with mainstream news reporting in an effort to piggyback on mainstream journalism's stronger reputation. In a case from Tennessee heard in federal court in 2011, for example, the plaintiff complained that a reality television program titled "The Squad: Prison Police" had placed her in a false light and had defamed her by suggesting that she had carried drugs into prison while visiting her inmate husband.[35] The court described the program's use of hidden video as it followed the plaintiff, with the voiceover provided by a government agent assigned to the case. "I think we got her . . . inmates have found a weakness in our security," the agent said as the woman's driver's license picture was shown in mug shot-like fashion, "we're expecting this lady today." When there was little physical interaction between the couple at first, the official suggested that "it [the drug exchange] don't look like it's been done yet, so now it's just a waiting game." Later, after the couple kisses, he predicted that time for the "nitty gritty" had begun: "[H]old on now," he noted after the kiss, "she's going to the bathroom [and] [t]ypically these woman hide stuff up in their vaginal cavity and then go to the restroom to take it out." When the woman left the bathroom quickly, he suggested that that move implicated her further: "She didn't have time to pee. She went in and came right back out." After more kissing, the agent seemed certain that "some [expletive] just happened [and] I think we got 'em." At various points, as the video focused in on the woman and her behavior, the producers used ominous sounds and background music to enhance the crime-fighting theme.

As might be expected given her false light and defamation claims, nothing was found on the woman (despite, as the program explained, a "strip search of the suspect") or on her husband (despite, as the program noted, a 24-hour "dry cell" hold in which he had no access to running water). Even so, the agent warned at the end, "We might not get you today, maybe next week, next month, next year, but eventually we're going to catch up with you, and we're gonna get you."

The woman argued that the program suggested that she had and would smuggle drugs into prison. The court agreed that her case was a valid one and, in doing so, rejected the main defenses put forth by the producers. First, they had argued that a notice at the beginning of the program suggesting that all were innocent until proven guilty and the ultimate "false alarm" conclusion of the narrative at the program's end negated the overall effect of the videotape and voiceover. The court skeptically rejected that argument, pointing to the heavy focus on the plaintiff and the suggestion at the end that officials had not caught anyone yet, but would. The court also rejected the defense argument that the voiceover comments were merely opinions, noting that even opinions are not necessarily protected when they implicate someone in wrongdoing.

But what the court called the most "important" defense argument was the producers' claim that the program – a reality television show – was merely doing real-time news reporting, as would a television news station during a breaking news event. In effect, the defense seems to have argued, the viewer was carried along by the narrative as the criminal investigation moved forward, just as a television station presumably would cover a bank robbery or some other crime as it happened. But the court rejected this defense as well. It recognized that the program had been taped well in advance and had then been edited down into the thirty-minute program that the viewers saw, with producers having full control over the end product. As a "canned" program, then, the court found that it was very different from typical coverage of a breaking news event in which journalists are given little control over how a suspect might ultimately be portrayed.

That decision, though clearly finding a distinction between mainstream news reporting and this type of reality television, still has the potential to affect future journalism cases in which the editing and narrative of a news story implicates a suspect until the end.

The problem with reality television – one in which its methods have a lasting legal impact on journalism generally – is likely to continue. Today's courts seem quite averse not only to some of its newsgathering techniques but also to the format and its impact on American values. "In popular culture," one Rhode Island court wrote in 2011, "we see reality television constantly lowering the bar of civility and common courtesy."[36] A court in New York suggested that the genre "offers opportunities for embarrassing and insulting participants and the more outlandish the conduct, the higher the ratings," lamenting that "[t]here does not seem to be a bottom to the viewing public's appetite for this brand of entertainment."[37] A federal court in Indiana – hearing a case involving college students who had lured a fellow student to a fake Facebook page and then had recorded and posted on YouTube the point at which the fellow student learned that the Facebook girl did not exist – linked the students' video prank to reality television. It quoted a psychology article that had characterized such shows as like "'freeway car accident[s] or train wreck[s]' that 'seem to exploit and reward outrageous behavior' and allow viewers to 'take delight in the problems and misfortunes of others.'"[38] "Indeed," the judge in that case wrote, "the very objectionable or offensive nature of the show's subject matter can make it a hit." A federal judge in Kansas also joined in the criticism of the genre, writing that "the reality TV business . . . (whether the shows involve bachelorettes, stranded survivors on faraway islands, or hunting game in the wild) . . . is inconsistent with the notion of always telling the truth."[39]

That is the real problem with much of quasi-journalism: it cannot be trusted as much as mainstream journalism should be trusted. And yet the negative opinions in its cases can be read to affect even strongly ethical media.

Meantime, a casting call went out for what producers promised would be an "upcoming premium reality television series." It described the planned program this way:

> The upcoming series will be based loosely on the theme of blackmail and deceit. The series will primarily focus on the entrapment of rich and affluential [sic] married men. Chosen actresses will be provided a team of analysts which will generate dossier's [sic] on these men in order to aide [sic] in each man's entrapment by our actresses. There will also be an added sense of competition between the actresses of different cities revolving around a $500,000 cash prize

> and vacation to a location of the winners choosing for one week. . . . The overall goal of the actress towards her target should be to entrap the target so much that the target becomes so entangled in the deceit that they lavish the actress with gifts, trips, etc. obsessing with the actress to the point where they are infatuated.
>
> Then comes the blackmail portion[:] the men are given the suggestion of making a substantial donation to a charity or the information being turned over for public viewing.
>
> During the course of the entrapment the gentleman's face will be blurred however if he chooses to donate time or funding to charity his face will not be revealed. If the entrap [sic] chooses to refrain from the donation his face will be revealed.[40]

If that "premium reality television series" is not an O'Keefe undercover experiment – or even if it is – the courts are likely to hear more about it and, afterward, be forced to make decisions that will have the potential to harm all reporting of truth, including mainstream journalism.

Quasi-Journalism and Journalism: The Difference Between "Reality" and News

The struggle to decide which publications should be considered "true" journalism – how we delineate between mainstream journalism and quasi-journalism – is more than an academic exercise. As discussed in greater detail in Chapter Eight, currently, journalists are protected in important ways that quasi-journalists are not. State laws shielding them from forced court testimony, for example, recognize that journalists bring something special to society and that journalism's role should be protected so the public can be informed both about government from press releases and about government wrongs from inside sources who would not come forward but for a shield of protection.

But there is another reason why the distinction is an important one and why one group should be protected more than the other: decisions made by mainstream journalists based on ethics considerations help protect those who are the focus of news coverage. Ethics considerations will stop many journalists from reporting private embarrassing things about others, even when the revelation would have significant news value. Rightly or wrongly, reporters in Idaho, for example, were said to have known about Senator Larry Craig's dalliances for "decades,"[41] but no one reported on these alleged affairs likely because they felt they needed additional on-the-record sources. There are multiple other examples at all levels of government and otherwise. One cannot imagine any push-the-envelope gossip website maintaining such standards. In fact, one blogger had outed Craig well in advance of mainstream media outlets, but, lacking additional sources, mainstream media did not re-report the story.[42]

Consider too the ethics of Gawker's campaign in 2013 to raise enough money to buy a videotape that Gawker believed showed the mayor of Toronto, Canada, smoking crack. "We are Raising $200,000 to Buy and Publish the Rob Ford Crack Tape," a *Gawker* headline at the time read,[43]and the story promised that for a $1000 donation the donor would be invited for dinner with the *Gawker* staff. While the fundraising effort was successful, a few days later, *Gawker* reported that the tape was "gone" and, therefore, no longer for sale from that source that had demanded the money.[44] Traditional journalism ethics provisions suggest that exchanging money for information is wrong and would certainly not encourage crowdsourcing such funds.

But aside from such ethics protections, there is also the legal recognition that only “newsworthy” stories that invade privacy are protected while crass and morbidly sensational stories are not. A word like newsworthy necessitates that someone decide what news is and what it is not. The best one to make that call is a practicing journalist who has had experience weighing the private interests in privacy and the public interest in the information, lest the four-million viewers of the Hulk Hogan video determine our future.

Recall that the Restatement suggests that news is determined by looking at what is published by news organizations. If we allow all truth publishers, including mugshots.com and Girls Gone Wild, to make newsworthiness determinations, then someone with a laptop but no journalistic training could well decide that private medical information or private family information or private sexual information about anyone was newsworthy. The Hulk Hogan videotape? Absolutely newsworthy in a world where Gawker gets to decide what has news value and what does not.

Consider too those girls outed internationally in the Girls Gone Wild videotape series, or those whose images have been posted on revenge porn websites, or those private persons humiliated because hidden camera video of a private discussion was posted on YouTube. Traditional methods of defining newsworthiness – those that focus on a journalist’s discretion – would allow those people to bring privacy claims. If news is defined more broadly, in a way that accepts all publications as capable of determining news value, then privacy as a legal claim and legal deterrent will all but disappear.

Moreover, when courts extend the definition of journalist to include everyone or of news to include everything, the First Amendment is strained. After all, if everyone is a journalist, then the foundational reasons for a reporter’s shield law disappear and no one is protected; government officials with insiders’ knowledge of real wrongs will fear revealing key information to journalists. If we extend journalism to cover anyone who publishes anything online, then newsworthiness necessarily includes the crass, morbidly sensational “stories” about everyday people that are published on websites like The Dirty and Gawker, but also on websites like College Wall of Shame and 4chan.

The difficulty in delineation is a key reason why Congress has yet to pass a federal shield law. “There are some major carve-outs in the [reporter’s shield] legislation,” *The New York Times* reported in 2013 in an article that predicted that Congress was close to enacting such a law, “limitations on what constitutes an act of journalism, most of which seem aimed at next-generation news organizations that sometimes simply post classified material, rather than report more in-depth articles based on that information.”[45]

Toward a Narrower Definition for Journalist

Additional examples come from courtrooms and show courts’ struggles today with deciding who is a journalist. Not surprisingly, courts seem to be inclined toward a narrower definition.

A court in a 2013 case from Texas defined journalist more narrowly. There, a labor union for service employees had published website posts as a part of a “Justice for Janitors” campaign and the union argued that such publications made it a member of the news media. It was an important issue because Texas gives electronic or print media special jurisdictional consideration, a distinction based upon the Constitution’s press freedoms. The court, forced to define journalism, decided that such posts did not qualify. "A 'journalist,'" the court wrote, quoting Texas law, "is defined as 'a person who for a substantial portion of the person's livelihood or for substantial financial gain, writes news or information that is disseminated by a news medium."[46] It also suggested that other factors would contribute to such a determination: the authors' journalistic background, how established in journalism the reporter was, the character of the posts at issue, the editorial process involved including decisions based on the newsworthiness of stories, and the size and nature of the readership. Given the Texas law and those considerations, the court found that the union should not receive the special jurisdictional considerations that a traditional journalist would.

A New Jersey state court facing the definition issue that same year defined journalist more broadly and decided that a blogger who wrote for a website called "The County Watchers" would be protected under the state's shield law, preventing her from having to testify regarding her journalistic research in a criminal case. The court found that the blogger's posts on something the community called "Generatorgate," her exposé on "Musicfest," and her stories on pension padding and theft of county property, among others, would be considered "news" under the statute. Moreover, the court decided, the blogger's purpose was to disseminate news to the community as opposed to publishing information for a limited audience. Given those considerations, the shield law – one written to protect "a person engaged on, engaged in, connected with, or employed by news media for the purpose of gathering . . . editing or disseminating news for the general public – protected the blogger. In delineating between journalist and quasi-journalist, however, the court suggested that the definition for the former would not always be inclusive; it reiterated an earlier warning that "new media should not be confused with news media." It also suggested that the legislature might further define the term within the shield law if it found it necessary given the "changing times."

The trend seems to be going the Texas way – toward a narrower definition for journalist – even in cases far closer than that of a service union. Charles Tobin, a chair of the American Bar Association Forum on Communications Law and a media defense attorney, called the trend "disturbing" and worried that courts' or legislators' willingness to define who counts as a journalist would inevitably leave some legitimate truth-seekers outside the scope of protection.[47] These "recent decisions," Tobin wrote, "teach[] us that the First Amendment shield is perhaps less resilient for some classes of journalists than for others."

There are additional reported cases that support Tobin's assessment. In 2012, a federal trial court rejected media protection for a company website that had published a press release, finding the defendant website owners "private parties with their own websites" and not media even though the press release was picked up by 130 media outlets; the court specifically wrote that it was worried that finding otherwise would "abolish any distinction between private parties and members of the media," a distinction that was important in Florida pre-suit notice law.[48] A federal trial court in Maine made a similar determination that same year, finding that a website that advocated against a gubernatorial candidate was not entitled to a press exemption for election disclosure requirements; the website creator's First Amendment arguments failed because the court found the website much more like a negative campaign advertisement than a periodical publication.[49]

And, in particularly close case, a website known as Media Takeout, one calling itself "the most visited urban website in the world,"[50] was unable to use a newsworthiness defense because the court, in effect, found its story not journalistic enough: incorrect, too short, and not sufficiently linked with a celebrity. The website had published a story in which the plaintiff was identified incorrectly as celebrity Kimora Lee Simmons' sister.[51] The woman featured in the story, who was not related to Simmons at all, sued on privacy-related grounds, arguing that the website had used her identity to make money. Media Takeout argued in response that the story itself was not published for commercial reasons because "a news article reporting on a celebrity . . . involves 'a matter of public interest' and thus fits comfortably within the 'newsworthiness' exception." The court, however, rejected the website's attempt to categorize itself as a journalistic enterprise. "At the outset," it wrote, "Media Takeout's contention that its article 'reported on a celebrity' is greatly exaggerated," finding that the fifty-word article only included photographs of the plaintiff, a quick mention of her desire to get into modeling, and no mention of the celebrity at all other than the misinformation that the two were sisters. The court allowed the plaintiff's invasion-of-privacy lawsuit to continue to trial, finding that the falsity within the article could make it not newsworthy and, therefore, unprotected.

In other words, there is often a need to distinguish between who is a mainstream journalist and who is a quasi-journalist in a legal sense and courts, therefore, are defining that term and newsworthiness out of necessity. As suggested in greater depth in Chapter Eight, a narrow definition, one that excludes quasi-journalistic publishers as journalists, may harm some truthful expression by refusing to give them protections afforded more mainstream reporters. But a narrow description for news, one that rejects Gawker's claim that it can publish anything it decides is newsworthy, can also help protect the privacy of many.

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The Value of Online Privacy: Evidence from Smartphone Applications[1]

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Abstract

We estimate the value of online privacy with a differentiated products model of the demand for Smartphone apps. We study the apps market because it is typically necessary for the consumer to relinquish some personal information through "privacy permissions" to obtain the app and its benefits. Results show that the representative consumer is willing to make a one-time payment for each app of $2.28 to conceal their browser history, $4.05 to conceal their list of contacts, $1.19 to conceal their location, $1.75 to conceal their phone's identification number, and $3.58 to conceal the contents of their text messages. The consumer is also willing to pay $2.12 to eliminate advertising. Valuations for concealing contact lists and text messages for "more experienced" consumers are also larger than those for "less experienced" consumers. Given the typical app in the marketplace has advertising, requires the consumer to reveal their location and their phone's identification number, the benefit from consuming this app must be at least $5.06.

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1 Introduction

The concealment of personal information or "privacy" has been the subject of much recent debate. Most discussion has centered on the low-cost collection of large amounts of personally identifiable data in online markets, and the sharing of these data with third-parties such as advertisers, application developers, and government agencies. The policy responses to increased privacy concerns include: industry self-regulation, full disclosure of how personal information is used (i.e., similar to food labels), government laws to restrict the use of personal information, and the assignment of property rights so that market forces will allocate personal information efficiently. Despite several interesting theoretical and empirical contributions from economists, this discussion has largely evolved without relevant measures of consumer preferences for privacy (Hermalin and Katz, 2006; Goldfarb and Tucker, 2010). This is surprising given that estimates of consumer valuations would help policy makers better understand the trade-offs associated with the protection of personal information when evaluating these proposed initiatives.

This paper estimates the value of online privacy with a differentiated products model of the demand for Smartphone applications ("apps"). We study the apps market because it is typically necessary for the consumer to relinquish some personal information through "privacy permissions" to obtain the app and its benefits.[2] For example, when a consumer provides a weather app with information on the location of their phone, they obtain the convenience benefit of receiving weather conditions where they are currently located. Furthermore, there is potential for variation in the required permissions across apps, allowing more accurate estimation of the individual aspects of privacy such as location, online browsing history, etc.

[2] We borrow the term "privacy permission" from Google Play Store terminology. For the purposes of this study, we extend this definition to the Apple, Blackberry and Windows platforms.

This is in contrast to privacy software for computers. A second aspect of the app market is that it is extremely fast growing, coming from literally nowhere to a projected five billion downloads in the next year (Gartner, 2012). This results in a significant and growing percentage of the population sending and receiving information via Smartphones, potentially heightening online privacy concerns. Third, apps are free or relatively inexpensive, making field experiments feasible.

We first present a theoretical framework that considers a household's labor-leisure choice along with choices about their consumption of apps and their privacy. Households use apps to produce savings in time and trade off these time-savings against their privacy forgone from relinquishing permissions to the app developer. Model results show that, all other things held constant, an experienced consumer will produce time savings more efficiently than an inexperienced consumer, which increases their marginal benefit from apps. This relatively high benefit suggests that an experienced consumer may be more willing to give up personal information that is highly valuable to them. The empirical implications are that experienced consumers should download more apps than inexperienced consumers and they should have larger valuations for concealing personal information.

We examine these predictions with data obtained from choice experiments. The experiments were administered in an in-person survey to consumers at their homes or public places during summer, 2013. A total of 1,726 respondents completed surveys in Atlanta, Chicago, Denver, Philadelphia, Portland, Salt Lake City and San Diego. During the experiments, consumers were presented with a choice set containing one app currently traded in the marketplace and five "new" apps that were purported to have identical functionality to the market app, but varied in their levels of price, advertising and five privacy permissions.

Consumers were informed that the new apps would soon be available in the marketplace and that they must commit to buying one app from the six alternatives or opt out and not make a purchase. The five permissions describe the personal information a consumer must relinquish to the app developer when they download and use the app. They are: the location of the consumer while carrying their phone (*LOCATION*), the websites the consumer has browsed on their phone (*BROWSER HISTORY*), the contacts in the address book on the consumer's phone (*CONTACTS*), the unique identification number of the consumer's phone (*PHONE ID*), and the text messages the consumer has written and received on their phone (*READ TEXTS*).

Our empirical results show that price, advertising and the five privacy permissions are all important characteristics a consumer considers when purchasing a smartphone app. The representative consumer is willing to make a one-time payment of $2.28 to conceal their online browser history, $4.05 to conceal their list of contacts, $1.19 to conceal their location, $1.75 to conceal their phone's identification number, and $3.58 to conceal the contents of their text messages. The representative consumer is also willing to pay $2.12 for not having advertising interfere or distract from their use of the app. Given the typical app in the marketplace has advertising, requires location and at least one other type of personal information, the benefit from consuming this app must be at least $5.06. Our results also show that the willingness-to-pay (WTP) for concealing contact lists and text messages for "more experienced" consumers are larger than those for "less experienced" consumers. This finding is robust to a specification that holds preferences constant across respondents and suggests that we are indeed largely measuring an experience effect and not simply a stronger preference for privacy.

Other recent studies have used experiments to quantify the value of online privacy and security.[3] For example, Hann et. al. (2007) find that protection against errors, improper access, and secondary use of personal information on financial portals is worth about $30 to $45 to consumers. Egelman et. al. (2012) report that about a quarter of their 368 sample respondents were willing to pay a $1.50 premium for the smartphone app that did not require the location and record audio permissions. Grossklags and Acquisti (2007) find that students value privacy differently when asked to pay to protect rather than accept payment for personal information on quiz performance, and that the dollar value on this type of privacy is low in both cases. Our paper contributes to this literature by using a large national sample, and in-person surveys of all types of smartphone users, e.g., Android, iPhone, Windows, etc., to offer new evidence on online privacy from the apps market. Furthermore, we examine valuations for concealing several different types of personal information, and show that these valuations vary systematically with online experience.

Section 2 presents a theoretical framework of the demand for apps or, alternatively, the supply of personal information. The choice experiments and administration of the survey are described in Section 3. Section 4 outlines the empirical model and econometric method used to estimate consumer preferences for online privacy. Empirical results are presented in Section 5, and Section 6 provides concluding remarks.

2 Theoretical Background

Privacy is often defined in three contexts; the concealment of information, the right to peace and quiet, and the right for freedom and autonomy (Posner, 1980). We are interested in the

[3] This paper focuses on *privacy* or how much a consumer is willing to pay to control their personal information. We do not directly measure *security* – the malicious use of one's personal information by unauthorized third-parties (e.g., identify theft) – but recognize this is also a major concern of many consumers.

first definition and, more specifically, we want to estimate the value consumer's place on giving up their personal information online net of the benefits received. We are also interested in how consumer valuations vary with their experience. Below, we outline a theory of the optimal choice for smartphone apps. The theory explains the tradeoff between savings in time and privacy foregone and suggests that proxies for experience should be included in empirical specifications of app demand to correctly model this tradeoff.

The labor-leisure choice model is extended to include the costs and benefits from consuming apps. We assume that the representative consumer has a stock of privacy (*P*), and this stock has a value in a manner similar to the existence value of Antarctica or Tasmanian rain forests in the environmental economics literature. Under this assumption, consumers do not require that utility (or disutility) be derived from the direct or third-party use of their privacy. Rather, utility is derived from simply knowing that their stock of privacy exists and that the individual is able to conceal their personal information in order to withdraw from the public spotlight. Even if there is no direct cost from others knowing one's location or the contents of one's address book, individuals value the confidentiality of this information and will not relinquish it without compensation.

Because they typically relinquish personal information to the app developer when purchasing an app, one of the predominant indirect costs of an app to consumers is the diminishment of their privacy stock.[4] Moreover, because multiple sources of information will magnify the uniqueness of individuals, the marginal diminishment of privacy stock likely increases, in absolute terms, with the number of permissions relinquished (Montijoye et. al., 2013). Accordingly, the consumer's stock of privacy is represented by $P(a)$, where a is the

[4] The other is advertising, which we abstract away from in our theory, but include in our empirical model.

number of apps consumed, and we assume P_a and P_{aa} are negative (subscripts indicate partial derivatives). For ease of exposition, we assume a monotonic relationship between the number of apps consumed and the amount of personal information relinquished.[5] This permits the consumer's optimal choice of apps, a^*, to simultaneously represent both the demand for apps and the supply of personal information.

Smartphone apps benefit consumers by producing reductions in "essential time" defined as the non-remunerated time lost when doing fundamental living activities such as banking, driving, playing games, shopping, travelling, watching movies, etc. (Savage and Waldman, 2009). For example, a weather app produces a time-saving benefit by providing detailed information on conditions anywhere, at any time, without the need to consult traditional news media or a telephone hotline. Essential time is represented by the production function $\bar{T}(a, e)$, where e is the experience of the individual. The essential time function is convex in a reflecting diminishing marginal returns from additional consumption of apps. However, because experience also measures one's technical ability, the parameter e augments consumer production of essential time so that increasing e will raise the marginal productivity of a. As such, $\bar{T}_a$, $\bar{T}_e$, $\bar{T}_{ae}$ are negative and $\bar{T}_{aa}$ is positive.

The consumer is assumed to maximize a utility function of consumption (c), leisure (L) and privacy, subject to monetary and time constraints:

$$
\begin{aligned}
&\max_{h,\, a}\; U(c, L, P(a)) \\
s.t.\;\; &c = y + wh - pa \qquad\qquad (1) \\
&L = T - h - \bar{T}(a, e)
\end{aligned}
$$

[5] The model disregards apps that ask for multiple permissions. While more realistic, explicit consideration of the benefits and costs from these apps unnecessarily complicates the results without changing key economic insights.

where U is utility, y is non-wage income, w is the wage rate, p is the per-unit price of an app and T is total time available. Utility is concave in c, L and P so that U_c, U_L, and U_P are positive and U_{cc}, U_{LL}, and U_{PP} are negative. First-order conditions with respect to the choice variables h and a are:

$$\begin{aligned} h &: 0 = U_c w - U_L \\ a &: 0 = -U_c p - U_L \bar{T}_a - U_P P_a \end{aligned} \qquad (2)$$

The first condition in equation 2 equates the wage with the marginal rate of substitution of leisure for consumption. Substituting the first condition, $U_L/U_c = w$, into the second condition gives:

$$-w\bar{T}_a = p + (-(U_P/U_c)P_a) \qquad (3)$$

where U_P/U_c is the marginal rate of substitution of privacy for consumption. Equation 3 has a familiar interpretation; the consumer maximizes utility by choosing the number of apps such that the marginal benefit equals the marginal cost. In this case, the marginal benefit is the dollar value of the time-savings produced by the app, $-w\bar{T}_a$. The marginal cost is the price of the app, p, plus the dollar value of the privacy forgone from relinquishing permissions to the app developer, $-(U_P/U_c)P_a$.

Equation 3 provides useful information about the first-order effects of experience on the demand for apps or, alternatively, the supply of personal information $\frac{\partial a^*}{\partial e}$. Because experience also captures one's technical ability, all other things held constant, an experienced consumer will produce time savings more efficiently through $\bar{T}_{ae} < 0$ than an inexperienced consumer, which increases their marginal benefit from apps. As a result, the consumer can afford to give up more personal information at the margin, and as such, part of the total effect of an increase in experience will always be an increase in the demand for apps or the supply of personal information so that $\frac{\partial a^*}{\partial e} > 0$.[6] Moreover, because their marginal disutility of privacy forgone decreases with the number of apps consumed, the experienced consumer must give up personal information that is more valuable to them. The empirical implications are that experienced consumers should download more apps than inexperienced consumers and they should also have larger valuations for concealing personal information.[7] We test these implications below by estimating consumer demand for smartphone apps.

3. Data

3.1 Experimental Design

There are two key problems when estimating the demand for apps with market data alone. First, market data are unlikely to exhibit sufficient variation for the precise estimation of demand parameters. For example, the levels for the price and advertising characteristics are often highly, negatively correlated, while personal information on the location of the consumer while carrying their phone and their phone's unique identification number are positively correlated. Second, because consumers often make no payment for consumption, market data contain many zero cost apps, which makes identification of the marginal disutility of price problematic.

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[6] This relatively simple analysis does not consider the second-order effects contained in formal comparative static results. When second-order effects run opposite to the effect described above, and have relatively large magnitudes, it is possible that $\frac{\partial a^*}{\partial e} \leq 0$.

[7] It is possible that privacy could be convex for some consumers so that P_{aa} is positive. The empirical implications would be that experienced consumers should still have larger valuations for concealing personal information than inexperienced consumers, but will download fewer apps. Ultimately, the effect of experience on the demand for apps and the supply of personal information is an empirical question and the subject of the remainder of this paper.

We overcome these problems by using an indirect valuation method similar to that used in the environmental economics and transportation choice literature that employs market and experimental data. We use this method to measure consumers' propensity to supply personal information online by the dollar value they place on this information when it is relinquished to the app developer in exchange for the app. The willingness-to-pay for five specific types of personal information, *LOCATION*, *BROWSER HISTORY*, *CONTACTS*, *PHONE ID*, and *READ TEXTS*, and *ADVERTISING*, is estimated with data obtained from an in-person survey employing repeated discrete-choice experiments. Table 1 displays the descriptions of the privacy permissions and other characteristics presented to respondents during the survey.

The survey begins with a cognitive build up section where the interviewer asks the respondent about the type of phone they own, how frequently they use it, their familiarity and use of apps, and their knowledge of the personal information that must be relinquished to download certain apps. Cognitive build up is an important precursor to the choice experiment section. Here, respondents are carefully informed about the functionality of game, shopping, social, travel, TV/movie, and utility apps, their costs, extent of advertising, and the types of personal information requested by app developers. Respondents also indicate the types of activities they like to do with their smartphones. This information permits the interviewer to dynamically select apps in categories of potential interest to the respondent for the choice experiment that follows. The categories and description of the apps in these categories are presented in Table 2. The cognitive buildup section is followed by a series of choice questions where respondents compare similar apps and indicate their preferences.

The interviewer first opens an app currently available on their own smartphone (the "market app") and asks the respondent if they have this app. If the answer is "no", the interviewer continues. If the answer is "yes", the interviewer chooses another app category.[8] The market app is briefly demonstrated and the interviewer discusses its price, whether or not it has advertising, and the personal information that must be relinquished to the app developer if it is used. The respondent is then presented with a "show card" that displays the market app and an alternative app (the "new app") that differs in price, level of advertising, and required information. See Figure 1 for an example for the social app category. The interviewer informs the respondents that the new app will soon be available in the marketplace, and will have exactly the same functionality and potential benefits as the market app but will do so at a different price and with a different combination of advertising and privacy permissions. After comparing the benefits and costs of the market app and the new app, the respondent indicates which of the two apps she or he prefers.

Next, the respondent is informed that the developer of the new app is considering several alternative versions, labeled A and B in Figure 2. It is explained that these versions have the same functionality as the market app and the new app, but again differ by price, advertising and the required personal information. The two versions are displayed on a card and the respondent indicates her or his preference. This is repeated once more with two additional versions, labeled C and D in Figure 3. So at this point in the interview, the respondent has made three, binary choices.

The respondent is now very familiar with the app, its characteristics, and the cognitive task of comparing characteristics and indicating preferences. He or she is next presented with a show card that lists the market app and all five versions of the new app, in the same, easy to compare format where the rows in Figure 4 are the app characteristics and the columns are the

[8] Because they do not have a smartphone and do not use apps, this question is skipped for 17 percent of respondents in our sample who are not currently smartphone users.

different app versions. Again, the respondent is asked to indicate which of the (now six) alternatives she or he prefers. Say, for example, that the respondent answers that he or she likes "new app D" best. The interviewer then informs the respondent that this app will be available in the market " . . . in about a month," and asks the respondent if she or he would actually purchase, download, and use this app. The respondent answers yes or no and the choice occasion ends.

This series of choice questions is repeated, but with a different app from a different category, and with different levels of the characteristics of the app alternatives.[9] To summarize, each respondent answers three, binary choice questions and one multiple choice question, for each of two apps. We analyze the multiple choice data below.

The experimental design has several important advantages. We design a choice set that manipulates the levels of the app characteristics to obtain the optimal variation in the data needed to estimate the demand parameters precisely. The choice alternatives are believable to consumers because they could conceivably be provided by app developers in the marketplace. This is in contrast to different privacy software for computers, where all brands typically provide protection against identity theft and revelation of browser history and, as such, it is difficult to construct believable alternatives. Moreover, because cookie blockers conceal the websites a person has visited on a computer, computers are becoming increasingly less attractive to app developers and advertisers for collecting personal information. Because our design exogenously determines the levels of the characteristics of each app alternative, and randomly assigns the levels across respondents, we limit measurement and collinearity

[9] 1,444 of 1,713 sample respondents completed two choice occasions. In some cases, where the interviewer deemed it was necessary, the survey was politely cut short after occasion one.

problems.[10] By asking respondents to complete two choice occasions, we increase parameter estimation precision, and reduce sampling costs by obtaining more information on preferences for each respondent. Since the experiments are implemented by in-person survey, the interviewer can explain and demonstrate the functionality of the apps, their privacy permissions and type of advertising, and directly answer respondent's questions. This results in less noise in respondent's choices, relative to mail and online survey modes, and improves the efficiency of our estimator.[11]

A potential disadvantage of the experimental design is hypothetical bias. This arises when the behavior of the respondent is different when making choices in an experimental versus a real market. For example, if the respondent does not fully consider her budget constraint when making choices, WTP may be overestimated, because the cost parameter in the denominator of the WTP calculation (see section 4) will be biased toward zero. We minimize this source of bias with a sequence of "cheap talk" protocols intended to assure respondents that the apps are real, are traded in markets, and that they will be making (or, not making) an actual purchase (List, 2001; Aadland and Caplan, 2006). For example, the interviewer demonstrates an actual app at the beginning of each experiment, informs the respondent that they will have to purchase the market app after the experiment is over, or purchase the new app when it is available in a month, and seeks a commitment from the respondent to follow through on their purchase. The focus groups and random exit interviews in the field indicate that most survey participants were committed to purchasing the app they chose in the experiment.

[10] Moreover, by holding all other dimensions of the app alternatives constant, the choice experiment controls for potential correlation between price and quality that is not observed by the researcher.
[11] Feedback from interviewers indicated that respondents were attentive, interested, and engaged in the choice experiment, which is often not the case in a typical mail or online survey.

Data from the various marketplaces for apps were used to choose the six app categories and the market apps used in our experiments. Apps were selected that are relatively easy to explain and understand, can be easily opened and demonstrated at the front door of a house or at a public place, are potentially interesting to a wide audience, and are available on all major platforms, e.g. Google Play, iTunes, Windows Marketplace, etc. We used information from app developer's promotional materials, industry journals, two focus groups and a pilot study to develop, test and refine our descriptions of the app characteristics.[12] Measures developed by Huber and Zwerina (1996) were used to generate an efficient, linear design for the levels of the app characteristics.[13] We created the universe of all reasonable characteristic combinations (ensuring adequate variability on all characteristics) and from this chose 24 app alternatives that were grouped into four choice sets of six alternatives. The alternatives in each choice set are described by *ADVERTISING* and *COST*, and *three* of the five privacy permissions, *LOCATION*, *BROWSER HISTORY*, *CONTACTS*, *PHONE ID* or *READ TEXTS*.[14] The five permissions were distributed across all choice sets so that they were approximately equally represented in the total sample of respondents. Each of the four choice sets were assigned to interviewers so that choice occasions one and two contained a different set of permissions and different levels for all characteristics. This ensured optimal variation in the data across all sample cities.

3.2 Survey Administration and Sample Statistics

[12] The focus groups were conducted in Boulder, CO on June 13 at the Department of Economics and on June 27, 2013 at RRC Associates. They involved 13 subjects aged 21 to 65 years. Seven were male, eleven owned a smartphone, and two owned a basic cell phone. The pilot test collected data from 44 subjects at their homes and public places in Boulder from July 2 to July 6, 2013.

[13] See Kuhfeld, 2010.

[14] We want to estimate the WTP for five privacy permissions but do not want to burden the cognitive task for respondents by asking them to evaluate an app with seven characteristics. Therefore, we constrain each choice set to five characteristics; cost, advertising, and three of the five privacy permissions.

The survey was administered to consumers at their home and in public places from July 10 to August 19, 2013. Cluster sampling was used to locate survey participants. A starting location was randomly drawn from a sampling area and a cluster of a maximum of twelve participants were interviewed around this location. All participants had an equal chance of being the starting point. To improve the efficiency of data collection, interviewers visited starting locations where they would find a relatively larger population of smartphone users. We used data from Hiller et. al. (2012) to estimate a probit model of household smartphone adoption as a function of age, education, household size, income, gender and race. Probit model estimates, reported in Table 3, show that smartphone adoption is more likely when the head of the household is young, male and non-white, and has relatively higher education and income. Probit estimates and similar demographics from census block groups (CBGs), were then used to calculate the predicted probability of smartphone adoption for all CBGs in our seven sample cities. We used the predicted probabilities to determine the top ten percent of CBGs in each target city with respect to likelihood of smartphone adoption. Survey locations were randomly drawn from this list for each city and interviews were conducted around these locations. Interviewers offered a cash incentive to respondents for participating in the survey.

Prior to completing the survey, respondents were screened to ensure that they owned a smartphone or owned a basic cellular phone *and* were interested in purchasing a smartphone. A total of 1,726 respondents from Atlanta (306), Chicago (259), Denver (316), Philadelphia (279), Portland (208), Salt Lake City (77) and San Diego (281) completed valid survey questionnaires. Table 4 compares sample demographics with the US population (United States Census Bureau, 2009). Column two shows that 71.9 percent of sample respondents are white and 60.3 percent have at least a four-year college degree. Approximately 50 percent of respondents are female, 52 percent are 18 and 34 years old and 25 percent between 35 and 50 years, while 51 percent earned annual income in 2012 of $50,000 or more. Column four shows relatively large differences between our data and the population with respect to age and education. Specifically, our sample is younger and more educated. We remedy this possible source of bias in our demand results by estimating with weighted maximum likelihood (see Section 5.1).

In our data, about 83 percent of sample respondents own a smartphone and 62 percent of these own an iPhone. The proportion of smartphone users in our sample is high relative to a recent PewInternet (2013) estimate of 61 percent but is expected as we deliberately oversampled locations with a high likelihood of smartphone adoption. About 63 percent of smartphone and basic cell phone users check their phone "frequently" or "all the time." About one-third of smartphone users have been using a smartphone for three or four years, and just over 30 percent have been using a smartphone for five or more years. Almost 60 percent of smartphone users have 20 to 40 apps installed on their smartphone, and about 35 percent have 40 or more apps installed on their smartphone. The average number of apps per smartphone user is 23. About 44 percent of smartphone users indicated that they have never paid money to download an app. For those users that have paid for an app, the median price was $0.99. About 78 percent of respondents indicated that they are knowledgeable about computers and electronics, 45 percent indicated that they have a paper shredder in their home, and 61 percent indicated that they password-protect their cellular phone.

One of the implications of our theoretical framework is that experienced consumers should download more apps than inexperienced consumers. We test this implication with an ordered probit model that relates *APPS* (equals one if respondent has downloaded no apps; two if one to 20 apps; three if 20 to 40 apps; four if 40 to 60 apps; five if 60 to 80 apps; and six if more than 80 apps) to a proxy for online experience. The proxy measures the number of years the consumer has been using a smartphone: three years or fewer, four years, and five or more years. The model is estimated on the 1,431 smartphone users in our sample and shows a strong positive relationship between the number of apps downloaded and experience. The estimated coefficient on experience is 0.198 and is statistically significant at the one percent level ($t = 5.91$; $P > |t| = 0.00$).

4. Empirical Model

The consumer faces seven alternatives; one market app, five new apps, and the option not to purchase. The conditional indirect utility for consumer $n = 1, \ldots, N$ from app alternative $j = 0, \ldots 6$ on choice occasion $t = 1, 2$ is assumed to be[15]:

$$U^*_{njt} = \beta' x_{njt} + \varepsilon_{njt} \qquad (4)$$

where β is a vector of marginal utility coefficients that are common to all individuals, x_{njt} is a vector of observed app characteristics, and ε_{njt} is an unobserved random error term that is independently and identically distributed extreme value. Given these assumptions, the probability of consumer n choosing alternative j on choice occasion t is:

$$prob_{nit} = \frac{exp(\beta' x_{nit})}{\sum_j^J exp(\beta' x_{njt})}$$

The probability of each consumer's sequence of choices across choice occasions is:

$$prob_n = \prod_{t=1}^{T} prob_{ni(n,t)t}$$

where $i(n, t)$ is the alternative chosen by consumer n on choice occasion t, and the log likelihood is:

[15] Utility for the outside option is normalized to zero and has zero cost, no advertising, and no privacy permissions.

$$LL(\beta) = \sum_{n=1}^{N} \ln prob_n \qquad (5)$$

An alternative model specification recognizes that consumer's preferences may vary across individuals. The conditional indirect utility function with heterogeneous preferences is:

$$U_{njt}^{*} = \beta_n^{'} x_{njt} + \varepsilon_{njt} \qquad (6)$$

where β_n is a vector of consumer-specific marginal utility coefficients. The density of the distribution for β_n is $f(\beta_n|\theta)$ with the vector θ containing the mean and covariance parameters of β_n. The probability of consumer n choosing alternative j on choice occasion t is:

$$prob_{nit}(\beta_n) = \frac{exp(\beta_n' x_{nit})}{\sum_j^J exp(\beta_n' x_{njt})}$$

The probability of each consumer's sequence of choices across choice occasions is:

$$prob_n(\beta_n) = \prod_{t=1}^{T} prob_{ni(n,t)t}(\beta_n)$$

Given ε is distributed extreme value, and assuming an appropriate distribution for β_n, mixed logit estimation of equation 6 is possible by simulated maximum likelihood (Revelt and Train, 1998). The simulated log likelihood is:

$$SLL(\theta) = \sum_{n=1}^{N} \ln\left(\frac{1}{R}\sum_{r=1}^{R} prob_n(\beta^r)\right) \qquad (7)$$

where R is the number of replications and β^r is the rth draw from $f(\beta_n|\theta)$.

The vector ***x*** measures the benefit and costs from the app. The elements of this vector are the benefit from the app to the consumer (which includes a constant), *PRICE*, *ADVERTISING*, and the five privacy permissions, *BROWSER HISTORY*, *CONTACTS*, *LOCATION*, *PHONE ID*, and *READ TEXTS*. The privacy permissions are coded as qualitative variables that equal one when the consumer's personal information is revealed to the app developer, and zero when it is not. Similarly, *ADVERTISING* equals one when the app has advertising, and zero when it does not. Given that the privacy permissions and advertising are measured net of the consumer benefit received from the app (α_{njt} on the constant), our *a priori* expectations for the signs of the marginal utility parameters on these variables are negative. A higher priced app will also provide less consumer satisfaction so we expect the sign on *PRICE* to be negative.

Since they do not have an understandable metric, it is convenient to convert the estimated marginal utilities for changes in x_{njt} into WTP. For example, the WTP for preventing the app developer from knowing the consumer's location (WTP_L) is defined as how much more the app would have to be priced to make the consumer just indifferent between the old (cheaper but reveals the consumer's location) app and the new (more expensive but does not reveal location) app. Mean WTP for privacy with respect to location can be calculated from our estimates of utility as $WTP_L = \frac{-\beta_L}{\beta_p}$, where β_L is the mean marginal utility of *LOCATION* and β_p is the mean marginal utility of *PRICE*. This approach to estimating consumer valuations is used for the five other non-price characteristics of apps.

5. Results

Data from the conditional logit choice of the six apps are used to estimate consumer utility from smartphone apps and to calculate WTP.[16] Because most respondents face two choice occasions for two different app categories, the starting maximum sample size for econometric estimation is 3,345 observations, obtained from 1,713 respondents. In models where

[16] In 54 percent of the choice occasions, respondents agreed to buy the app, approximately evenly distributed between the market app and the new apps. The distribution of app categories across respondents was: games (18.78 percent), shopping (16.64 percent), social (8.68 percent), travel (20.27 percent), TV and movies (17.21 percent), utility (18.42 percent).

respondent demographic data are used to measure preference heterogeneity the sample size is reduced as made necessary by missing values for demographic variables.

5.1 Baseline Estimates

In the columns labeled model (i) of Table 5 we report maximum likelihood estimates of the conditional logit model, where the marginal utility parameters are assumed to be the same for all consumers. The data fit the model well as judged by the sign and statistical significance of most parameter estimates. The marginal utility parameters for *BROWSER HISTORY*, *CONTACTS*, *LOCATION*, *PHONE ID*, and *READ TEXTS*, reported in column two, are negative and significant at the one percent level. These estimates imply that, all other things held constant, the representative consumer will have higher utility when they conceal their browser history, list of contacts, location, phone identification number, and the contents of their text messages. The estimated parameters for *ADVERTISING* and *PRICE* are also negative and imply that consumer utility is higher when the app has no advertising and when the dollar amount paid for their app is lower.

WTP estimates are presented in column three. Here, we observe that the representative consumer is willing to pay \$2.28 to conceal their online browser history, \$4.05 to conceal their list of contacts, \$1.19 to conceal their location, \$1.75 to conceal their phone’s identification number, and \$3.58 to conceal the contents of their text messages. The consumer is also willing to pay \$2.12 for no advertising. Because the benefit from each app alternative within the choice occasion is held constant, the parameter α_{njt} cannot be estimated. However, it is possible to use consumer valuations for privacy and advertising to estimate the indirect cost of buying a typical smartphone app and this can be used to calculate a lower-bound estimate of the benefit of an app. Given the typical app in the marketplace has advertising, and requires the consumer to reveal their location and phone's identification number, the benefit from consuming this app must be at least $5.06 (= $2.12 + $1.20 + $1.74). See Section 5.4 for more detail on how we constructed this typical app.

For robustness, we estimate two alternative specifications of utility. Model specification (ii) permits the marginal utility of *PRICE* to vary with income by adding two interaction terms, *PRICE*×*MEDIUM INCOME* and *PRICE*×*HIGH INCOME*, to equation 4. The variable *MEDIUM INCOME* equals one when the respondent's income is greater than $25,000 and less than $50,000, and zero otherwise. The variable *HIGH INCOME* equals one when the respondent's income is greater than $50,000, and zero otherwise. In this specification, the estimated parameter on *PRICE* measures the marginal utility of price for low-income consumers (i.e., income of $25,000 or less), the estimated parameter on *PRICE*×*MEDIUM INCOME* measures the marginal utility of price for medium-income consumers, and the estimated parameter on *PRICE*×*HIGH INCOME* measures the marginal utility of price for high-income consumers. Estimates of the non-price marginal utilities, reported in column four of Table 5, are qualitatively similar to those reported for the baseline conditional logit model. The parameter for *PRICE* is negative and the corresponding parameters for *PRICE*×*MEDIUM INCOME* and *PRICE*×*HIGH INCOME* are positive, albeit imprecisely estimated. These estimates imply that consumer utility decreases when the dollar amount paid for their app increases but that the effect diminishes with increases in income, especially at the high income level.

Hiller et. al. (2012) find that consumers tastes for advertising in news media varies across individuals in the population. To examine whether there is a similar effect in app markets, we estimate equation 5 with the marginal utility of *ADVERTISING* assumed to be independently normally distributed. The mixed logit model (ii) estimates, reported in column five of Table 5, are similar to the conditional logit model estimates, although the mean parameter for *ADVERTISING* has decreased from about -0.5 to -0.75.[17] The standard deviation of the random marginal utility parameter of 0.981 is significant at the one percent level, indicating that tastes for advertising vary in the population. Using the normal distribution, the random parameter estimates indicate that, all other things held constant, about three-quarters of the population prefer having less advertising on their smartphone apps.

Table 4 showed some differences in age and education between our sample and the population. We remedy this possible source of bias in our results by estimating the baseline conditional logit model by weighted maximum likelihood, where the contribution to the likelihood is the weight times the log of the choice probability for the individual choice occasion. Since we oversample the young (i.e., 18 to 34 years) and more educated (i.e., bachelor's degree and higher), we employ post-stratification weights designed to return the sample to census proportions. The weights are constructed by dividing the census proportion for any category by the corresponding sample proportion. For example, 30.4 percent of the population is in the age 18 to 34 category according to the census, while in our sample that percentage is 52.2 percent. Therefore the weight for any observation with age 18 to 34 years is calculated as 30.4/52.2 = 0.582.

Weighted maximum likelihood estimates of the baseline model of utility are reported in Table 6. Columns two and three present utility estimates when observations are weighted by age, and columns four and five present estimates when weighted by education. In addition, columns six and seven present results using the product of the age and education weights, in

[17] The mixed logit model was estimated by simulated maximum likelihood using 500 Halton draws.

lieu of weights constructed from a full age-education cross tabulation, which was not available. Although normally problematic, these results should be meaningful in our case as the correlation between age and education is only approximately 0.02 in our data. Focusing on columns six and seven, we observe that the ranking of consumer valuations for the five privacy permissions are unchanged between the weighted and un-weighted estimates. Consumer's WTPs to conceal their lists of contacts, text messages and location are somewhat lower when calculated from the weighted estimates.

5.2 Heterogeneous preferences

Because they do not have identical preferences, it is possible that individual's valuations for online privacy varies with observable characteristics such as age, education, gender, and income. Table 7 reports conditional logit model (i) estimates for subsamples of respondents aged from 18 to 34 years, 35 to 50 years and over 50 years. Younger consumers, aged 18 to 34, appear to be less concerned about advertising on their apps, and also less concerned about their privacy. Their valuations for concealing personal information about their browser history, contacts, location, phone identification number, and text messages are about 34 to 63 percent lower than consumers over 50 years of age.

The possibility that valuations of privacy vary with education is examined in Table 8, which reports estimates for subsamples of respondents with no college education, with a four-year college education, and with a graduate-level college education. Valuations for all five privacy permissions increase with years of education. Consumers with a graduate degree have WTPs for personal information that are substantially larger than consumers with no college degree. Qualitatively similar results are obtained when examining differences in income, which is typically highly correlated with education. Table 9 shows that low- and medium-income consumers have similar valuations for online privacy. However, high-income consumers have WTPs for all five privacy permissions that are about two to three times larger than low- and middle-income consumers.

Estimates for females and males are reported in Table 10. The WTP for concealing personal information on contacts and text messages, and for no advertising, are very similar across these two groups. However, females are willing to pay $1.42 more to conceal their location ($1.99 compared to $0.57), $1.05 more to conceal their phone's unique identification number ($2.29 compared to $1.24), and $0.82 more to conceal their online browser history ($2.74 compared to $1.92).[18]

5.3 Experience

Our theoretical framework implies that consumer valuations for online privacy are a function of experience. All other things held constant, an experienced consumer can produce time savings more efficiently than an inexperienced consumer, which increases their marginal benefit from apps. This higher benefit suggests that an experienced consumer would be willing to give up personal information that is more valuable to them. The empirical implication is that the valuations for concealing personal information for experienced consumers should be larger than valuations for inexperienced consumers. We examine this relationship empirically with two proxies for online experience. The first, defined in Section 3.2, measures the number of years the consumer has been using a smartphone: three years or fewer, four years, and five or more years. The second measures intensity of smartphone activity. Specifically, we formed a composite measure of smartphone activity by combining several question responses.

[18] We also estimated utility on subsamples for each city in the sample. The results, not reported, show similar rankings of privacy valuations across all cities although Portland respondents do not value the concealment of their online browser history.

Respondents are “more experienced” if they use their smartphone in four or more ways, either for games, shopping, social media, travel, TV and movies, and utilities, have downloaded 20 or more apps, *and* check their smartphones “frequently or “all the time.” Respondents who are not more experienced are “less experienced.”

Table 11 presents estimates of the marginal utilities and WTPs for three subsamples of respondents based on the number of years they have been using a smartphone. The “three years or fewer” and “four years” groups have relatively similar valuations for all measured aspects of online privacy. Respondents with five years or more experience also have similar valuations to their less experience counterparts for concealing information on their location and their phone’s identification number. However, the experienced consumer’s valuations for concealing personal information on their browser history, contacts and text messages are substantially higher. Specifically, their valuations for concealing personal information on browser history is 48 percent higher than consumers who have owned a smartphone for three or fewer years. Valuations for concealing information in contacts and text messages are 87 and 65 percent higher, respectively. A similar finding arises when “more” and “less” experienced smartphone users are compared on the basis of their intensity of activity. Table 12 shows that valuations for concealing personal information on contacts and text messages are about 48 percent higher for more experienced consumers.

It is possible that the estimates in Table 12 are actually measuring a preference effect and not an increase in efficiency due to more experience. That is, the higher consumer valuations for concealing personal information in column three could be observed because this subsample of respondents have a relatively stronger preference for privacy. One way to control for this potentially confounding effect is to split the sample into respondents with “weak” and "strong" preferences for privacy so that preferences are held reasonably constant within each group. The model can then be estimated on each subsample to see if the relationship between valuations for online privacy and experience hold.

We explore this possibility by defining a strong preference consumer as a respondent who owns a paper shredder and who password protects her or his phone. A weak preference consumer does neither. The estimates in Table 13 show that consumers with a strong preference for privacy have valuations for personal information that are two to three times higher than consumers with weak preferences for privacy. Table 14 reports estimates for subsamples of strong preference-more experience, strong preference-less experience, weak preference-more experience, and weak preference-less experience respondents. The subsamples are not well balanced in terms of number of observations so the results should be treated somewhat cautiously. Nevertheless, similar to Table 12, the estimates continue to show that experienced consumers have much higher valuations for concealing personal information on contacts and text messages. By holding preferences for privacy constant, the evidence suggests that we are indeed largely measuring an experience effect.

5.4 Self Selection

5.5 External Verification

5.6 The Benefits of Smartphone Apps

Finally, we use our estimates of utility to make a rough calculation of the benefits of smartphone apps to the US population. For this calculation, we first construct a typical app with data from the Google Play Store. During April, 2013 we used a web crawler to download a sample of 15,107 apps which comprised about two percent of the total population of apps available on the store. About 84 percent of the apps in the sample are actual applications and

16 percent are games. The average price for an app is $1.35, ranging from $0.00 to $193.14[19] Almost 74 percent of the sample apps are free, about eight percent are less than a dollar, and about eight percent are more than $0.99 but fewer than two dollars.

Based on this information, we describe the typical app in the market as being free, with advertising, and requiring personal information on a consumer's location and their phone's identification number.[20] Our un-weighted (weighted) estimates of utility in Table 5 (Table 6) indicate that the benefit from consuming this typical app must be at least $5.06 ($4.74).[21] Given the number of apps per smartphone user in our sample is 23, we calculate a lower-bound benefit of $116.63 ($109.25) per user. Multiplying this benefit by PewInternet's (2013) estimate of the number of adults using a smartphone in the US of 146,487,987 gives an estimated aggregate lower-bound benefit of 17.08 (16.00) billion dollars.[22]

6. Conclusions

Choice experiments were used to estimate consumer preferences for the different price, advertising, and privacy characteristics of apps. The five privacy permissions described the personal information a consumer must relinquish to the app developer when they download and use the app. They are: the location of the consumer while carrying their phone, the websites the consumer has browsed on their phone, the contacts in the address book on the consumer's

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[19] This business app *ShopManager:POS,Buy-Sell-StockBoss*, which is a point-of-sale, buy-and-sell shop mobile management system, retails at $193.14.

[20] Although our sample identified about 400 individual permissions, many of these are similar, and many do not impinge on consumer's privacy. The five most commonly requested permissions by app developers are: (1) "INTERNET", (2) "WRITE EXTERNAL STORAGE", (3) "READ EXTERNAL STORAGE", (4) "READ PHONE STATE", and (5) "ACCESS LOCATION." Permission (1) determines if Internet connectivity is available and is used largely to request an advertisement. Permissions (2) and (3) permit the app to read, write and delete data stored on the consumer's phone SD card. Permissions (4) and (5) are the same as *PHONE ID* and *LOCATION* in our model of utility.

[21] The un-weighted benefit is $5.06 = $2.12 + $1.20 + $1.74. The weighted benefit is $4.74 = $2.28 + $0.81 + $1.65.

[22] For context, Rubinson Partners (2011) estimated that the app economy generated $20 billion in revenue in 2011. This includes downloads, in-app revenues, sales of virtual goods, and sales of physical goods and services.

phone, the unique identification number of the consumer's phone, and the text messages the consumer has written and received on their phone.

Results show that price, advertising and the five privacy permissions are all important characteristics a consumer considers when purchasing a smartphone app. The representative consumer is willing to make a one-time payment of $2.28 to conceal their online browser history, $4.05 to conceal their list of contacts, $1.19 to conceal their location, $1.75 to conceal their phone's identification number, and $3.58 to conceal the contents of their text messages. The consumer is willing to pay $2.12 for not having advertising interfere or distract them from their use of the app. Our results also show that experienced consumers download more apps than inexperienced consumers and that experienced consumers have WTPs for concealing contact lists and text messages that are much higher than those with less experience.

The concealment of personal information has been the subject of much recent debate and many initiatives have been proposed for alleviating privacy concerns. These include industry self-regulation, full disclosure of how personal information is used, laws that restrict the use of personal information, and the assignment of property rights so that market forces will allocate information efficiently. Our research provides more understanding of the value consumers place on the personal information they give up in app markets. We find that when they are informed about privacy permissions and how their personal information is used, consumers have a very clear understanding of their preferences for privacy. This suggests that full disclosure of how apps use personal information, similar to the labeling of food contents in grocery stores, could be mutually beneficial to consumers and app developers. Here, app developers could design a variety of apps with varying prices, levels of advertising and privacy permissions to better match the heterogeneous preferences of well-informed consumer groups.

For example, a consumer with high value of privacy could buy a relatively expensive app that places a premium on not using and/or protecting personal information.

Your focused on how much consumers value privacy. For this purpose you abstracted from the possibility that the collected information could benefit consumers. For instance, the consumer location information may enable the apps to help the consumer find restaurants, shops, or weather information; the phone identity may enable the apps to help the consumer find the phone if it gets lost; etc. If consumers are presented with such potential benefits when asked for the respective permission to disclose private information, some of them may be willing to provide the information freely. It might be interesting for future research to introduce such potential benefit/cost trade off, which I think will be relevant for policy considerations. In other words, what should be the optimal privacy policy/regulation in an environment in which consumers value privacy but consumer information may also enable the firms to provide better service/products to consumers?

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Table 1
App Characteristics as Described in the Survey

Characteristic	Survey Description
LOCATION	The *Location* permission allows the app to know where you are at all times. For example, a weather app with the *Location* permission will save you time by displaying the conditions where you are currently located.
BROWSER HISTORY	The *Browser History* permission allows the app to know all the websites you have visited on your smartphone. This permission can speed up website logins and Internet searches.
CONTACTS	The *Contacts* permission allows an app to read your address book on your phone. With this permission an app can speed dial, easily share your contact information with others, and make video calls (e.g., Skype, Facetime) from your phone.
PHONE ID	The *Phone ID* permission allows an app to find your phone if lost or stolen. However, with this information, a third party can obtain a list of all the apps on your smartphone, and when you use them.
READ TEXTS	The *Read Texts* permission allows an app to know what you have received or written in your text messages. Some apps require this permission to provide enhanced texting, such as spell check, and speech-to-text messaging.
ADVERTISING	Many apps contain *Advertisements* ("Ads"). This could be a small banner that is stationary, or moves across your cell phone screen.
COST	Many apps are free. Others have a one-time *Cost* for unlimited usage, ranging from $0.99 to about $9.99.

Table 2
App Descriptions

Category	App
Shopping	*Barcode Shopper* is useful when shopping. With your smartphone you scan the bar code of an item at the store, and do comparison shopping. Barcode Shopper requires the Contacts and Phone ID permissions.
TV & Movies	*Crackle* lets you watch thousands of free Hollywood movies and TV shows anywhere, any time. You can watch instantly, or download and watch later when you're not connected. Crackle's content is updated monthly and current titles include Pineapple Express, Big Daddy, Joe Dirt, Seinfeld, Spiderman, and Rescue Me. Crackle requires the Location and Phone ID permissions.
Games	*CSR Racing* is a free racing app that allows you to customize your dream car from Audi, BMW, Ford, and Nissan, and drag race along deserted city streets. It's you versus your rivals, and you will need all your power, skill and tactics to race in a straight line. Hit the right revs and let the turbo work. However, deploy the nitrous oxide at the wrong time, and you're doomed. This app requires the Location and Phone ID permissions.
Games	*Doodle Jump* is an arcade game where you travel up a sheet of graph paper, jumping from one platform to the next, picking up jet packs, avoiding black holes, and blasting baddies with nose balls. You can play alone and compare your score with other players' scores scribbled in the margins. This app requires the Phone ID permission.
Social	*HootSuite* allows you to view and update all your social media accounts at the same time, and to easily share photos and videos. It supports Facebook, FourSquare, LinkedIn, and Twitter and may offer services. HootSuite requires the Location and Phone ID permissions.
Utilities	*Life360* will locate your lost or stolen phone. By giving up the location permission, you can use your tablet/PC, or a friend's phone, to find your misplaced phone. The app can also locate family members at parks, concerts, sporting events, etc.
Games	*Solitaire* allows you to solve your favorite card puzzles, such as Solitaire and Free Cell, anytime, anywhere. Solitaire requires the Location and Phone ID permissions.
Travel	An app that is useful when traveling is the smartphone form of the popular website TripAdvisor.com. By giving it the location permission, *TripAdvisor* finds restaurants, hotels, and things to do wherever you go. You can read reviews, look at pictures and menus, and get directions. TripAdvisor also requires the Phone ID and Browser History permissions.

Table 3
Determinants of Smartphone Adoption

	Coefficient	s.e.	|t|
HOUSEHOLD SIZE (number of persons)	-0.0316**	0.0150	2.11
WHITE	-0.2214***	0.0445	4.98
FEMALE	-0.1064***	0.0393	2.71
AGE (number of years)	-0.0279***	0.0014	19.91
EDUCATION (number of years of schooling)	0.0416***	0.0081	5.16
HOUSEHOLD INCOME ($ per annum)	6.73e-06***	4.63e-07	14.52
CONSTANT	-0.1016*	0.1451	0.70
Likelihood	-2,698.2		
Observations	5,535		

NOTES. Sample of 5,535 households obtained from Hiller et. al. (2012). Dependent variable equals one if the household owns a Smartphone at March, 2011, and zero otherwise. 25.4 percent of sample households have a smartphone. s.e. denotes robust standard errors. ***denotes significant at the one percent level. **denotes significant at the five percent level. *denotes significant at the ten percent level. t denotes the t value.

Table 4
Sample Demographics (%)

	Sample		Census
Region		Region	
Northeast	16.2	Northeast	18.4
Midwest	15.0	Midwest	21.8
South	17.7	South	36.5
West	51.1	West	23.2
Age		Age	
18-34 years	52.2	18-34 years	30.4
		35-44 years	17.8
35-50 years	25.3		
		45-54 years	19.5
50-64 years	13.4	55-64 years	15.5
65 years or over	9.10	65 years or over	16.8
Race		Race	
Non-white	28.1	Non-white	18.9
White	71.9	White	81.1
Gender		Gender	
Female	49.7	Female	51.7
Male	50.3	Male	48.3
Education		Education	
< High school	2.57	< High school	13.8
High school	11.0	High school	30.7
Some college	26.1	Some college	28.2
Bachelor's degree or higher	60.3	Bachelor's degree or higher	27.4
Household income		Household income	
< $25,000	28.7	< $25,000	23.4
$25,000-$49,999	19.9	$25,000-$49,999	26.2
$50,000-$74,999	16.8	$50,000-$74,999	19.5
> $75,000	34.5	> $75,000	30.8

NOTES. Census data are from December, 2009. Sample data are from July and August, 2013.

SOURCE. United States Census Bureau (2009).

Table 5
Baseline Estimates of Utility

	Conditional Logit			Mixed Logit
	Model (i)		Model (ii)	Model (iii)
	MU	WTP	MU	MU
BROWSER HISTORY	-0.607***	$2.28	-0.578***	-0.566***
	(0.064)	(0.26)	(0.069)	(0.070)
CONTACTS	-1.078***	$4.05	-1.074***	-1.095***
	(0.073)	(0.32)	(0.078)	(0.080)
LOCATION	-0.317***	$1.19	-0.294***	-0.287***
	(0.056)	(0.21)	(0.060)	(0.060)
PHONE ID	-0.465***	$1.75	-0.434***	-0.434***
	(0.066)	(0.28)	(0.071)	(0.071)
READ TEXTS	-0.952***	$3.58	-0.967***	-0.988***
	(0.086)	(0.35)	(0.090)	(0.092)
ADVERTISING	-0.565***	$2.12	-0.520***	-0.753***
	(0.050)	(0.22)	(0.053)	(0.082)
ADVERTSING STD. DEV.				0.981***
				(0.129)
PRICE	-0.266***		-0.286***	-0.291***
	(0.010)		(0.020)	(0.020)
PRICE×MEDIUM INCOME			0.017	0.021
			(0.030)	(0.031)
PRICE×HIGH INCOME			0.035	0.042*
			(0.024)	(0.025)
Log likelihood	-4,884	-	-4,284	-4,272
Respondents	1,713		1,444	1,444
Observations	3,345		2,888	2,888

NOTES. MU is marginal utility. WTP is willingness to pay. STD. DEV. is the standard deviation of the random MU parameter for ADVERTISING. Standard errors in parenthesis. ***denotes significant at the one percent level. **denotes significant at the five percent level. *denotes significant at the ten percent level.

Table 6
Weighted Baseline Estimates of Utility

	Weighted by Age		Weighed by Education		Weighted by Age and Education	
	MU	WTP	MU	WTP	MU	WTP
BROWSER HISTORY	-0.597	$2.43	-0.536	$2.15	-0.529	$2.21
	(0.039)	(0.28)	(0.033)	(0.26)	(0.033)	(0.28)
CONTACTS	-1.123	$4.57	-0.939	$3.76	-0.810	$3.38
	(0.083)	(0.35)	(0.063)	(0.31)	(0.054)	(0.31)
LOCATION	-0.322	$1.31	-0.223	$0.89	-0.195	$0.81
	(0.018)	(0.24)	(0.012)	(0.22)	(0.011)	(0.23)
PHONE ID	-0.484	$1.97	-0.361	$1.45	-0.397	$1.65
	(0.032)	(0.30)	(0.023)	(0.28)	(0.026)	(0.30)
READ TEXTS	-0.979	$3.99	-0.761	$3.05	-0.720	$3.00
	(0.085)	(0.39)	(0.058)	(0.33)	(0.056)	(0.34)
ADVERTISING	-0.604	$2.46	-0.526	$2.11	-0.548	$2.28
	(0.030)	(0.25)	(0.025)	(0.22)	(0.026)	(0.24)
PRICE	-0.246		-0.250		-0.240	
	(0.003)		(0.003)		(0.003)	
Log likelihood	-4848.4		-5,221		-4,987	
Respondents	3,333		3,342		3,324	
Observations	1,715		1,716		1,699	

NOTES. Conditional logit model. MU is marginal utility. WTP is willingness to pay. Standard errors in parenthesis.

Table 7
Estimates of Utility by Age

	18 to 34		35 to 50		Over 50	
	MU	WTP	MU	WTP	MU	WTP
BROWSER HISTORY	-0.636	$2.02	-0.525	$2.34	-0.636	$3.10
	(0.090)	(0.30)	(0.123)	(0.58)	(0.142)	(0.77)
CONTACTS	-1.007	$3.19	-1.179	$5.25	-1.101	$5.37
	(0.100)	(0.35)	(0.149)	(0.81)	(0.152)	(0.92)
LOCATION	-0.324	$1.03	-0.218	$0.97	-0.441	$2.15
	(0.078)	(0.25)	(0.106)	(0.48)	(0.130)	(0.66)
PHONE ID	-0.408	$1.29	-0.458	$2.04	-0.652	$3.18
	(0.093)	(0.31)	(0.128)	(0.64)	(0.143)	(0.88)
READ TEXTS	-0.886	$2.81	-1.141	$5.08	-0.874	$4.26
	(0.114)	(0.38)	(0.174)	(0.89)	(0.195)	(1.03)
ADVERTISING	-0.463	$1.47	-0.564	$2.51	-0.817	$3.99
	(0.069)	(0.24)	(0.097)	(0.52)	(0.109)	(0.73)
PRICE	-0.316		-0.225		-0.205	
	(0.015)		(0.020)		(0.021)	
Log likelihood	-2542.7		-1275.8		-1056.4	
Respondents	897		434		395	
Observations	1,755		842		754	

NOTES. Conditional logit model. MU is marginal utility. WTP is willingness to pay. Standard errors in parenthesis.

Table 8
Estimates of Utility by Education

	Less than college		Four-year college		Advanced degree	
	MU	WTP	MU	WTP	MU	WTP
BROWSER HISTORY	-0.475	$1.85	-0.578	$2.02	-0.827	$3.36
	(0.10)	(0.42)	(0.11)	(0.40)	(0.13)	(0.59)
CONTACTS	-0.863	$3.35	-1.201	$4.21	-1.255	$5.10
	(0.11)	(0.49)	(0.13)	(0.53)	(0.15)	(0.71)
LOCATION	-0.167	$0.65	-0.344	$1.20	-0.491	$2.00
	(0.09)	(0.35)	(0.09)	(0.34)	(0.11)	(0.49)
PHONE ID	-0.374	$1.45	-0.494	$1.73	-0.554	$2.25
	(0.11)	(0.46)	(0.11)	(0.44)	(0.12)	(0.59)
READ TEXTS	-0.791	$3.08	-1.149	$4.02	-0.991	$4.03
	(0.114)	(0.53)	(0.15)	(0.60)	(0.18)	(0.78)
ADVERTISING	-0.433	$1.68	-0.562	$1.97	-0.760	$3.09
	(0.08)	(0.34)	(0.09)	(0.35)	(0.10)	(0.51)
PRICE	-0.257		-0.286		-0.246	
	(0.017)		(0.02)		(0.02)	
Log likelihood	-1846.1		-1925.7		-1313.0	
Respondents	594		615		517	
Observations	1,156		1,204		991	

NOTES. Conditional logit model. MU is marginal utility. WTP is willingness to pay. Standard errors in parenthesis.

Table 9
Estimates of Utility by Income

	Less than $25,000		$25,000 to $50,000		Greater than $50,000	
	MU	WTP	MU	WTP	MU	WTP
BROWSER HISTORY	-0.517	$1.63	-0.544	$2.01	-0.660	$2.77
	(0.13)	(0.41)	(0.14)	(0.55)	(0.10)	(0.46)
CONTACTS	-0.851	$2.68	-0.833	$3.07	-1.360	$5.71
	(0.13)	(0.45)	(0.17)	(0.68)	(0.12)	(0.61)
LOCATION	-0.188	$0.59	-0.196	$0.72	-0.422	$1.77
	(0.11)	(0.34)	(0.12)	(0.46)	(0.09)	(0.38)
PHONE ID	-0.277	$0.87	-0.492	$1.82	-0.509	$2.14
	(0.13)	(0.44)	(0.15)	(0.63)	(0.10)	(0.48)
READ TEXTS	-0.868	$2.74	-0.691	$2.55	-1.189	$4.99
	(0.15)	(0.50)	(0.18)	(0.70)	(0.15)	(0.68)
ADVERTISING	-0.332	$1.05	-0.558	$2.06	-0.633	$2.66
	(0.09)	(0.32)	(0.11)	(0.49)	(0.08)	(0.40)
PRICE	-0.317		-0.271		-0.238	
	(0.02)		(0.02)		(0.02)	
Log likelihood	-1316.2		-917.78		-2092.0	
Respondents	434		300		775	
Observations	847		592		1,512	

NOTES. Conditional logit model. MU is marginal utility. WTP is willingness to pay. Standard errors in parenthesis.

Table 10
Estimates of Utility by Gender

	Men		Women	
	MU	WTP	MU	WTP
BROWSER HISTORY	-0.52	$1.92	-0.714	$2.74
	(0.09)	(0.34)	(0.09)	(0.40)
CONTACTS	-1.012	$3.75	-1.162	$4.46
	(0.10)	(0.42)	(0.11)	(0.49)
LOCATION	-0.153	$0.57	-0.518	$1.99
	(0.08)	(0.28)	(0.08)	(0.34)
PHONE ID	-0.334	$1.24	-0.596	$2.29
	(0.09)	(0.37)	(0.10)	(0.42)
READ TEXTS	-0.948	$3.51	-0.955	$3.66
	(0.11)	(0.46)	(0.13)	(0.53)
ADVERTISING	-0.563	$2.08	-0.559	$2.15
	(0.07)	(0.30)	(0.07)	(0.33)
PRICE	-0.27		-0.26	
	(0.01)		(0.01)	
Log likelihood	-2559.9		-2298.5	
Respondents	862		855	
Observations	1,678		1,659	

NOTES. Conditional logit model. MU is marginal utility. WTP is willingness to pay. Standard errors in parenthesis.

Table 11
Estimates of Utility by Years of Smartphone Experience

	Three years or fewer		Four years		Five years or more	
	MU	WTP	MU	WTP	MU	WTP
BROWSER HISTORY	-0.685	$2.30	-0.570	$1.92	-0.773	$3.41
	(0.12)	(0.41)	(0.12)	(0.43)	(0.13)	(0.66)
CONTACTS	-0.890	$2.99	-0.963	$3.25	-1.271	$5.60
	(0.13)	(0.49)	(0.14)	(0.51)	(0.15)	(0.84)
LOCATION	-0.356	$1.19	-0.453	$1.53	-0.291	$1.28
	(0.10)	(0.35)	(0.11)	(0.37)	(0.12)	(0.52)
PHONE ID	-0.719	$2.41	-0.450	$1.51	-0.516	$2.27
	(0.13)	(0.48)	(0.13)	(0.47)	(0.13)	(0.66)
READ TEXTS	-0.893	$3.00	-0.871	$2.93	-1.124	$4.95
	(0.16)	(0.56)	(0.16)	(0.56)	(0.19)	(0.92)
ADVERTISING	-0.434	$1.46	-0.458	$1.54	-0.649	$2.86
	(0.09)	(0.34)	(0.09)	(0.36)	(0.10)	(0.56)
PRICE	-0.298		-0.297		-0.227	
	(0.02)		(0.02)		(0.02)	
Log Likelihood	-1460.5		-1362.3		-1186.3	
Respondents	519		478		433	
Observations	1,016		930		843	

NOTES. Conditional logit model. MU is marginal utility. WTP is willingness to pay. Standard errors in parenthesis.

Table 12
Estimates of Utility by More or Less Experience

	More experienced		Less experienced	
	MU	WTP	MU	WTP
BROWSER HISTORY	-0.276	$1.47	-0.363	$1.41
	(0.12)	(0.67)	(0.07)	(0.26)
CONTACTS	-0.913	$4.86	-0.847	$3.29
	(0.14)	(0.94)	(0.07)	(0.29)
LOCATION	0.093	-$0.49	-0.128	$0.50
	(0.11)	(0.56)	(0.06)	(0.22)
PHONE ID	-0.111	$0.59	-0.102	$0.40
	(0.13)	(0.73)	(0.07)	(0.28)
READ TEXTS	-0.870	$4.63	-0.531	$2.06
	(0.16)	(0.97)	(0.07)	(0.30)
ADVERTISING	-0.262	$1.39	-0.273	$1.06
	(0.09)	(0.55)	(0.05)	(0.20)
PRICE	-0.188		-0.257	
	(0.02)		(0.01)	
Log likelihood	-1,165.9		-4598.5	
Respondents	336		1390	
Observations	659		2692	

NOTES. Conditional logit model. MU is marginal utility. WTP is willingness to pay. Standard errors in parenthesis.

Table 13
Estimates of Utility by Privacy Preferences

	Weak Preference		Strong Preference	
	MU	WTP	MU	WTP
BROWSER HISTORY	-0.520	$1.68	-0.828	$4.43
	(0.13)	(0.44)	(0.13)	(0.83)
CONTACTS	-0.957	$3.09	-1.249	$6.68
	(0.15)	(0.55)	(0.15)	(1.03)
LOCATION	-0.096	$0.31	-0.658	$3.52
	(0.11)	(0.37)	(0.12)	(0.71)
PHONE ID	-0.347	$1.12	-0.767	$4.10
	(0.14)	(0.49)	(0.13)	(0.89)
READ TEXTS	-1.012	$3.27	-1.098	$5.87
	(0.18)	(0.62)	(0.19)	(1.16)
ADVERTISING	-0.648	$2.09	-0.764	$4.09
	(0.11)	(0.40)	(0.10)	(0.73)
PRICE	-0.310		-0.187	
	(0.02)		(0.02)	
Log likelihood	-569.98		-665.25	
Respondents	385		498	
Observations	748		965	

NOTES. Conditional logit model. MU is marginal utility. WTP is willingness to pay. Standard errors in parenthesis.

Table 14
Estimates of Utility by Privacy Preferences and Experience

	Strong Preference/ More experienced		Strong Preference/ Less experienced		Weak Preference/ More experienced		Weak Preference/ Less experienced	
	MU	WTP	MU	WTP	MU	WTP	MU	WTP
BROWSER HISTORY	-0.234	$1.57	-0.962	$4.85	-0.421	$1.26	-0.533	$1.74
	(0.26)	(1.81)	(0.15)	(0.94)	(0.32)	(0.95)	(0.15)	(0.50)
CONTACTS	-2.250	$15.09	-1.073	$5.40	-1.615	$4.83	-0.898	$2.92
	(0.45)	(4.65)	(0.16)	(1.00)	(0.56)	(1.93)	(0.16)	(0.58)
LOCATION	-0.046	$0.31	-0.827	$4.17	0.185	-$0.55	-0.155	$0.51
	(0.23)	(1.55)	(0.14	(0.84)	(0.26)	(0.78)	(0.13)	(0.42)
PHONE ID	-0.607	$4.07	-0.813	$4.10	-0.672	$2.01	-0.279	$0.91
	(0.27)	(2.36)	(0.14)	(0.96)	(0.36)	(1.18)	(0.16)	(0.53)
READ TEXTS	-2.538	$17.01	-0.818	$4.12	-1.248	$3.73	-0.980	$3.19
	(0.56)	(5.43)	(0.21)	(1.11)	(0.48)	(1.62)	(0.19)	(0.67)
ADVERTISING	-1.077	$7.22	-0.736	$3.71	-0.606	$1.81	-0.665	$2.17
	(0.23)	(2.42)	(0.11)	(0.76)	(0.29)	(0.97)	(0.11)	(0.44)
PRICE	-0.149		-0.199		-0.335		-0.307	
	(0.04)		(0.02)		(0.06)		(0.02)	
Log Likelihood	-278		-999.3		-176.4		-927.6	
Respondents	108		390		61		324	
Observations	208		757		122		626	

NOTES. Conditional logit model. MU is marginal utility. WTP is willingness to pay. Standard errors in parenthesis.

Figure 1
Binary Choice Question for Social App

	HootSuite	Social Me
Contacts	✓	✓
Phone ID	✓	✓
Read Texts	✓	x
Advertising	✓	✓
Cost	**$0.00**	**$1.99**

Figure 2
Binary Choice Question with New App

	Social Me A	Social Me B
Contacts	✓	x
Phone ID	✓	x
Read Texts	X	✓
Advertising	X	✓
Cost	**$2.99**	**$3.99**

Figure 3
Binary Choice Question with Alternative Versions of New App

	Social Me C	Social Me D
Contacts	X	✓
Phone ID	✓	X
Read Texts	X	X
Advertising	X	✓
Cost	**$5.99**	**$4.99**

Figure 4
Multiple Choice Question for Social App

	HootSuite	Social Me	Social Me A	Social Me B	Social Me C	Social Me D
Contacts	✓	✓	✓	x	x	✓
Phone ID	✓	✓	✓	x	✓	x
Read Texts	✓	x	x	✓	x	x
Advertising	✓	✓	x	✓	x	✓
Cost	**$0.00**	**$1.99**	**$2.99**	**$3.99**	**$5.99**	**$4.99**

A Pragmatic Framework for 21st Century Communications Law:

From Intelligent Design to Digital Darwinism

WORKING PAPER

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March 28, 2014

Introduction[1]

So far, those proposing new policy frameworks for communications law in an all-IP world follow the unfortunate pattern of decades of earlier academic treatment of regulatory policy across industries. Authors begin with an ideological bias that assumes all regulation is objectionable as an encumbrance on private property or, on the opposite side, that catastrophic market failures, such as the 2008 meltdown of the financial services sector, provide sufficient evidence to justify the re-regulation of industries back to early 20th century standards.

For the emerging broadband ecosystem, this paper rejects both approaches as elevating ideology over methodology. It offers instead a framework based on a more pragmatic view of dynamic communications markets, whose core technologies and attendant business models continue to evolve rapidly, following an emerging model of business and product innovation that has recently been termed "Big Bang Disruption."[2]

In the fast-changing broadband ecosystem, the abundance of successful and failed business and technological experiments, as well as the unintended negative consequences of antiquated legacy regulation, offer profound opportunities for the development of a new policy framework based on the principles of what John Mayo has called Results-Based Regulation (RBR).[3]

As technological disruption increases, desired policy outcomes become more difficult to design and engineer. Yet commentators continue to overstate the limits of the FCC's technical, economic and

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[1] This paper draws on new research at the Georgetown Center for Business and Public Policy and its recently-announced Evolution of Regulation and Innovation Project. The Project is aimed at developing fact-based policy recommendations to encourage the continued development of broadband networks in a world where voice, video and data have converged into a single ecosystem of infrastructure, content, and service providers using all-IP networking technology.

[2] Larry Downes and Paul Nunes, BIG BANG DISRUPTION: STRATEGY IN THE AGE OF DEVASTATING INNOVATION (Penguin Portfolio 2014).

[3] John W. Mayo, *The Evolution of Innovation: Twentieth Century Lessons and Twenty-First Century Opportunities*, 65 FEDERAL COMMUNICATIONS LAW JOURNAL 119 (2013).

business expertise. Implicitly and explicitly, they encourage the agency to continue a failing strategy that could be thought of as a form of "intelligent design": a bankrupt idea that complex and fast-changing information markets can be shaped by deliberative regulatory bodies operating under a statutory framework that has changed little from the days of early radio.

This paper evaluates the danger of such proposed policy frameworks and their failure to consider empirical evidence of market dynamism as a natural source of skepticism both about the potential for regulators to keep pace and for the strong possibility that market forces will more efficiently and quickly resolve unpredictable future failures.

This paper proposes an alternative framework, one based on overwhelming data demonstrating that industries undergoing dramatic transformation at the hands of disruptive technologies correct their own failures faster and more cost-effectively than regulators can, and with fewer undesirable side-effects. In contrast to the "intelligent design" approach, the proposed framework might be thought of as pursuing instead in a kind of "digital Darwinism"—letting the ecosystem heal itself until such time it is clear a narrowly-tailored intervention can do better.

As with its biological counterpart, digital Darwinism is a pragmatic theory based on directly-observed phenomenon, rather than an article of religious dogma in either the power of government or of capitalist systems. It is rooted not in absolute faith in market mechanisms but in the realities of hundreds of years of technological change.

To be clear, even markets experiencing constant disruption are by no means perfect regulators of anti-consumer behavior. But they can be shown to be more likely to resolve failures than ex ante outcome-determinative interventions, and do so without the high risk of imposing unintended negative consequences.

For failures that are not resolved quickly and effectively by a next and fast-approaching generation of technology disruptors, regulators including the FCC can still play a valuable role, not by trying (and often failing) to shape outcomes but rather by crafting targeted remedies to specific consumer harms, whether through adjudication of complaints or through rulemakings with limited scope and duration.

In this context, existing antitrust and anti-competitive laws provide the ultimate backstop to protect against market failure, especially when applied with what FTC Commissioner Maureen Ohlhausen has referred to as "regulatory humility."[4] Rather than directing regulation as an omniscient first mover in industry evolution, such an approach approximates the goals of modern genetic engineering, operating under strict scientific controls to minimize the potential of unforeseen consequences and environmental damage.

This paper concludes with a review of key touchstones in the history of communications policy, both those that did and did not rely on RBR approaches in both design and execution. Failures of "intelligent design" include the long-running proceeding on set top box standards, the 2010 Open Internet order, recent spectrum auctions (including the 2008 C Block auction and the 2014 H Block auction), and the dangerously ad hoc spectrum "screen" applied in the FCC's review of license transfers.

By contrast, successes in "digital Darwinism" include the balanced approach of Section 332 of the Communications Act, the incentives for competition inherent in the FCC's 1999 draft strategic plan, the vision and stretch goals offered in the 2010 National Broadband Plan and the general approach toward the Internet of both the Clinton and Bush Administrations encapsulated in the 1996

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[4] "The Internet of Things: When Things Talk Among Themselves," Remarks of Commissioner Maureen K. Ohlhausen, FTC Internet of Things Workshop, November 19, 2013, *available at* http://www.ftc.gov/sites/default/files/documents/public_statements/remarks-commissioner-maureen-k.ohlhausen-ftc-internet-things-workshop/131119iotspeech.pdf .

Communications Act, recently summarized by Clinton Senior Advisor Ira Magaziner as "first do no harm."

Time for a Change

The Communications Act, the FCC's governing statute, has not been significantly reformed since 1996, at the dawn of the consumer information revolution and the emergence of the Internet as the central networking technology across communications technologies and applications. While most commentators consequently agree on the need for a general reconsideration of core communications law, few understand the underlying engineering and business realities that have long since taken over as the de facto regulator of today's dynamic and fast-changing information industries.

Communications technologies and their associated industries are now in the midst of their most profound technological transformation in over a century of evolution. The old public-switched telephone network (PSTN) is joining other obsolete networking technologies in converting to the packet-switched network protocols of the Internet. Analog equipment is being replaced with digital; copper is being replaced or supplemented with fiber optic cable. Voice, video and data are converging onto a single standard, and moving over a single global network infrastructure.

The emerging communications ecosystem, which includes broadband networks using fiber, cable, satellite and mobile technologies, is exponentially more efficient, extendable, and powerful than the separate, aging networks it is or has replaced. It offers new services that were unimaginable just a few years ago, including real-time video chat, entertainment programming on demand, telemedicine, distance education, smart grids, and machine-to-machine communications--and promises to accelerate its offerings in the coming decade. It is generating profound economic growth and new competitive advantage for businesses that are leading the revolution.

The nature of data, voice and video communications has changed utterly, and will continue to evolve as technology industries complete their conversion to Internet standards. Wireline voice networks that were once isolated as a matter of technology, application, and law, increasingly compete not only with each other but with providers of mobile and other broadband networks, as well as cloud hosting and digital commerce services, content providers, consumer electronics device manufacturers, and operating system and other software developers.[5] Already, American consumers are enjoying the benefits of highly competitive, integrated markets for all manner of communication and information services.

While phone companies once dismissed the Internet as an inferior communications protocol for voice, carriers large and small have now embraced it. As switched network technology matured, IP has zoomed ahead, supporting exploding demands from consumers, small businesses, cloud-based services, and the coming deluge of machine-to-machine communications known as "the Internet of Things." This new ecosystem is emerging organically from the deployment of robust, global broadband IP networks, a dividend from over $1 trillion in private funding invested in IP-based technologies in the first decade of the commercial Internet.[6]

These disruptors are unique in economic history in that they emerge both better and cheaper than established products and technologies. In a matter of days or weeks, as a result, consumers can abandon the old for the new, leaving incumbent providers little time or opportunity to respond. The result is often the decimation of long-standing industry supply chains, a sudden and violent version of

[5] Larry Downes, *FCC Refuses to State the Obvious: Mobile Market is Competitive*, CNET NEWS.COM, April 3, 2013, *available at* http://news.cnet.com/8301-1035_3-57577630-94/fcc-refuses-to-state-the-obvious-mobile-market-is-competitive/.

[6] *See* Reed Hundt & Blair Levin, THE POLITICS OF ABUNDANCE: HOW TECHNOLOGY CAN FIX THE BUDGET, REVIVE THE AMERICAN DREAM, AND ESTABLISH OBAMA'S LEGACY 9 (2012).

what economist Joseph Schumpeter famously characterized as the "perennial gale of creative destruction" of modern capitalist economies.[7]

The smartphone alone has already spawned many such disruptors. Consider just a partial list of the products and services already or soon-to-be retired by mobile devices, including: address books, video cameras, pagers, wristwatches, maps, books, travel games, flashlights, home telephones, Dictaphones, cash registers, Walkmen, day timers, alarm clocks, answering machines, yellow pages, wallets, keys, phrase books, transistor radios, personal digital assistants, dashboard navigation systems, remote controls, newspapers and magazines, directory assistance, travel and insurance agents, restaurant guides and pocket calculators— just to name a few.

As these examples suggest, the communications industry itself is being affected more profoundly than any other by disruptive technologies. It perfectly fits the pattern of gradual then sudden industry transformation Paul Nunes and I refer to as "Big Bang Disruption." Based on an on-going multi-industry study of disruptive innovation conducted in collaboration with the Accenture Institute for High Performance, Big Bang Disruption argues that the nature of innovation has entered a new era of ultra-competitiveness, driven not by old-fashioned static approaches to strategic planning but by the largely uncontrollable force of technologies that continue to experience exponential improvements in price and performance.

Chief among these disruptive platforms are computer processors and related technologies including storage, memory, displays, sensors and broadband networks. Digital technologies continue to follow the radical prediction of Intel co-founder Gordon Moore, who wrote in 1965 that economies of scale in manufacturing, along with miniaturization of components, would for the foreseeable future

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[7] Joseph A. Schumpeter, CAPITALISM, SOCIALISM, AND DEMOCRACY (Harper 3d ed. 2008) (1942).

allow semiconductor manufacturers to produce chips with twice the computing capacity every twelve to eighteen months, while holding price constant.[8] (See Figure 1)

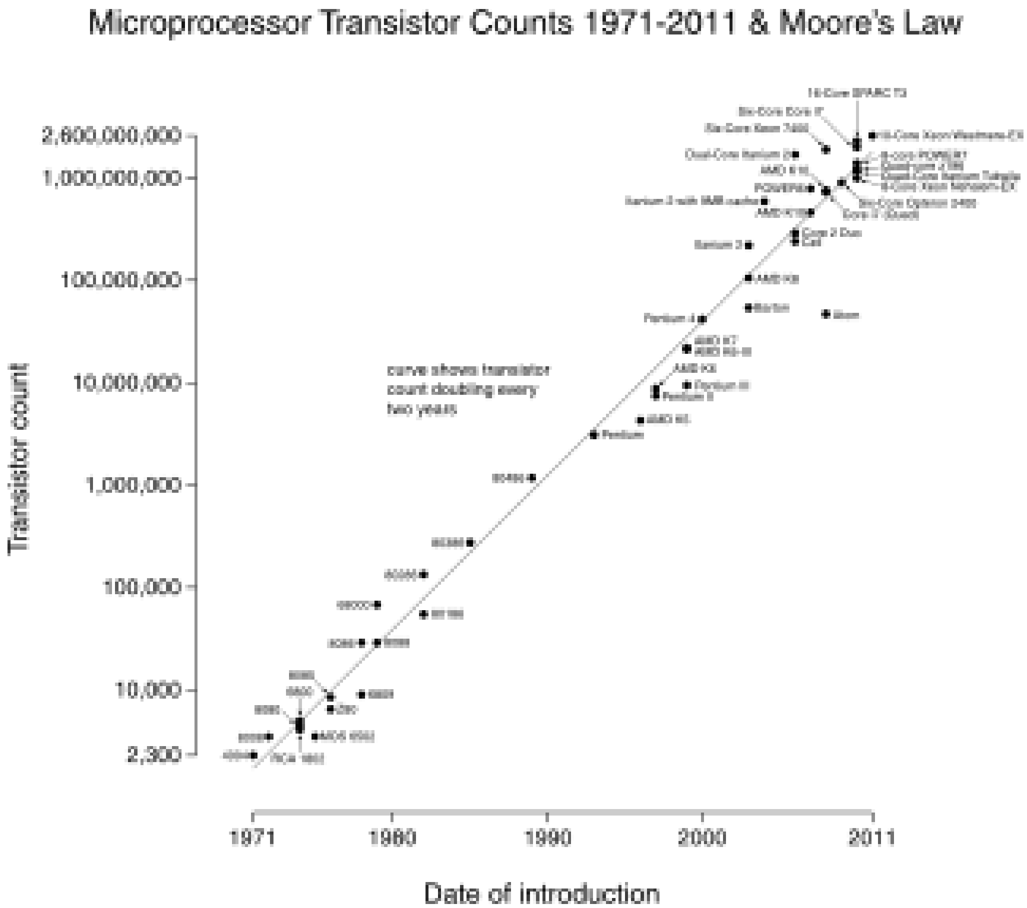

Figure 1 – Moore's Law

Fifty years of continued application of the faster-cheaper-smaller principle of Moore's Law has created the information revolution experienced by consumers around the world. Even without adjusting for inflation, computer-intensive products and services, encompassing much of the computing, consumer electronics and entertainment industries, continue to become better ***and*** cheaper in each of increasingly short new product cycles. Consumers now expect the phenomenon to continue and punish

[8] Gordon E. Moore, *Cramming More Components onto Integrated Circuits*, Electronics, pp. 114–117, April 19, 1965.

even industry leaders if they feel any hesitation to cannibalize existing products and markets. Today's market dominator can quickly become tomorrow's also-ran, or worse.

As embedded computing capacity becomes an increasingly important component of products and services far from traditional electronics markets—including automotive, manufacturing, agriculture, consumer products, energy, and health care—the digital revolution is becoming the central driver of economic performance, growth, and wealth creation for every sector of the economy, and for both developed and developing nations.

The introduction of new goods that are both better and cheaper right from the beginning is changing the nature of competition across industries. Incumbents who could once rely on scale and high switching costs to produce only incrementally improved products while comfortably maintaining profit margins now find that life-cycles have become shorter and customers defiantly disloyal. In goods including games, electronics, smartphones, the jump to better and cheaper alternatives, even from new entrants, can be sudden, crossing all traditional marketing segments from early adopter to laggard.

Beyond these traditionally hypercompetitive industries, the dramatic explosion of mobile broadband devices and networks has given software-based companies new opportunities to exploit inefficiencies in more stable industries. Innovators are now using that platform to introduce more consumer-friendly interfaces that are disrupting services including hotels, taxicabs, professional services, energy and even health care. It is no exaggeration to say that the very idea of industry is now under extreme pressure, a kind of "creative destruction" on steroids.

Nowhere is the better and cheaper transformation of industry, the driving force of Big Bang Disruption, more visible than in the industries overseen directly and indirectly by the FCC—communications, computing, entertainment and other forms of information creation, distribution and consumption. As prices for voice, video and data transmission continue to plummet at the pace predicted by Moore's Law,[9] incumbents have scrambled to reinvent their businesses from within what are often closely-regulated constraints. As content providers, device manufacturers, and operating system providers increase their competitive leverage, traditional voice, video and data carriers have diversified into new businesses and new technologies, now offering digital voice and multi-channel video services, for example, and some of the most robust mobile broadband networks in the world. (See Figure 2)

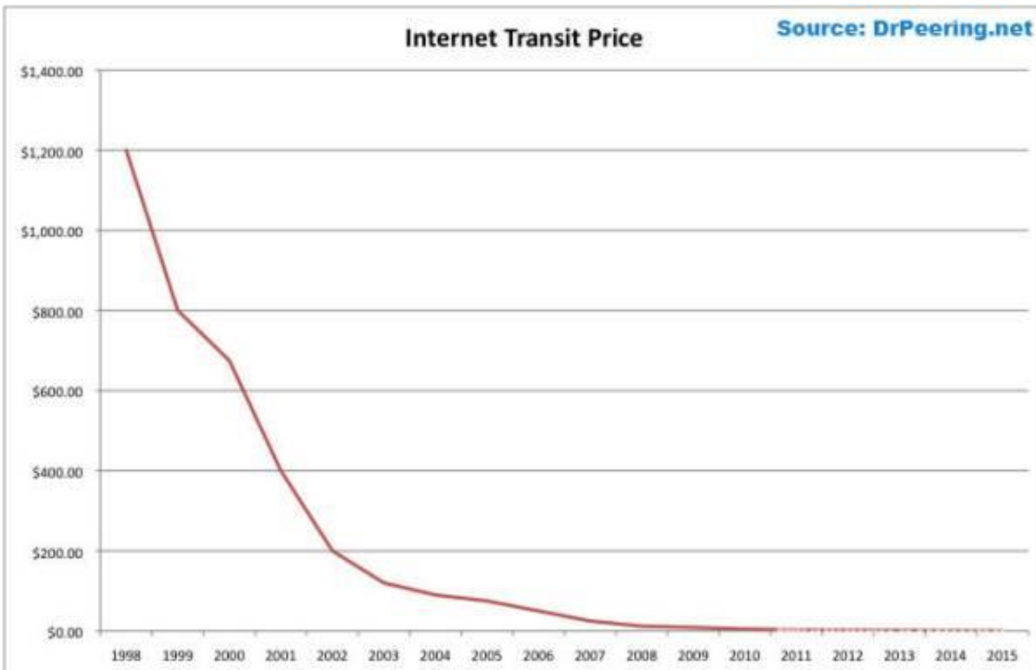

Figure 2 – Collapsing Price of Internet Transit

This accelerating pace of industry change has profound implications for the regulatory process, particularly for agencies operating at the center of Big Bang Disruption. Dynamic, technology-driven markets, for example, increasingly remedy their own harms more quickly and far more efficiently than regulators can. As change accelerates, on the other hand, the deliberative pace of regulation

[9] See FCC, *16th Mobile Competition Report,* WT Docket 11-186, Section 5.E at ¶¶ 265-275 (2013).

increasingly means that by the time laws are passed and rules are made, consumers, markets, and providers have long since moved on.

Under laws that date back nearly a century, regulatory agencies such as the FCC continue to tinker with 21st century problems using a 19th century toolkit. They are encouraged to do so by the siren song of competitors who prefer to lobby than to evolve, and by state and local regulators who fear they will play a far smaller role in the broadband future.

But it is simply impossible even for those of us in Silicon Valley and other technology hubs to anticipate how future technology improvements will evolve and the kinds of markets they will both create and destroy. Governments and their cheerleaders who believe otherwise must admit to and correct this institutional hubris. Today's laws and regulatory rules reflect a profoundly dangerous belief that, despite being disconnected from the messy realities of rapid technology change, regulations can nonetheless predict the future and head off consumer harms that haven't yet occurred.

<u>New Approaches to Communications Policy: Now Wait for Yesterday</u>

[N.B. This section will review the growing literature from two largely opposing views of how to rethink communications policy in the 21st Century. Authors begin with an ideological bias that assumes all regulation is objectionable as an encumbrance on private property or, on the opposite side, that catastrophic market failures, such as the 2008 meltdown of the financial services sector, provide sufficient evidence to justify the re-regulation of industries back to early 20th century standards.]

The latter viewpoint reflects a largely academic faith, untested by empirical evidence or market realities even in previous incarnations, in a policy version of "intelligent design": a belief that regulators, given enough jurisdictional power and judicial deference, can shape market outcomes to desired public policy goals even in industries undergoing rapid and even constant transformation. The intelligent design view relies heavily on the myth of agency expertise and ignores a long history of efforts to create competition or empower consumers that foundered not so much on a failing of the experts so much as the unpredictability of emerging ecosystems with complex interactions and a regular infusion of disruptive technologies, products, services, and entrepreneurs whose behavior and capabilities simply can't be predicted.

In today's hyper-dynamic information ecosystem, the FCC can no more use even an expanded jurisdiction to conform long-term industry structure and practices to general policy goals than the National Weather Service could use expanded authority to change the weather. And like the Weather Service, even with the best experts, the FCC's ability to predict the behavior of industry participants can't hope to extend beyond a few days, at least not with any level of confidence.

Beyond the limits of agency expertise, the FCC is hamstrung by a charter that has become hopelessly anachronistic, leaving the agency with little to ground their decisions and priorities. As a function of its very structure, the FCC still views the world of communications in stovepipes—it has a bureau for broadcast TV and radio, a bureau for wired communications, a bureau for mobile--still called "wireless," as if it were a fad.

The stovepipes were organized for communications technologies in which non-overlapping providers operated at particular frequencies to offer specific forms of communications—voice, television and radio programming, data, cellular service. Technologies, in other words, that pre-date the move to send everything digitally over the combined network assets of everyone, using the open standards of the Internet.

The more blurred the lines, the more difficult it is for the agency is to respond quickly and effectively to changing needs. And the lines have blurred beyond all recognition. The FCC's organization makes it difficult if not impossible for the agency to see what the rest of us see – networks converging at breakneck pace onto the open, global IP standard.

Given its structure, the agency treats every digital innovation as a special case requiring special rules. First there were special rules for Voice over IP, then for television over IP, and now for radio over IP. But these aren't exceptions. They represent the new normal. As Commissioner Kathleen Abernathy presciently observed in 2004, the agency needs to stop making exceptions and reorganize itself for a future version of communications technology and applications based on "everything over IP."

We've long-since arrived at that future. Digital convergence has erased distinctions between voice and data, between broadcast and telephone, between television, radio, and "other," between wired and wireless, between modes of transit whether copper, cable, satellite, radio, fiber, power line, between carriers private or public, single mode or intermodal. We use computers to watch television and make phone calls; we use phones and televisions to process data. It's a brave new world, populated by wondrous creatures.

But compare that world—the world in which consumers live—to the FCC's 2011 organization chart,[10] with separate bureaus for separate technologies and local offices to handle local requirements. The bureaus and offices reflect, in structure and law, the pre-IP world, where these differences mattered, where consumers had single-purposes devices that worked with particular content over particular communications technologies, where available content differed dramatically in different parts of the country, and where industries were separate and companies offered only one mode of communications, either of infrastructure or content.

The mismatch between the real world and the agency's organizational view of it is the real problem here. Every time a new problem (in Silicon Valley, we call it an "innovation") comes up—Voice over IP, cable Internet, mobile broadband--the Communications Act and the structure it imposes on the FCC offers the agency's staff no guidance. Political forces want the FCC to take partisan positions. Entrenched players want the agency to stop the upstarts, or force them to abide by the same

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[10] See http://www.fcc.gov/bureaus-offices.

obsolete regulations that constrain legacy providers. With little else to fall back on, the FCC is left, more and more frequently, to improvise, falling back dangerously on the undefined and chameleon-like "public interest" provision of the law as justification.

And as soon as it does, the agency becomes untethered from it engineering, economic, and expert staff, leaving nothing but the shifting winds of political and interest-group change to blow it around, like a plastic bag, from one tree to another. Thus arises the myth of intelligent design: that, absent real data and real authority, the agency nonetheless has the expertise, capacity, and the imperative to intervene at its own pace in markets that have long-since moved on to new destinations and new challenges.

As an example of the dangers of intelligent design, consider the agency's current practice with regard to spectrum license transfers associated with merger and acquisition transactions. Under the FCC's "public interest" review, the agency has backed itself into a crabbed and dismal view of the mobile marketplace, more 19^{th} century than 21^{st} century. It reviews each transaction as if mobile technologies were stagnant, demand were flat, and the only competitive pressure on licensees comes from other "national carriers." The FCC gives no consideration to the vital role played by nearly a dozen distinct forms of technology-driven market discipline (described below) that the agency dutifully catalogs and tracks in its reports.

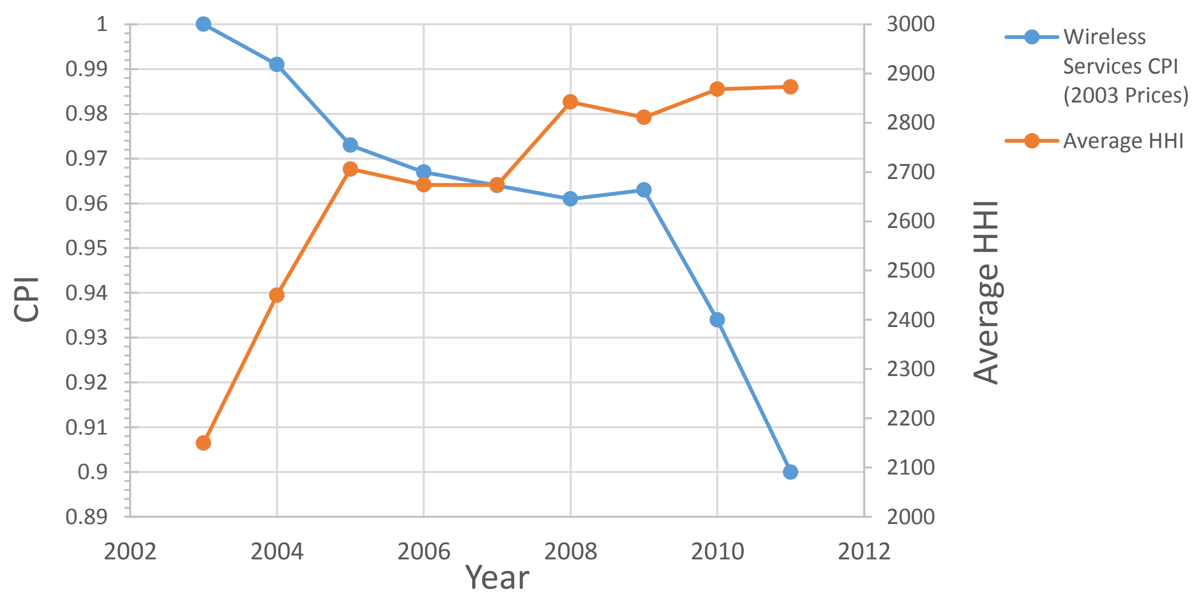
Today, the absence of basic technological or economic rigor in transaction reviews is masked by page after page of detailed data analysis that is then ignored. The FCC then obscures this failure with the misapplication of obsolete and inapplicable pseudo-measures of market concentration, notably the Herfindahl-Hirschman Index (HHI) and the so-called "spectrum screen."

The HHI, a 1940's era calculation that estimates the level of concentration in a given industry, mechanistically sums the squares of market share for each direct competitor in whatever the agency decides is a relevant local market. The FCC then assumes without evidence that arbitrary numerical ranges predict "concentrated" or "highly concentrated" conditions that would result from a merger.

The agency next takes a dangerous leap of faith, assuming that such concentration is likely to lead to anti-competitive behavior the market would not correct on its own, and that such behavior would result in higher prices and other consumer harms.

Yet measured simply by HHIs, the overall mobile industry has been "highly concentrated" since 2005, at levels the FCC has recently said, without any evidence, trigger a "presumption" of "harm to competition."

Figure 1: Industry Concentration is Rising While Cellular Prices are Falling



Source: HHI from 16th Wireless Report Table 14; Wireless CPI from 16th Wireless Report Table 37.
Notes: Population-weighted average HHI of 172 Economic Areas as computed by the Commission. Cellular CPI is denominated in 2003 prices.

As every consumer knows, the untortured data tell a very different story. Despite those levels of concentration, prices for voice, text, and data have continued to plummet.[11]

The HHI calculation, in any event, is of no value. As the FCC explains in all of its reports, competition in the mobile ecosystem is much more complex and sophisticated than simplistic market concentration might infer, affected in critical ways by a wide range of factors beyond the customer base or spectrum holdings of direct competitors. According to the FCC's most recent Mobile Competition reports,[12] for example, these include:

1. **Regional and local competitors** – Despite the FCC's focus on national market share, most consumers choose their carrier based on local alternatives; they don't buy based on the strength of nationwide coverage. At the local level, 90% of U.S. consumers can choose from five or more carriers for voice; 80% have three or more choices for mobile broadband.

2. **Device manufacturers** – The availability of particular tablets and smartphones on a network plays a significant role in which carrier a consumer chooses. From 2008-2009, for example, 38 percent of those who switched carriers did so because it was the only way to obtain the particular handset that they wanted. If anyone has market power, it is the device manufacturers—and that power rises and falls with each new model and the changing market share of different operating systems and app stores.

3. **Operating system developers** – Consumer decision-making is also highly influenced by the availability of a particular operating system (iOS, Android). Android captured 20% of the mobile O/S market in the first six months, giving Google considerable leverage in the market overall.

4. **Apps** – Consumers also make choices based on the availability of preferred apps, including music, video, geolocation, and social networking services. The most popular activity by far for today's smartphone users is games, some of which are only available on some devices or operating systems.

5. **Enhanced spectrum** – Technology has continued to make more bands of spectrum usable for more types of communications. Clearwire now offers mobile broadband using spectrum in the >1 GHz range; Dish Networks has proposed the use of satellite spectrum to offer 4G service.

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[11] *See also* Gerald R. Faulhaber, Robert W. Hahn & Hal J. Singer, *Assessing Competition in U.S. Wireless Markets: Review of the FCC's Competition Reports* (July 11, 2011), *available at* http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1880964.

[12] *See* 16th Annual Mobile Competition Report, *supra* note 7. *See also* Annual Report and Analysis of Competitive Market Conditions with Respect to Mobile Wireless, Including Commercial Mobile Services, Fifteenth Report (June 27, 2012), http://hraunfoss.fcc.gov/edocs_public/attachmatch/FCC-11-103A1.pdf.

And the LTE protocol is dramatically more efficient in its use of spectrum than earlier generations.

6. **Available spectrum and cell tower infrastructure** – Carriers continue to invest billions every year in enhanced infrastructure. But the quality of service network operators can provide is still highly constrained by the lack of available spectrum. At the local level, delays and even corruption in approving applications to add towers or antennas makes it difficult for network operators to make the best use of the limited spectrum they have. At the end of 2009, over 3,000 applications to add or modify cell towers and antennae had been pending for over a year; many for over three years.

7. **Off-the-charts demand for capacity** – Carriers are also pressured by incredible increases in demand for mobile broadband. Since the introduction of the iPhone in 2007, AT&T reported an increase of over 8,000% in data traffic.

8. **No-contract carriers** – As capacity constraints push contract carriers to curtail unlimited data plans, competition from no-contract or "pre-paid" providers has intensified. The distinction between pre- and post-paid networks is increasingly meaningless, yet the FCC gives little to no weight to the discipline such providers exert in reviewing transactions.

9. **Inter-modal competition with wired networks** – By 2010, 25% of all U.S. households relied exclusively on mobile connections for home voice service ("cutting the cord."). As high-speed, high-capacity LTE networks (and whatever comes after LTE) are deployed, mobile carriers will increasingly compete with wired carriers for the same customers, including traditional phone and cable companies. The pool of competitors is expanding, not contracting.

Thanks to these varied forms of market discipline, even a mobile ecosystem that is "highly concentrated," at least as measured by HHIs, doesn't seem to have harmed consumers. To the contrary. As every measure of market performance collected by the FCC makes clear, the broadband ecosystem is providing consumers with a phenomenal range of new products and services, at the most competitive prices of any industry.

That's because there are plenty of other sources of competition in the market beyond direct competitors, sources well documented by the FCC itself. Put more simply, concentration measured by HHI concentration has become a worthless tool in evaluating mobile competition.

Backing up the HHI analysis is the voodoo of the spectrum screen, a remarkably elastic and utterly unscientific tool that purports to test the competitive impact in local markets of proposed license transfers.

The spectrum screen was introduced to simplify the review of license transfers,[13] but in recent reviews it has morphed into a presumption of harm in markets where the screen is exceeded.

In either case, the spectrum screen is a poor proxy for several reasons. It includes only some frequencies licensed for mobile services and leaves out others more or less randomly, often modifying that list in different markets — as if radio technology worked differently in California than it does in Virginia.

Worse, the screen treats all the included frequencies as if each band, whether above or below 1 GHz, whether complementary or not to the parties' existing holdings or those of its competitors, were of identical value to each network operator. The FCC's own data collection amply reveals the technical and economic fallacy of such a gross simplification.

The screen is also modified from transaction to transaction on an *ad hoc* basis, based on no established or even articulated criteria, leaving the strong impression that the adjustments are made simply to get the numbers to come out the way a majority of the Commissioners wants them to come out, for reasons that can only be guessed. Even the appearance of post hoc rationalization undermines the integrity of the FCC's transaction reviews.

The spectrum screen's failings as an analytic tool are legion. Since its invention, it has never been the subject of any formalization subject to notice-and-comment; the screen simply lumbers, like Frankenstein's monster, from one transaction review to the next. To its credit, the FCC recently issued a Notice of Proposed Rulemaking aimed at making some sense of it, or perhaps to put it to a much-

[13] Applications of AT&T Wireless Services, Inc. and Cingular Wireless Corporation For Consent to Transfer Control of Licenses and Authorizations, WT Docket No. 04-70, Memorandum Opinion and Order, 19 FCC Rcd 21522, 21552 ¶¶ 58, 106-112 (2004), http://hraunfoss.fcc.gov/edocs_public/attachmatch/FCC-04-255A1.pdf.

needed demise.[14] But the Commission's true intentions are unclear. As Commissioner Pai pointed out, the NPRM did not, in fact, propose any rules.[15]

There is, in fact, no sense to be made of the screen, beyond its stated purpose to quickly eliminate those local markets that clearly require no competitive review. All that can be said in support of the screen as a measure of harm, on the other hand, is that it is marginally less arbitrary and open to manipulation than the previous *per se* spectrum cap, which, incredibly, the Commission is now considering reinstating.

Digital Darwinism

[N.B. This section details an alternative framework for communications policy, which rejects the religious dogma of regulatory and deregulatory absolutists—both forms of "intelligent design." The alternative framework, based on fact-based observation of fast-changing ecosystems, constitutes what might be thought of as "digital Darwinism:" a theory based on the actual behavior of current and historic markets undergoing profound and accelerating disruption and transformation driven by exponential improvements in core technologies.]

Digital Darwinism is built on the principles of Results-Based Regulation (RBR). RBR methods employ detailed empirical analysis of counterfactual alternative governance mechanisms as guideposts for regulatory and deregulatory policymaking. Such methods have arguably provided the most successful vehicle to date for determining when policy should move more toward regulatory, or more toward deregulatory market governance mechanisms.

[14] *In the Matter of Policies Regarding Mobile Spectrum Holdings*, WT Docket No. 12-269, Notice of Proposed Rulemaking (Sept. 28, 2012), http://www.fcc.gov/document/mobile-spectrum-holdings-nprm.
[15] Concurring Statement of Commissioner Ajit Pai, *In re Policies Regarding Mobile Spectrum Holdings*, WT Docket No. 12-269, at 49 (Sept. 28, 2012) ("[T]oday's Notice of Proposed Rulemaking contains no notice of proposed rules."), http://hraunfoss.fcc.gov/edocs_public/attachmatch/FCC-12-119A1.pdf#page=49.

A core element of such a regulatory approach asks whether proposed, or extant, regulations affirmatively can be shown to benefit economic welfare relative to the alternative of resource allocation that relies more heavily on market-based transactions.

This paper proposes an alternative framework based on overwhelming data demonstrating that industries undergoing dramatic transformation at the hands of disruptive technologies are much more likely to correct their own failures faster and more cost-effectively than regulators can. As with its biological counterpart, digital Darwinism is a pragmatic theory based on directly-observed phenomenon, rather than an article of religious dogma in either the power of government or of capitalist systems.

To be clear, even markets experiencing on-going disruptions are by no means perfect regulators of anti-consumer behavior. But they can be shown to be more likely to resolve failures than outcome-determinative interventions, and do so without the high risk of imposing unintended negative consequences.

For failures that are not resolved quickly and effectively by a next and fast-approaching generation of technology disruptors, regulators including the FCC can still play a valuable role, but not in designing outcomes. Rather, the regulatory role of expert agencies undergoing high-speed evolution should be the development targeted remedies to specific consumer harms, whether through adjudication of complaints or through rulemakings with limited scope and duration. Think of these as genetic engineering—carefully planned and limited interventions to address specific failings of the functioning ecosystem.

Beyond regulation, the primary job of agencies practicing digital Darwinism is to encourage and even inspire future innovation in the public interest. That goal is supported by continually reviewing and eliminating legacy regulatory obstacles that skew the natural trajectory of technological change and by liberal use of the agency's bully pulpit and expert-driven credibility to develop and promote stretch goals that challenge industry participants.

A good example of that kind of complementary activity is the FCC's 2010 National Broadband Plan, discussed below. Though the agency thus far has largely failed to actively promote the powerful visions of a connected future detailed in the last several chapters of the Plan, the document itself laid the foundation for what could still be a major public education campaign by the FCC to get both consumers and industry participants focused on those goals the agency has made a strong case for prioritizing.

In this context, existing antitrust and anti-competitive laws provide the ultimate backstop to protect against market failure, especially when applied with what FTC Commissioner Maureen Ohlhausen has referred to as "regulatory humility."[16] Rather than operating as the first mover in industry evolution, such an approach approximates the goals of modern genetic engineering, operating under strict scientific controls to minimize the potential of unforeseen consequences and environmental damage.

In rejecting the intelligent design approach to communications policy, digital Darwinism explicitly disfavors any regulatory proceeding that proceeds on the assumption that regulators can both predict and change the future of industry structure and competitive outcomes. It rejects as both dangerous and overconfident rulemakings that purport to head-off consumer harms that have not yet occurred--that is, regulations that are, to use the FCC's term, "prophylactic" in nature.[17]

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[16] "The Internet of Things: When Things Talk Among Themselves," Remarks of Commissioner Maureen K. Ohlhausen, FTC Internet of Things Workshop, November 19, 2013, *available at* http://www.ftc.gov/sites/default/files/documents/public_statements/remarks-commissioner-maureen-k.ohlhausen-ftc-internet-things-workshop/131119iotspeech.pdf .

[17] Larry Downes, *Unscrambling the FCC's Net Neutrality Order: Preserving the Open Internet, but Which One?,* 20 Comm Law Conspectus 83 (2011), available at http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2164985. The phrase "prophylactic" appeared nearly a dozen times in the Open Internet order, an acknowledgment that despite

It also cautions strongly against agency action of any kind that is based on hyperbolic but theoretical worst-case scenarios, fact-free hypotheticals, and transient albeit serious interruptions in the smooth performance of the ecosystem--what Adam Thierer refers to as "techno-panics."[18]

In a related constraint, it urges regulators to be particularly cautious of entreaties to act on behalf of protected consumer interests when those interests are being vigorously urged by industry competitors who will themselves benefit directly from agency action, or what former FCC Commissioner Robert McDowell has called the "please regulate my rival" approach.[19]

Finally, it encourages the agency to act whenever possible in a bi-partisan manner, focusing on fact-based determinations and true expertise rather than political expediency—often the source of the most ill-fated actions.

When and how should the FCC act under a framework of digital Darwinism? The short answer is only when it is clear that intervention is necessary to resolve market failures that have not been and are not likely to be corrected by the next generation of Big Bang Disruptors, and where the agency can fashion remedies that do not do more harm than good.

A digital Darwinism framework based on the principles of RBR would require the FCC to identify actual consumer harms before regulating to correct them; to conduct realistic economic analysis; to subject proposed remedies to neutral cost-benefit analysis; to consider more effective alternatives; and to evaluate the performance of rules after they have been put into effect and retire them at the earliest possible moment.

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a vast data collection effort, the agency could find almost no examples of non-neutral behavior in over a decade of commercial ISP services, despite the absence of enforceable FCC rules that prohibited it.

[18] Adam Thierer, *Technopanics, Threat Inflation, and the Danger of an Information Technology Precautionary Principle,* 14 Minnesota Journal of Law, Science and Technology 309 (2013).

[19] See http://www.fcc.gov/document/commr-mcdowells-speech-possible-itu-regulation-internet.

While that approach does not preclude rulemakings, it is strongly biased in favor of adjudications based on general principles of antitrust and anti-competitive law already established by a long history of agency and judicial review.

Specifically, agency action should be limited to situations where each of the following conditions has been satisfied:

1. Market failures have continued long enough to generate a record of demonstrable consumer harm.

2. It is objectively unlikely that an upcoming change in core technology will resolve the harm in a relatively short (less than two years) period of time.

3. The FCC reasonably believes it can fashion a limited remedy to address the consumer harm with limited side-effects elsewhere in the industry or to other ecosystem participants, positive or negative.

4. The costs of developing, implementing, and policing the remedy can be reasonably shown not to exceed simply accepting the continuing harm, until such time as a more acceptable remedy can be developed or technology change ultimately resolves the failure.

5. In developing, implementing, and policing the remedy, the FCC's expertise makes it the least-cost and most effective of possible institutions (including the Federal Trade Commission, the Department of Justice, or public or private litigation based on existing antitrust or anti-competitive law) with authority to intercede.

The foundations for a more productive role for the FCC—a role consistent with the agency's long-stated statutory purposes--are already in place. In preparation for the many reports the agency is required to produce, agency staff have become adept at collecting and reporting vast troves of useful information regarding market conditions, consumer behavior, and competition.

These reports describe an increasingly complex communications ecosystem in which all manner of content is now being delivered on converged IP networks, and in which market discipline comes not just from direct competitors but from every participant in the ecosystem—including device makers, software developers, service providers, and consumers themselves. In some sense, the agency simply needs to integrate that knowledge into its regulatory activities.

The minimal level of analytic rigor required by RBR has long been mandatory for Executive agencies. As if such confirmation were necessary, in 2011, President Obama made clear that he expected (though could not require) the same basic tools be applied as a matter of course by independent regulatory agencies including the FCC.[20]

But an RBR-based framework for the dynamic communications industry would go farther in the direction of common sense. For rules and amendments that may have a significant economic impact, the RBR approach requires the agency to identify specific market failures, actual consumer harm, the burden of existing regulation and a reasoned determination that the benefits of the adopted rule or amendment justify its costs, taking into account alternative forms of regulation. In deference to the realities of markets involving digital technology, it also sensibly requires that the agency consider the possibility that market forces or changes in technology are unlikely to resolve within a reasonable amount of time the specific market failure or actual consumer harm.

In effect, an RBR-based framework replaces the free-ranging and often-opaque intelligent design approach of today's FCC with the reasonable and uncontroversial genetic engineering tool of cost-benefit analysis. Ensuring that the costs of regulation do not exceed their benefits, and requiring the agency to consider alternative rules that could address the same harms more efficiently, has been a goal of "good government" reform for decades. It is an entirely bi-partisan goal.

[20] Exec. Order No. 13579, 76 Fed. Reg. 70913 (July 11, 2011), *available at* http://www.whitehouse.gov/the-press-office/2011/07/11/executive-order-regulation-and-independent-regulatory-agencies.

Indeed, it is a goal shared by the current Administration. In another 2011 Executive Order, President Obama imposed precisely the same rigor on executive agencies.[21] The Executive Order requires executive agencies to

> (1) propose or adopt a regulation only upon a reasoned determination that its benefits justify its costs (recognizing that some benefits and costs are difficult to quantify); (2) tailor its regulations to impose the least burden on society, consistent with obtaining regulatory objectives, taking into account, among other things, and to the extent practicable, the costs of cumulative regulations; (3) select, in choosing among alternative regulatory approaches, those approaches that maximize net benefits (including potential economic, environmental, public health and safety, and other advantages; distributive impacts; and equity); (4) to the extent feasible, specify performance objectives, rather than specifying the behavior or manner of compliance that regulated entities must adopt; and (5) identify and assess available alternatives to direct regulation, including providing economic incentives to encourage the desired behavior, such as user fees or marketable permits, or providing information upon which choices can be made by the public.[22]

The Executive Order, likewise, requires departments and executive agencies to operate with the same level of transparency mandated by an RBR approach. Specifically, the order called for agencies

> to provide the public with an opportunity to participate in the regulatory process. To the extent feasible and permitted by law, each agency shall afford the public a meaningful opportunity to comment through the Internet on any proposed regulation, with a comment period that should generally be at least 60 days. To the extent feasible and permitted by law, each agency shall also provide, for both proposed and final rules, timely online access to the rulemaking docket on regulations.gov, including relevant scientific and technical findings, in an open format that can be easily searched and downloaded. For proposed rules, such access shall include, to the extent feasible and permitted by law, an opportunity for public comment on all pertinent parts of the rulemaking docket, including relevant scientific and technical findings.[23]

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[21] Exec. Order No. 13563, 76 Fed. Reg. 3821 (Jan. 18, 2011), *available at* http://www.whitehouse.gov/the-press-office/2011/01/18/improving-regulation-and-regulatory-review-executive-order.
[22] *Id.*
[23] *Id.*

There is no relevant reason these common-sense requirements should not apply to independent regulatory agencies such as the FCC, which the President made clear in a subsequent Executive Order extending earlier Orders to independent regulatory agencies, "to the extent permitted by law"[24]

Indeed, given the increasingly significant economic impact of FCC decisions affecting the broadband ecosystem, the RBR-based approach is urgently needed to meet what the President defined as the goal of cost-benefit analysis: not to neuter regulatory agencies or deny them flexibility but to "protect public health, welfare, safety, and our environment while promoting economic growth, innovation, competitiveness, and job creation."[25]

The shift to digital Darwinism need not be traumatic. The FCC's expert staff stands ready, willing and able to help the Commission make reasoned, timely decisions based on simple, economically sound principles that are grounded in real data. The agency already has the capacity to operate transparently, involving the public and explaining itself coherently to consumers. But it must be weaned from the inconsistent and dangerous practice of confounding markets with overbroad and misdirected rulemakings, amendments, orders and auction and transaction conditions.

The FCC, as noted, already collects precisely the kind of data it needs to perform meaningful analysis, yet time after time the agency steps back from the brink just before reaching a reasoned decision. Replacing the unstructured processes that have developed in recent decades with the kind of rigorous tools called for in the President's Executive Order would take the FCC far along the road toward the 21st Century, where we urgently need it to be.

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[24] *See* Exec. Order No. 13,579, *supra* note XX.

[25] *See* Exec. Order No. 13,563, *supra* note XX. Congress has already mandated such analysis for regulations that affect small businesses, a requirement largely irrelevant to FCC actions. *See* Curtis W. Copeland, *Economic Analysis and Independent Regulatory Agencies* (April 30, 2013), *available at* http://www.acus.gov/sites/default/files/documents/Copeland%20Final%20BCA%20Report%204-30-13.pdf.

[N.B. This section would apply the RBR framework to several recent and historical examples of FCC action, highlighting both the limits of intelligent design on the one hand and the benefits of digital Darwinism on the other.

Examples of failed "intelligent design" initiatives include:

- The on-going set top box inquiry, hopelessly outrun by unanticipated developments in consumer electronics markets
- The open internet order, highlighting the danger of "prophylactic" rulemaking
- Spectrum auctions for the 700 MHz. C block and the recent H block, highlighting how agency efforts to shape competition in the dynamic mobile ecosystem can easily backfire, generating unintended negative side-effects
- The ad hoc spectrum screen, whose transaction-by-transaction modification increasingly exposes the FCC to credible charges of being outcome-determinative

Examples of successful "digital Darwinism" initiatives include:

- The bi-partisan approach to light-touch regulation of the broadband ecosystem expressed in the 1996 Communications Act, and in a string of supporting policy decisions made by both the Clinton and Bush I administrations.
- The pragmatic, balanced approach to mobile markets embodied in Section 332 of the Communications Act
- The 1999 draft strategic plan prepared under the direction of FCC Chairman William Kennard, which accurately predicted that "In five years....The advent of Internet-based and other new technology-driven communications services will continue to erode the traditional regulatory distinctions between different sectors of the communications industry. ***As a result, over the next five years, the FCC must wisely manage the transition from an industry regulator to a market facilitator."***[26]
- The 2010 National Broadband Plan, which painted a vivid vision of a fully-connected broadband future and established aggressive targets for speed, adoption, spectrum availability and the retirement of the PSTN network, but did not seek to mandate how these goals should be achieved.

Conclusion

From these core principles, future research will develop specific RBR-based recommendations for regulation of broadband networks in the all-IP world, with close attention paid to crucial topics that include:

1. Spectrum auction design and license transfer

[26] FCC, *Strategic Plan: A New FCC for the 21st Century* (draft), 1999, available at http://transition.fcc.gov/21st_century/draft_strategic_plan.pdf.

2. Interconnection and peering
3. Network management and engineering
4. M&A transaction review and the application of “public interest” standards
5. Price regulation and network asset
6. Promoting universal broadband adoption through market and non-market mechanisms

Measuring Consumer Preferences for Video Content Provision via Cord-Cutting Behavior

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Abstract

The television industry is undergoing a generational shift in structure; however, many demand-side determinants are still not well understood. We model how consumers choose video content provision among: over-the-air (OTA), paid subscription to cable or satellite, and online streaming (also known as over-the-top, or OTT). We apply our model to a U.S. dataset encompassing both the digital switchover for OTA and the emergence of OTT, along with a recession, and use it to analyze cord-cutting behavior (i.e., dropping of cable/satellite subscriptions). We find high levels of cord cutting during this time, and evidence that it became relatively more prevalent among low-income and younger households – suggesting this group responded to changes in OTA and streaming options. We find little evidence of households weighing relative content offerings/quality when choosing their means of video provision during the timespan of our data. This last finding has important ramifications for strategic interaction between content providers.

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1. Introduction

Television is the single biggest use of leisure time (Wallsten, 2013), and all participants widely acknowledge that it is undergoing a generational shift in structure as video content provision is converging. The demand-side determinants are not well understood, but the recent U.S. boon in digital television offers an opportunity to cast light on those determinants. Specifically, over the years 2008 and 2009, the telecommunications landscape experienced two major changes: 1) the digital switchover for over-the-air (OTA) television and 2) a mass increase in network content available for online streaming (primarily in the form of Hulu and Netflix), often labeled as over-the-top (OTT). At the same time, the United States experienced the brunt of a very large recession. During this period, we also observe a significant reduction of pay television subscriptions. Any or all of the aforementioned changes could have generated the observed change in pay television subscriptions. Further, the way in which households responded to these changes has important implications concerning consumer preferences and the competitive landscape that may emerge.

In this paper, we measure key determinants of consumers' choices across these video provision options by analyzing cord cutting behavior (i.e, the dropping of subscription cable/satellite television services). In doing so, we determine: which subgroups of consumers are most likely to cord cut, whether there is a convergence to the general population among the group that cord cuts, and the extent to which relative content offerings/quality impacts households' choices over content provision. To accomplish this last task, we employ a well-known choice model, allowing households to choose between OTA via digital antenna, paid subscription to cable or satellite, and OTT. To our knowledge, this is the first paper to attempt to measure consumer preferences across video provision methods that include online streaming.

Understanding how consumers choose across these options can provide key insights into the evolution of the telecommunications landscape. In particular, we can track whether demographic indicators of cord cutting behavior are converging or diverging, and thus determine whether or not cord cutting is heading toward the main stream. Further, knowing the role that content offerings play in consumers' choice of content provision sheds light on how competition across provision methods is evolving. More concretely, if relative content is weighed heavily, then expansion of content availability on OTT could be a key driver of future cord cutting; if not, then other changes to OTA and OTT are likely important toward these options becoming more viable substitutes for a paid subscription to cable or satellite.

To perform our analyses, we employ a rich dataset provided by Forrester Research. The data consist of independent cross sectional surveys of tens of thousands of American households on an annual basis. These surveys collect information on technological purchases and preferences, as well as a wide range of demographic information (income, education, etc.) and location. We focus our analysis on the last few years of the survey in our possession (2007-2009), when the aforementioned shifts in the video content provision market occurred in the United States.

Our econometric analysis focuses on cord cutting behavior, and how it was influenced by changes in the telecommunications landscape. We begin by developing a simple choice model over video content provider options. A key feature of this model is that it allows utility for each option to depend on individual-level content preferences and relative content availability across options. This feature allows us to identify whether consumers notably weigh relative content offerings (which changed with the emergence of OTT) and/or relative content quality (which changed with the digital switchover). We estimate this model utilizing methods suitable for repeated cross-sectional data (as in Prince and Greenstein, 2013).

Our data indicate a significant increase in cord-cutting between the years of 2008 and 2009. We do not find evidence that this shift can be explained by wealth shocks; however, we do find evidence that households already prone to cord cut (i.e., young and low income) likely became even more prone to this behavior during this time. This latter finding is suggestive of a response by this group to the change in OTA and emergence of OTT. Lastly, we find no evidence that relative content availability/quality is a notable driver of cord cutting behavior. Specifically, households with pre-existing preferences for content that was either added to (in the case of OTT), or improved for (in the case of OTA), alternative provider options did not demonstrate a notable difference in their propensity to cord cut. This finding suggests changes along these dimensions were not major factors behind the cord cutting we observed.

Our results indicate a divergence in demographic characteristics driving cord cutting behavior. That is, the standard cord cutter was becoming less similar to the average U.S. household. Further, they show that increased content offerings (OTT) / quality (OTA) by alternatives to paid cable/satellite subscriptions alone are not key drivers toward these options becoming stronger substitutes. For example, with regard to OTT, they suggest that other changes such as an alternative delivery method or original content development will likely need to occur for this provision option to become a more viable competitor to cable/satellite.

An important caveat to these findings is the relatively early stage during which we observe these changes to OTA and OTT. However, the time period between 2008 and 2009 is also a highly attractive time to analyze given the great turmoil in the telecommunications markets at that time. It would take several years of data during alternative time periods to match the (potential) identification power of the data during this turbulent year. Nevertheless, we recognize this analysis occurs while the telecommunications markets are in a state of flux, and view these findings as valuable first steps toward understanding the direction it is headed and key underlying determinants of competition.

The remainder of the paper is organized as follows. In Section 2, we detail the key changes to the video content provision market that occurred between 2008 and 2009. In Section 3, we describe our data. In Section 4 we lay out our theoretical model, and in Section 5 we detail our econometric specification and estimation method. In Section 6, we discuss our results, and Section 7 concludes.

2. Three Events Impacting the On-Demand Video Market

In this section, we discuss three events that may have significantly impacted the landscape of the on-demand video market. Each event has measurable implications in out data, particularly with regard to cord-cutting behavior, as we discuss in greater detail in Section 4.

2.1. The Great Recession

In late 2007, a significant global recession began that affected many countries around the world, including the United States. The recession became especially pronounced in the Fall of 2008. The ramifications of this economic downturn were felt in many industries, including telecommunications. To the extent that paid subscriptions for cable and satellite (henceforth "pay TV") are normal goods, we should expect an increase in cord-cutting behavior (i.e., dropping of cable/satellite paid subscriptions) corresponding to the drop in income and wealth due to the recession. Hence, this macroeconomic event may be a key driver of cord cutting we observe in our data (described below).

Even for households not hit hard by the Recession, the change it brought to consumer confidence and outlook can also have an impact on consumers' decision-making for household purchases. Paid television subscriptions can cost $1,000 per year or more, so it is reasonable to believe that households making such a purchase may have taken pause to reconsider it during this time. Consequently, the shift in financial means and outlook during the Recession is a key factor in helping us identify drivers behind the provision choices households make.

2.2. The U.S. Digital Switchover

The Digital Switchover is the process by which analog television broadcasting is discontinued and replaced by digital television. Beginning in 2006 in the Netherlands, this process has taken place (and is scheduled to take place) in many countries spanning the subsequent twenty years. In the United States, the switch by television stations initially was scheduled to take place in February of 2009. It largely did at the beginning of 2009, and following the DTV Delay Act, was mandated to occur by June 12, 2009.

By using digital technology, broadcasters could provide higher quality reception compared to analog (e.g., it is less prone to ghosting of images), and they could offer high-definition television service. Broadly speaking, the switchover allowed broadcasters to offer content of higher quality along several dimensions, among other things. This improvement in a potential substitute for subscription television may have contributed to an increase in cord cutting, particularly if the quality of OTA content is generally considered when making a provider decision.[1]

2.3. The Emergence of Over-the-Top from Network Television

From 2003 to 2008 the average household allocated an average of eight minutes a day to using the internet for leisure. By 2011 that had increased by 50%, to over twelve minutes a day. Many commentators forecast that the increase in time on the Internet would come at the expense of television viewing, the activity to which households devote more than half their leisure time (Wallsten, 2013, page 10).[2] Many suppliers prepared for this transition.

The ability to stream network television content over a broadband connection largely began due to Netflix and Hulu. Netflix began as a DVD-by-mail company that eventually offered streaming content over the Internet as well. It first allowed for streaming of movies in mid-2007, but did not have notable television content available for streaming until its partnership with Starz Entertainment in late 2008. It also added deals with CBS, NBC and Disney to stream their content shortly thereafter. A subscription for streaming content is typically around $10 or less per month in the U.S. as of this writing, and this price has been relatively stable since 2008.

Hulu is a website that offers OTT content. It was available to the public in March of 2008. Unlike Netflix, Hulu began with a stronger focus on streaming television (rather than movie) content, partnering with several television networks early on (detailed more in Section 3).

[1] Most households experienced an increase in quality, and in spite of fears of considerable variance in the quality of the digital signal. This smooth transition occurred in spite of a great deal of fear-mongering, as well as a four month delay in the full switchover. See, e.g., http://www.fcc.gov/digital-television, and for an example of the fear mongering, see http://usgovinfo.about.com/od/consumerawareness/a/dtvmaps.htm (accessed October, 2013).

[2] As of 2011 Wallsten (2013) finds no strong evidence of the reallocation of time from television to the internet.

Similar to Netflix, Hulu currently offers a subscription version of its service at less than $10 per month; however, prior to 2010, all of Hulu's content was available for free.

With Hulu and Netflix firmly in place as OTT content providers by 2009, television subscribers (through cable or satellite) possessed another ubiquitous alternative for television content via a broadband connection. Since a broadband connection was necessary to receive OTT content, the cost of this option could be substantial ($500+ per year); however, for the approximately 60% of U.S. households already with broadband by this time, the added cost of using OTT was quite small. The emergence of this new potential substitute for subscription television may also have contributed to an increase in cord cutting behavior. To the extent that households weigh the content offerings of OTT when choosing a content provider, OTT could become an even stronger contributor to cord cutting behavior if OTT content increases.

3. Data

The data for this project come from multiple sources. The first is Forrester Research, Inc. Each year, Forrester privately collects cross-sections consisting of thousands of household surveys, known as their "technographics" surveys. The surveys contain detailed information on households' technology purchases, activities, and preferences, along with a wide range of demographic measures. Our analysis focused on the three most recent waves, which surround the events described above and have similar survey structure: 2007-2009. Although Forrester attempts to produce a survey that samples the population across different locations and economic circumstances, it also makes no pretense that its sample precisely represents the U.S. population. In total, this demographic information serves three purposes: 1) as controls, 2) to identify comparable subgroups across years when constructing a pseudo-panel (as described in Section 5), and 3) to determine differential shifts in behavior across demographic subgroups. The demographic information we utilized includes DMA,[3] education, income, household size, and age.

Beyond demographics, the questions most pertinent to our analysis are those concerning: whether the household subscribes to cable or satellite, whether the household has broadband Internet, and the television channels the respondent consistently watches. Regarding television-watching behavior, the surveys ask respondents “Which of the following TV channels do you regularly watch on TV?” followed by an exhaustive list of popular television channel options (over 55). This component of the survey is particularly valuable to our analysis, as it allows us to establish content preferences, and determine how responses to changes in the telecommunications market depend on these preferences.

We provide summary statistics for our key variables in Table 1 below. Among these statistics, we include proportions of households who had all four binary (Yes or No) combinations of (satellite or cable) subscription TV and broadband. Particularly interesting statistics are the large change between 2008 and 2009 in the proportion of households with broadband Internet and no TV, along with the large drop in overall TV subscribers. While these data are not necessarily a representative sample of the U.S. population (e.g., they tend to over-sample high income households), these results are highly suggestive of a notable change in consumer behavior between 2008 and 2009, especially given there is no evidence of any change between 2007 and 2008[4]. The last set of variables in Table 1 are indicator variables as to

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[3] A DMA is a designated market area. DMAs generally coincide with sizeable cities in the United States.
[4] Note that, even when we weight results to be representative along observable demographics, this shift is still evident.

whether the respondent claimed to watch a given television channel regularly. The particular channels we include are those with the highest rate of consumption in the prior year (approximately 20% or higher) along with two that are seemingly particular to Netflix (Starz and Disney). In addition, we created a variable called "Broadcast" which equals one if the household watched at least two broadcast channels (and zero otherwise) and a variable called Non-broadcast which equals one if the household watched at least two non-broadcast channels among the list we consider for OTT (and zero otherwise). We use these last two variables to conduct further robustness tests, described in Section 6.

[Table 1 about here]

A key limitation of our data from Forrester is that it is not in the form of a panel, but rather repeated cross sections. As we detail below, much of our analysis focuses on (changes in) household behavior over time, which provided us many challenges for our econometric approach. In Section 5, we outline how we deal with these challenges using repeated cross-sectional data.

Our remaining data contain information about the television network offerings of Hulu and Netflix. For Hulu, we use the Internet archive (also known as the Way Back Machine), which provides website captures of the web page listing all networks associated with Hulu. In particular, we utilized a late-December (12/26/09) capture of the website www.hulu.com/partners. Among the channels included in the Forrester survey, Hulu is affliated with the following channels at that point in time: ABC, A&E Network, Bravo, CNBC, Comedy Central, Current TV, DIY Network, E!, Food Network, Fox, Fox Business, Fox News Channel, Fox Sports Net, FX, HGTV, MSNBC, MyNetworkTV, National Geographic, NBC, Oxygen, PBS, Showtime, Starz, and USA.

For Netflix, unfortunately it is not possible to use the Internet archive in the same way as with Hulu, since there is no single page listing network affiliations with Netflix of which we are aware. Therefore, we instead used archived public press releases to establish which television networks were affiliated with Netflix by late 2009. From this search[5], we were able to establish that Starz, CBS, and Disney were all affiliated with Netflix by this time.

4. A Simple Model of Video Media Demand

In this section, we provide a basic theoretical model of demand for video content provision. Using this model, we demonstrate how we can identify the set of characteristics for a given product that consumers consider when making a choice. We then build upon the ideas presented here when constructing our econometric model below.

Our theoretical framework follows the random utility approach of, e.g., Nevo (2000). Each period, consumers choose one video content provider among the following four choices: subscription television (cable or satellite), over the air (OTA) television, online streaming (OTT), and no provider. The utility for individual *i* from choosing video provision option *j* at time *t* is as follows:

$$(1)\ U_{ijt} = \alpha_i(y_{it} - p_{jt}) + (1 - \delta_j)[\overrightarrow{Content_{jt}} * \overrightarrow{\beta_i} + \overrightarrow{Content_{jt}} * \overrightarrow{Quality_{jt}} * \overrightarrow{\gamma_i}] + \eta_j + \varepsilon_{ijt}$$

[5] Sites utilized include: http://bits.blogs.nytimes.com/2008/10/01/starz-gives-netflix-fans-a-reason-to-stream/?_r=0, http://paidcontent.org/2008/09/23/419-netflix-makes-deals-with-cbs-disney-on-tv-shows/.

where y_{it} is income for individual i at time t, p_{jt} is price for option j at time t, Content is a vector of content available for option j, Quality is a vector of quality levels for each content component for option j, η_j is unobserved, time-invariant utility for option j (constant across individuals), and ε_{ijt} is unobserved utility for option j at time t for individual i. Also, α_i, β_i and γ_i are individual-level coefficients, representing heterogeneous preferences for option characteristics across individuals. Lastly, δ_j represents product-level discounting of utility from content and content quality, where $\delta_{subscription}$ has been normalized to equal 0. Note that this last parameter can capture differences across products in how individuals derive utility from that product's content and content quality.

Given this utility formulation and the standard Type I extremum distributional assumption for the idiosyncratic error, the probability that individual i chooses option j at time t is[6]:

$$(2)\, P_{ijt}(\overrightarrow{p_t}, \overrightarrow{Content_t}, \overrightarrow{Quality_t}; \alpha_i, \overrightarrow{\beta_i}, \overrightarrow{\gamma_i}, \overrightarrow{\delta_j}) =$$

$$\frac{\exp(-\alpha_i p_{jt} + (1-\delta_j)[\overrightarrow{Content_{jt}} * \overrightarrow{\beta_i} + \overrightarrow{Content_{jt}} * \overrightarrow{Quality_{jt}} * \overrightarrow{\gamma_i}] + \eta_j)}{\sum_{k=1}^{4} \exp(-\alpha_i p_{kt} + (1-\delta_k)[\overrightarrow{Content_{kt}} * \overrightarrow{\beta_i} + \overrightarrow{Content_{kt}} * \overrightarrow{Quality_{kt}} * \overrightarrow{\gamma_i}] + \eta_k)}$$

A primary aim of our empirics is to determine whether consumers take into account content availability and/or quality when considering whether to use OTA or OTT instead of subscription television. One could attempt to determine this by directly estimating the δ parameters for OTA and OTT and using standard maximum likelihood methods. If they are measured to be positive and significant, this would indicate that consumers consider these features notably less (or not at all) compared to pay television when making their choices.

[6] Note that income drops out of the expression since it is common in all terms.

Unfortunately, as we indicate in our data section, the above approach is not viable since we do not completely observe the choices made by consumers. Instead, we only know for certain whether or not they chose to purchase subscription television. While this is a limitation, we also have measures that provide direct information about consumer content preferences (i.e., provide information about β_i).

Consider now the probability of choosing pay television by person *i* at time *t*. For expositional purposes, assume that $\gamma_i = 0$. Then, this probability is:

$$(3)\ \mathrm{P}_{isubt}(\overrightarrow{p_t}, \overrightarrow{Content_t}, \overrightarrow{Quality_t}; \alpha_i, \overrightarrow{\beta_i}, \overrightarrow{\delta_j}) = \frac{\exp(-\alpha_i p_{subt} + \overrightarrow{Content_{subt}} * \overrightarrow{\beta_i} + \eta_{sub})}{\sum_{k=1}^{4} \exp(-\alpha_i p_{kt} + (1-\delta_k)(\overrightarrow{Content_{kt}} * \overrightarrow{\beta_i}) + \eta_k)}$$

Suppose now that $\beta_i \in [0, B]$, where B > 0. Then, it follows immediately that:

$$(4)\ \frac{\partial}{\partial Content_{OTT}}\Big(\mathrm{P}_{isubt}\big(\overrightarrow{p_t}, \overrightarrow{Content_t}, \overrightarrow{Quality_t}; \alpha_i, B, \overrightarrow{\delta_j}\big) -$$

$$\mathrm{P}_{isubt}\big(\overrightarrow{p_t}, \overrightarrow{Content_t}, \overrightarrow{Quality_t}; \alpha_i, 0, \overrightarrow{\delta_j}\big)\Big) < 0 \ \ iff \ \ \delta_{OTT} < 1$$

In words, this means that: the difference in likelihood of choosing subscription television between an individual that gains utility from content and one that doesn't is decreasing in OTT content availability if and only if OTT content is considered. We note here that it is also true that $\mathrm{P}_{isubt}\big(\overrightarrow{p_t}, \overrightarrow{Content_t}, \overrightarrow{Quality_t}; \alpha_i, B, \overrightarrow{\delta_j}\big)$ is decreasing in content availability for OTT if and only if δ_{OTT} is less than 1. However, this observation leads to a weaker empirical test, since it does not allow us to control for changes in other factors when content is added.

If we allow for $\gamma_i \neq 0$ but assume that $\beta_i = 0$ implies $\gamma_i = 0$, the above claim still holds. If we further assume that $\beta_i > 0$ implies $\gamma_i > 0$, we can make a similar claim with regard to content quality for both OTT and (more pertinent to our empirics) OTA. In words, these assumptions mean that an individual can't care about the quality of certain content, but not care about that content; and, if an individual cares about content, that individual cares to some extent about its quality. The similar claim for OTA is as follows:

$$(5)\ \frac{\partial}{\partial Quality_{OTA}}\Big(\mathrm{P}_{isubt}\big(\overrightarrow{p_t}, \overrightarrow{Content_t}, \overrightarrow{Quality_t}; \alpha_i, B, \overrightarrow{\delta_J}\big) -$$

$$\mathrm{P}_{isubt}\big(\overrightarrow{p_t}, \overrightarrow{Content_t}, \overrightarrow{Quality_t}; \alpha_i, 0, \overrightarrow{\delta_J}\big)\Big) < 0\ \ iff\ \ \delta_{OTA} < 1$$

In words, this means that: the difference in likelihood of choosing subscription television between an individual that gains utility from content and one that doesn't is decreasing in OTA quality if and only if OTA content is considered.

The above insights lead to two clear empirical tests.

1. Suppose two individuals are identical, but for preference for particular content (e.g., Comedy Central). Then if we observe the difference in their likelihood of purchasing subscription television decline when this content is added to the OTT option, it implies OTT content is considered when making their media choice; otherwise, it is not.
2. Suppose two individuals are identical, but for preference for particular content (e.g., NBC). If we observe the difference in their likelihood of purchasing subscription television decline when NBC quality is improved for OTA, this implies OTA content quality is considered when making their media choice; otherwise, it is not.

Our ability to conduct these two tests relies on there being proper variation in the data and utilization of a proper econometric model.   As described in Section 2, our data contain shifts in OTT content availability and OTA content quality. And, in Section 5 below, we design our econometric model to conduct these tests for our full population, and for relevant demographic subgroups. Further, it is easy to expand our model to allow for preferences to depend on demographic characteristics (typically labeled as a matrix, X), which include, e.g., income and age among others.

We conclude by noting that the choice we model above is a simplified one. For example, to choose OTT also requires a subscription to broadband services. Further, an individual could conceivably choose more than one of these options simultaneously (e.g., subscription and OTT, OTT and OTA, etc.). However, to the extent that claims #1 and #2 still hold in such extensions (which is likely to be the case barring some extreme forms of complementarity), our econometric approach described in Section 5 will still be appropriate for our purposes.

5. Econometric Model

The econometric model we analyze uses a binary variable indicating subscription to cable or satellite television in period *t* (2009 or 2008) as the dependent variable. The most basic version of this model includes explanatory variables consisting of household demographic characteristics, and allows for differential effects across the two years. The model looks as follows:

$$(6)\ TV_{it} = \beta_1 + \beta_2 TV_{it-1} + \beta_3 I(t = 2009) + \overrightarrow{\alpha_1}\overrightarrow{X_i} + \beta_4 I(t = 2009) TV_{it-1} + \overrightarrow{\alpha_2}\overrightarrow{X_i} I(t = 2009) + \varepsilon_{it}$$

Here, X_i is a set of time-invariant household characteristics for household *i* (e.g., education, location, family size, and income) and I(2009) is an indicator variable for the second wave of data. Using this model, we can get some basic notions as to which demographic groups are most prone to subscribe to pay cable/satellite television, and any changes in their relative propensity to do so in our second wave of data. Any differences we find are not directly indicative differing propensities to cord cut, but given the high penetration rate in 2008 (82%) and the large drop into 2009 (change of 5%), they are highly suggestive.

Next, we present the extended version of our model, which allows us to determine the role of content preferences in this decision process and test the two hypotheses put forth at the end of Section 4. We present it below:

(7) $$TV_{it} = \beta_1 + \vec{\alpha}_1\overrightarrow{X_\iota} + \overrightarrow{\alpha_2}\overrightarrow{X_\iota}I(t = 2009) + \beta_2 TV_{it-1} + \beta_3 \mathrm{I}(\mathrm{t} = 2009) + \beta_4 \mathrm{I}(\mathrm{t} = 2009)\mathrm{TV}_{\mathrm{it}-1} + \beta_5 Content_{i1t-1} + \cdots + \beta_{k+4} Content_{ikt-1} + \beta_{k+5}\mathrm{I}(\mathrm{t} = 2009) Content_{i1t-1} + \cdots + \beta_{2k+4}\mathrm{I}(\mathrm{t} = 2009) Content_{ikt-1} + \varepsilon_{it}$$

Here, $Content_{ijt-1}$ is a binary variable indicating whether household *i* viewed television content *j* at time *t-1*.

The identification strategy for this model is as follows. Content for non-broadcast channels can only be observed if the household subscribed to cable/satellite television, since these observations are made before OTT network content was available. Therefore, the non-broadcast content variable coefficients are only identified holding TV_{t-1} fixed and equal to 1. This means that these variables are only helping to predict the dropping of subscription service. For broadcast channels (e.g., NBC, ABC), this does not apply since they can be observed even if the household has not subscribed to cable/satellite. Therefore, these variables technically are helping to predict net changes in cable/satellite TV subscriptions; however, as the digital switchover enhances the value of OTA, any changes we observe in the relationship between broadcast content preferences and subscription TV preferences are almost certainly due to changes in cord cutting as well.

In general, we may worry that these Content variables are endogenous. That is, content choices last period may be correlated with unobservables influencing a household's decision to subscribe to cable/satellite television this period. It is also an obvious concern that TV_{it-1} may be endogenous as well. In addition, for a given household observed at time *t*, we cannot observe that household's choices at time *t-1*. However, using methods in Prince and Greenstein (2013), we can use group averages in place of the lagged variables, and with some basic assumptions (most importantly, no "group effects," explained below), we not only have a suitable proxy for these variables, but one that does not suffer from endogeneity. Of course, we must choose how to design these groups based on time-invariant household features.

Since a full discussion of the identification strategy using a pseudo panel is in Section 5.2 of Prince and Greenstein (2013), we provide a brief summary here. This approach follows a long line of research using repeated cross sections (e.g., Deaton, 1985; Moffitt, 1993; Collado, 1997; McKenzie, 2004; Verbeek and Vella, 2005). Here, we group the households according to location (DMA), education, size, age, and income (using the categories in Table 1, except for DMA). Then, for each household at time *t*, we replace variables that are not observed for that household at time *t-1* with the average for households we do observe at time *t-1* that are in the same group. For example, in equation (5), TV_{it-1} would be replaced with $\overline{TV}_{gt-1}$, where g is the group of which household *i* is a member. Taking this approach both addresses the problem of missing information, and alleviates some endogeneity concerns. The primary concern with regard to endogeneity that remains is whether unobservables harbor "group effects," i.e., time-invariant unobservables that vary at the group level. While we cannot completely rule out the possibility of such effects, our fine level of grouping (allowing for a great number of demographic controls) helps alleviate their presence.

Using the above model, we can identify the effects of prior content choice for both years. The structural shift in OTA and OTT television (through newly available streaming content via OTT and the digital switchover in OTA) suggests that prior content choice will have a differing impact on subscription cord cutting behavior in 2009 as compared to 2008. Specifically, we would expect that, if these changes were impactful via their content offerings, then the coefficients for Content available via OTA and/or OTT should decline between 2008 and 2009 (in line with Tests #1 and #2 at the end of Section 4). This is because these two changes had differing implications as to the availability of content through alternative means. For example, the digital switchover primarily impacted the quality of network television, and local stations, available over the air; in contrast, the increase in streaming capability allowed for access to a subset of non-broadcast channels, such as Comedy Central more easily over the Internet.

6. Results

Our results for variants of equation (6) are in Table 2 below. In column (1), we see that subscription to cable or satellite is strongly related to income and age (increasing in both). For education and household size, we see a non-monotonic relationship, where likelihood of subscription is greatest for the middle levels of each variable. In columns (2) and (3), we allow for the effects of demographic variables to change across 2008 and 2009. Here, we see that age, income, and education became even stronger predictors of cable/satellite subscription by 2009. In column (3), we add a control for the change in wealth experienced by the household. This variable is the household's stated wealth in time *t* minus the average stated wealth for households in the same group at time t-1. Using this control, we find no evidence of subscription decisions being strongly tied to changes in household wealth experienced during this time (we see a notable decline in wealth between 2007 and 2008, as expected). However, given the relatively low response for this particular variable in the data, we are cautious to draw any strong conclusions about the impact of wealth changes.

[Table 2 about here]

In Table 3, we present our results for variants of equation (7). The objective is to determine whether consumers of particular content (indicative of preference for that content) altered their purchasing patterns for cable/satellite subscription service in different ways than other consumers. The results in column (1) suggest this is not the case. As noted in Section 3, the particular channels we include are those with the highest rate of consumption in the prior year (approximately 20% or higher) along with two that are seemingly particular to Netflix (Starz and Disney). If consumers are responding to the content offerings and quality of OTT and OTA, we should expect the coefficients for the interaction terms (channel interacted with 2009) to be negative. However, we see no such pattern.

[Table 3 about here]

In column (2) of Table 3, we try even harder to find this pattern, by allowing for a differential effect for those particularly at high risk of dropping subscription television, i.e., the young and poor. Consequently, we define a dummy variable "High risk" to be one if the household has income less than $75,000 and age less than 45. Using this variable, we can zero in on the subgroup that may be most likely to exhibit any response to changes in content offerings since they are the most prone to drop service anyway. The results in column (2) corroborate our original findings; even the “high risk” households indicate no particular response to changes in content for OTA and OTT.

A possible shortcoming in the above analyses is their focus on single channels for preferences. In Table 4, we use our dichotomous variables Broadcast and Non-broadcast, which are designed to capture relatively high preference for broadcast channels (at least two) or non-broadcast channels offered by OTT (at least two non-broadcast channels included in Table 3). These variables allow us to focus on households that have a relatively high preference for content offered by OTT or improved by OTA. If there is a response to content offerings by these alternatives to cable/satellite, we might expect it to be particularly prevalent among this group. The results in Table 4 corroborate our findings in Table 3. In column (1), we again see no notable effects for the interactions of these terms with 2009, indicating no notable change in their propensity to subscribe to cable/satellite relative to other households. In column (2), we again allow for an interaction with being high risk. Here, there is some mild evidence of high risk, broadcast watchers becoming more prone to cord cut, but the estimate is not statistically significant.

[Table 4 about here]

It is natural to ask whether there is enough power in our data to find an effect if it exists. However, rather than engage in the complicated task of choosing what would be a “notable” effect and testing for power across many coefficients, we note the following. First, our sample size is quite large and capable of identifying effects for our demographic variables and TV_{t-1}. Second, our estimates for content do not exhibit any pattern suggestive of a broad effect – many estimates for content interacted with 2009 are positive, and very few are more negative than -0.01 (only CBS in column (1)). Last, our results focusing on "high risk" households also show no indication of a broad pattern. The channel with a particularly large amount of content and an audience squarely within this group is Comedy Central; however, we see no evidence of the high risk Comedy Central watchers cord cutting more in 2009.

We conclude this section by noting that the lack of a content effect in our data may be due to the timing of our data – perhaps it is too early to tell. We acknowledge this as a caveat for our findings. However, given the stickiness of telecom purchases (e.g., see Prince and Greenstein, 2013), these data are particularly well suited toward finding an effect if it exists due to the broad shock to the market over 2008-2009. At the very least, these results show that early on, OTA and OTT were not viably competing with cable and satellite on content. Whether that has continued to be the case, particularly for an evolving competitor in OTT, is a question for future research.

7. Conclusions

In this paper, we presented and estimated a model designed to identify how OTA and OTT compete with traditional cable and satellite subscription television. Our results indicate that the young and less wealthy are at the highest risk of cord cutting, and became even more likely to cord cut relative to other demographic groups over time. We also find that improvements in content quality and offerings for OTA and OTT respectively did not notably alter how these alternative content provision methods compete with cable and satellite. This is even the case when we focus on high risk cord cutters.

These findings have several implications. First, the digital switchover appears not to have had a notable effect on cable or satellite; hence this major government initiative does not appear to have had any of the feared detrimental effects on subscriptions. Second, there appears to be a divergence in the types of households prone to cord cut, at least during the time of our analysis – cord cutting was not moving in the direction of the “main stream.” Lastly, at least during the early stages of development, OTT does not appear to compete with cable and satellite in any meaningful way in terms of content offerings. To the extent that this remains the case, this limits OTT as a serious threat to cable and satellite. However, changes since 2009 including original content offerings and promotions by OTT providers (e.g., Netflix) may prove an effective strategic response to this initial indifference to OTT content offerings.

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Tables

Table 1
Summary Statistics

Variable	2007			2008			2009		
	Mean	Std. Dev.	Count	Mean	Std. Dev.	Count	Mean	Std. Dev.	Count
Television	0.806345	0.395166	53,936	0.823	0.382	47,698	0.774	0.418	36,194
Television & Broadband	0.4945	0.5000	53,936	0.5399	0.4984	47,698	0.5325	0.4989	36,194
Television & No Broadband	0.3084	0.4618	53,936	0.2785	0.4483	47,698	0.2167	0.4120	36,194
Broadband & No Television	0.0664	0.2490	53,936	0.0650	0.2384	47,698	0.1175	0.3220	36,194
No Broadband & No Television	0.1307	0.3371	53,936	0.1165	0.3208	47,698	0.1334	0.3400	36,194
Income < $25K	0.198309	0.39873	53,936	0.204055	0.403013	47,698	0.197408	0.398049	36,194
Income $25-50K	0.300004	0.458263	53,936	0.277328	0.447685	47,698	0.260955	0.439161	36,194
Income $50-75K	0.184496	0.387892	53,936	0.179483	0.383761	47,698	0.164641	0.370861	36,194
Income $75-100K	0.161117	0.367642	53,936	0.159147	0.365817	47,698	0.174891	0.379879	36,194
Income $100K+	0.156074	0.362929	53,936	0.179987	0.38418	47,698	0.202105	0.401576	36,194
Less than H.S.	0.061091	0.239499	53,936	0.063126	0.243193	47,698	0.062027	0.241208	36,194
High School diploma	0.251706	0.433997	53,936	0.260451	0.438885	47,698	0.249378	0.432659	36,194
Some College	0.341497	0.474216	53,936	0.336597	0.472551	47,698	0.330055	0.470239	36,194
College diploma	0.21075	0.407845	53,936	0.209191	0.406735	47,698	0.221307	0.415133	36,194
More than college diploma	0.134956	0.34168	53,936	0.130634	0.337004	47,698	0.137233	0.344098	36,194
HH size = 1	0.163935	0.37022	53,936	0.171307	0.376781	47,698	0.161988	0.368445	36,194
HH size = 2	0.365359	0.481535	53,936	0.368925	0.482519	47,698	0.343565	0.474905	36,194
HH size = 3	0.20541	0.404005	53,936	0.203363	0.402504	47,698	0.20263	0.401965	36,194
HH size = 4	0.167476	0.373404	53,936	0.161537	0.36803	47,698	0.177074	0.381736	36,194
HH size = 5+	0.09782	0.297073	53,936	0.094868	0.293035	47,698	0.114743	0.318716	36,194
Age < 25	0.090218	0.286497	53,936	0.082268	0.274775	47,698	0.093634	0.291323	36,194
Age 25-34	0.156778	0.363595	53,936	0.134974	0.3417	47,698	0.160773	0.367326	36,194
Age 35-44	0.190355	0.392585	53,936	0.17898	0.38334	47,698	0.196607	0.397438	36,194
Age 45-54	0.219149	0.413673	53,936	0.213699	0.409921	47,698	0.19622	0.397143	36,194
Age 55-64	0.170851	0.376382	53,936	0.189652	0.392029	47,698	0.174559	0.379595	36,194

Age 65+	0.172649	0.377947	53,936	0.200428	0.400325	47,698	0.178206	0.382692	36,194
TV Shows online	0.086	0.280	48,675	0.117	0.321	41,593	0.185	0.388	36,428
Wealth change ($mil)				-0.02273	1.520	19,146	0.03642	1.3660	15,227
ABC	0.702258	0.45727	53,936	0.626211	0.483814	47,698			
CBS	0.656741	0.474801	53,936	0.631683	0.482353	47,698			
NBC	0.643503	0.478969	53,936	0.628391	0.48324	47,698			
Fox	0.523343	0.49946	53,936	0.513963	0.49981	47,698			
A&E	0.251279	0.433753	53,936	0.310034	0.462512	47,698			
Food	0.267002	0.442397	53,936	0.283911	0.450899	47,698			
PBS	0.27681	0.447426	53,936	0.300558	0.458505	47,698			
ComCentral	0.195825	0.396838	53,936	0.201623	0.401216	47,698			
USA	0.31111	0.462952	53,936	0.326156	0.46881	47,698			
Starz	0.089143	0.284952	53,936	0.110424	0.313421	47,698			
Disney	0.147638	0.354744	53,936	0.167932	0.373809	47,698			
Broadcast	0.725731	0.446150	53,936	0.694809	0.460493	47,698			
Non-broadcast	0.417068	0.493079	53,936	0.463604	0.498679	47,698			

Table 2

Basic Cord Cutting Analysis[7]

Covariate	(1)	(2)	(3)
	Estimate	Estimate	Estimate
TV avg	0.163**	0.168**	0.172**
	0.009	0.009	0.011
2009	-0.093**	-0.174**	-0.180**
	0.012	0.026	0.034
TV avg * 2009	0.055**	0.044**	0.055**
	0.013	0.014	0.018
Income $25-50K	0.079**	0.075**	0.080**
	0.006	0.007	0.009
Income $50-75K	0.114**	0.110**	0.116**
	0.006	0.008	0.01
Income $75-100K	0.136**	0.124**	0.135**
	0.006	0.008	0.01
Income $100K+	0.157**	0.150**	0.153**
	0.006	0.008	0.01
High School diploma	0.043**	0.029*	0.033*
	0.009	0.012	0.015
Some College	0.046**	0.023	0.03
	0.009	0.012	0.015
College diploma	0.039**	0.019	0.026
	0.01	0.013	0.016
More than college diploma	0.029**	0.004	0.007
	0.01	0.013	0.017
HH size = 2	0.058**	0.055**	0.062**
	0.005	0.007	0.009
HH size = 3	0.061**	0.062**	0.067**
	0.006	0.008	0.01
HH size = 4	0.051**	0.047**	0.060**
	0.006	0.008	0.011
HH size = 5+	0.015	0.006	0.02
	0.008	0.01	0.013
Age 25-34	0.069**	0.055**	0.023
	0.008	0.011	0.015
Age 35-44	0.074**	0.067**	0.037*
	0.008	0.01	0.014
Age 45-54	0.075**	0.061**	0.039*
	0.008	0.01	0.014
Age 55-64	0.086**	0.070**	0.041*
	0.008	0.011	0.015
Age 65+	0.066**	0.052**	0.032*
	0.008	0.011	0.015

[7] All regressions include fixed effects for DMA and a constant term. Standard errors below each point estimate are robust to arbitrary heteroskedasticity. * is significant at 10%, ** is significant at 5%, and *** is significant at 1%. Note that column (3) has fewer observations due to non-response to the wealth question; this drives the seemingly significantly higher R-squared.

Income $25-50K*2009		0.008	0.01
		0.011	0.014
Income $50-75K*2009		0.007	0.019
		0.012	0.016
Income $75-100K*2009		0.027*	0.021
		0.012	0.016
Income $100K+*2009		0.017	0.019
		0.012	0.016
High School diploma*2009		0.031	0.032
		0.019	0.024
Some College*2009		0.052**	0.046
		0.019	0.024
College diploma*2009		0.044*	0.04
		0.02	0.025
More than college diploma*2009		0.057**	0.061*
		0.021	0.026
HH size = 2*2009		0.007	-0.008
		0.011	0.014
HH size = 3*2009		-0.001	-0.01
		0.012	0.015
HH size = 4*2009		0.01	-0.008
		0.013	0.017
HH size = 5+*2009		0.02	0.003
		0.016	0.02
Age 25-34*2009		0.032	0.048*
		0.017	0.023
Age 35-44*2009		0.017	0.025
		0.016	0.022
Age 45-54*2009		0.032*	0.039
		0.016	0.022
Age 55-64*2009		0.038*	0.055*
		0.017	0.022
Age 65+*2009		0.034*	0.045
		0.017	0.023
ln(wealth change)			-0.0017
			0.0013
R-squared	0.074	0.074	0.083
N	59,738	59,738	34,373

Table 3

The Role of Content in Cord Cutting[8]

Covariate	(1)	(2)
	Estimate	Estimate
TV avg.	0.158**	0.157**
	0.009	0.009
2009	-0.166**	-0.146**
	0.027	0.029
TV avg*2009	0.042**	0.042**
	0.014	0.014
ABC avg	-0.006	0.001
	0.008	0.01
CBS avg	0	-0.01
	0.008	0.01
NBC avg	0.005	0.001
	0.008	0.009
Fox avg	0.005	0.009
	0.006	0.007
A&E avg	0.015*	0.023*
	0.007	0.008
Food avg	0.003	0.004
	0.006	0.007
PBS avg	-0.012	-0.007
	0.007	0.008
ComCentral avg	0.011	0.007
	0.007	0.009
USA avg	0.015*	0.007
	0.006	0.007
Starz avg	-0.008	-0.007
	0.010	0.012
Disney avg	0.008	0.015
	0.008	0.010
ABC avg*2009	-0.005	-0.011
	0.012	0.015
CBS avg*2009	-0.015	-0.01
	0.012	0.015
NBC avg*2009	0.017	0.025
	0.012	0.014
Fox avg*2009	-0.007	-0.014
	0.01	0.011
A&E avg*2009	0.006	-0.006
	0.011	0.012
Food avg*2009	0.003	0.008
	0.01	0.012
PBS avg*2009	-0.007	0

[8] All regressions include fixed effects for DMA, a constant term, and demographic controls. Standard errors below each estimate are robust to arbitrary heteroskedasticity. + is significant at 10%, * is significant at 5%, and ** is significant at 1%.

	0.011	0.012
ComCentral avg*2009	-0.006	-0.026+
	0.011	0.014
USA avg*2009	-0.003	0.004
	0.01	0.012
Starz avg*2009	0.026+	0.033+
	0.015	0.017
Disney avg*2009	0.007	0.004
	0.012	0.015
High risk		-0.005
		0.014
High risk*2009		-0.033
		0.022
High risk*ABC avg		-0.017
		0.017
High risk*CBS avg		0.03
		0.017
High risk*NBC avg		0.012
		0.017
High risk*Fox avg		-0.013
		0.014
High risk*A&E avg		-0.027
		0.016
High risk*Food avg		-0.003
		0.015
High risk*PBS avg		-0.017
		0.016
High risk*ComCentral avg		0.01
		0.015
High risk*USA avg		0.025
		0.014
High risk*Starz avg		0
		0.022
High risk*Disney avg		-0.017
		0.017
High risk*ABC avg*2009		0.015
		0.026
High risk*CBS avg*2009		-0.013
		0.026
High risk*NBC avg*2009		-0.022
		0.026
High risk*Fox avg*2009		0.023
		0.022
High risk*A&E avg*2009		0.042
		0.024
High risk*Food avg*2009		-0.014
		0.023
High risk*PBS avg*2009		-0.02
		0.025

High risk*ComCentral avg*2009		0.051*
		0.024
High risk*USA avg*2009		-0.025
		0.023
High risk*Starz avg*2009		-0.025
		0.033
High risk*Disney avg*2009		0.006
		0.026
R-squared	0.075	0.076
N	59,738	59,738

Table 4

The Role of Content in Cord Cutting using Alternative Content Preference Measure[9]

Covariate	(1)	(2)
	Estimate	Estimate
TV avg.	0.162**	0.162**
	0.009	0.009
2009	-0.172**	-0.158**
	0.027	0.029
TV avg*2009	0.039**	0.039**
	0.014	0.014
Broadcast avg	0.0003	-0.011
	0.007	0.008
Non-broadcast avg	0.018**	0.020
	0.006	0.007
Broadcast avg*2009	-0.007	0.002
	0.010	0.012
Non-broadcast avg*2009	0.012	0.003
	0.009	0.011
High risk		-0.018
		0.014
High risk*2009		-0.019
		0.021
High risk*Broadcast avg		0.033*
		0.014
High risk*Non-broadcast avg		-0.006
		0.013
High risk*Broadcast avg*2009		-0.026
		0.022
High risk*Non-broadcast avg*2009		0.027
		0.020
R-squared	0.075	0.075
N	59,738	59,738

9 All regressions include fixed effects for DMA, a constant term, and demographic controls. Standard errors below each estimate are robust to arbitrary heteroskedasticity. + is significant at 10%, * is significant at 5%, and ** is significant at 1%.

VIDEO MARKETPLACE REGULATION: A PRIMER ON THE HISTORY OF TELEVISION REGULATION AND CURRENT LEGISLATIVE PROPOSALS

By Brent Skorup[1] & Adam Thierer[2]

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> "What distinguishes TV programs from other mass media content… is the extreme eagerness of Washington to engage in efforts to prevent markets from working freely, often in response to interest group pressures and opportunities for political advantage and with almost complete indifference to the welfare of consumers."[3] – Bruce Owen

Introduction

In a free market in video services, television distributors and creators would be able to contract freely and sell any variety of bundles of content to subscribers on any distribution platform they prefer.[4] Competition and consumer protection law, not *ex ante* distribution mandates, would guide business decisions.

Alas, that is not possible today. Indeed, the United States never had anything resembling a free market in the provision of television content and services. The video marketplace has been substantially regulated since the advent of broadcast television in the 1940s and 1950s.[5] These regulations have been enforced by the Federal Communications Commission (FCC), an agency regularly captured by the interests they regulate.[6] Because broadcasters used free government-provided airwaves,[7] the government withheld full First Amendment protections and imposed a variety of ostensibly public interest obligations on broadcasters.[8]

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1 Research Fellow, Mercatus Center at George Mason University.

2 Senior Research Fellow, Mercatus Center at George Mason University.

3 Bruce M. Owen, "Consumer Welfare and TV Program Regulation," Mercatus Center *Working Paper* (2012): 5, http://mercatus.org/publication/consumer-welfare-and-tv-program-regulation.

4 "One major difference between markets for telecommunications goods and markets for other goods is that governmental regulation plays a very large role in determining what kinds and quality of telecommunications services may be offered at what costs. The central issue in telecommunications law is why telecommunications goods and markets are not treated like most other goods and markets." Thomas G. Krattenmaker & Lucas A. Powe, Jr., *Regulating Broadcast Programming* 49 (AEI Press: 1994).

5 See, e.g., Thomas W. Hazlett, "If a TV Station Broadcasts in the Forest…: An Essay on 21st Century Video Distribution", working paper (2011), http://www.americantelevisionalliance.org/wp-content/uploads/2011/05/TV-Future-TWH-5-19-111.pdf.

6 Adam Thierer & Brent Skorup, "A History of Cronyism and Capture in the Information Technology Sector," Journal of Technology Law & Policy, Vol. 18., No. 2 (2014) [*forthcoming*].

7 Most current broadcast station owners have paid substantial sums for their broadcast networks and spectrum, but the original grants were assigned to broadcasters for free. See Jeffrey A. Eisenach, "The Equities and Economics

When competing television technologies like cable and satellite arrived and threatened the government-created broadcast markets, the FCC and Congress imposed obligations in an ill-conceived attempt to maintain government-managed competition.[9] "There are few alleyways of the administrative state more obscure or more littered with obstacles to efficient markets and improvements in consumer welfare than the interventions regulating ownership and licensing of TV stations and programs," summarizes media economist Bruce Owen.[10]

Despite this regulatory morass, the video marketplace has undergone a remarkable metamorphosis over the past two decades. This is not due to the evolution of policy but rather to the rapid evolution of technology.[11] New video technologies and business models have, in essence, evolved around regulatory encumbrances. Cable and satellite companies have invested in their networks and vastly expanded their channel capacity and, therefore, consumer choice. Further, the rise of Netflix, Amazon, YouTube, Apple iTunes, video game platforms, and countless other online video sites and services have made it easier than ever for consumers to find the content they demand. In other cases, companies like Aereo have relied on regulatory arbitrage to create new businesses.[12]

These technological developments have severely strained the adequacy of existing video laws, which had its last major updates in the 1992 Cable Act[13] and 1996 Telecommunications Act.[14] Since that time, Congress has only tinkered around the margins of this complex regulatory regime. Notably, satellite legislation, most recently authorized via the Satellite Television Extension and Localism Act of 2010 (STELA)[15], extended many cable regulations onto satellite video. And, as noted below, recent efforts to reform media ownership rules resulted in few changes.

With the likely congressional reauthorization of STELA in 2014, Congress, the FCC, and industry players have turned their attention to arcane video laws. Beyond simply describing what

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of Property Interests in TV Spectrum Licenses," working paper (2014), http://www.nab.org/documents/newsRoom/pdfs/011614_Navigant_spectrum_study.pdf.

8 See Red Lion Broadcasting Co. v. FCC, 395 U.S. 367, 400-01 (1969) ("In view of the scarcity of broadcast frequencies, the Government's role in allocating those frequencies, and the legitimate claims of those unable without governmental assistance to gain access to those frequencies for expressions of their views, we hold the regulations and ruling at issue here both authorized by statute and constitutional."); Thomas G. Krattenmaker & Lucas A. Powe, Jr., *Regulating Broadcast Programming* 229-36, 297-331 (AEI Press: 1994).

9 See discussion, infra, regarding must-carry, retransmission consent, nonduplication, and other regulatory obligations.

10 Owen, *supra*.

11 *See* Adam Thierer & Grant Eskelsen, The Progress & Freedom Foundation, *Media Metrics: The True State of the Modern Media Marketplace*, PFF Special Report, Summer 2008), www.pff.org/mediametrics; Adam Thierer, The Progress & Freedom Foundation, *Video Competition in a Digital Age*, Testimony before the Subcommittee on Communications, Technology and the Internet, U.S. House Committee on Energy and Commerce, Oct. 22, 2009, www.pff.org/issues-pubs/testimony/2009/10-22-09-thierer-testimony-video-competition-digital-age.pdf.

12 Aereo captures free over-the-air broadcasts on small antennas in one location and the company leases antennas to customers in the local area. Customers can watch these broadcasts via a broadband connection.

13 Pub. L. No. 102-385.

14 Pub. L. No. 104-104.

15 Pub. L. No. 111-175.

terms like "retransmission consent" and "network non-duplication" mean,[16] this paper analyzes video reform proposals and makes the case for comprehensive deregulation.

Americans currently enjoy what media critics call the Golden Age of Television—programming quality is arguably the best it has ever been.[17] However, consumers also see high cable and satellite bills in part because of the regulatory mandates that distort market negotiations and limit competition. With the required reauthorization of STELA in 2014, public fights over rising retransmission consent fees, and the possible disruption to existing broadcast markets posed by Aereo, there is a sense that the industry and congressional members have an appetite for video reform. Several bills pending in the 113th session of Congress are summarized below. Portions of those bills may be attached to STELA reauthorization or considered in future video law reforms. Most of these bills, we find, are inadequate and piecemeal and several actually increase video regulations. Currently only one bill, co-sponsored by Reps. Scalise and Gardner, moves television law in a significantly free-market direction. To provide context for these bills, we first discuss some of the history that led to the current calls for reform of video regulations.

I. How the Legal Thicket Grew

It's impossible to make sense of communications laws and the pending video bills without an understanding the history of existing laws. The history of television, therefore, will be briefly explored.

Broadcasters, beginning in the 1940s and 1950s with their original grant of free spectrum, have long enjoyed favoritism from the FCC and Congress. Cable was regulated in the 1960s "because, in the FCC's judgment, it posed a threat—if unregulated—to 'free television.'"[18] As the Copyright Office said in a 2008 report, today there is a "thicket of communications law requirements aimed at protecting and supporting the broadcast industry."[19] Television regulations attempt to further several public policy goals and, as the Congressional Research

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16 Researchers at the Congressional Research Service and Government Accountability Office provide excellent background for policymakers. See, e.g., Charles B. Goldfarb, "A Condensed Review of Retransmission Consent and Other Federal Rules Affecting Programmer-Distributor Negotiations," *CRS Report for Congress*, July 9, 2007.

17 David Carr, "Barely Keeping Up in TV's New Golden Age," New York Times, March 9, 2014, http://www.nytimes.com/2014/03/10/business/media/fenced-in-by-televisions-excess-of-excellence.html?_r=0 ("The vast wasteland of television has been replaced by an excess of excellence . . . ."); Lee Cowan, "Welcome to TV's second 'Golden Age'," CBS News, Oct. 1, 2013, http://www.cbsnews.com/news/welcome-to-tvs-second-golden-age/; Adam Thierer, "We Are Living in the Golden Age of Children's Programming," Progress & Freedom Foundation, *Progress Snapshot*, Release 5.6, July 2009, http://www.pff.org/issues-pubs/ps/2009/ps5.6-childrens-television-golden-age.html.

18 Charles O. Verrill, Jr., "CATV's Emerging Role: Cablecaster or Common Carrier?", 34 Law and Contemporary Problems 586, 593 (1969). See also Glen O. Robinson, "Regulating Communications: Stories from the First Hundred Years," 13 Green Bag J. 303, 309 (2010) ("The cable regulations were originally designed solely to protect licensed broadcast stations."); Thomas G. Krattenmaker & Lucas A. Powe, Jr., Regulating Broadcast Programming 225 (1994) ("There is no doubt that the Communications Act results in subsidies to broadcasters.").

19 U.S. Copyright Office, SHVERA § 109 Report 65 (2008), http://www.copyright.gov/reports/section109-final-report.pdf.

Service has said, the furtherance of some objectives impede other objectives.[20] Those FCC and congressional objectives include:

1. Localism – broadcasts should emphasize diverse content of local interest and importance.
2. Universal service – every media market, no matter the size or population density, should be served by several broadcasters.
3. Free television – broadcasts should be free to any person with a broadcast antenna. Subscription service is essentially prohibited.
4. Competition – broadcast as a distribution method should remain viable to compete with pay-television (cable, satellite, and IPTV) distributors.

These objectives cannot be accomplished simultaneously without substantial ongoing regulatory interventions and, at times, these goals may contradict each other. For example, the push by policymakers to ensure "localism" in broadcasting has, at times, undermined the development of greater national competition.[21] Further, "free"—that is, advertiser supported—television contradicts universal service because remote parts of the country cannot command the advertising dollars needed.[22]

Many related federal rules, therefore, continue to tip the regulatory scales toward local broadcasters and content creators, such as the requirement that video distributors carry broadcast signals even if customers don't demand the channels ("must carry"); rules that prohibit distributors from striking deals with broadcasters outside their local communities ("network non-duplication" and "syndicated exclusivity" rules); regulations specifying where broadcast channels appear on the cable channel lineup; rules covering how video distributors carry signals from local TV broadcasters ("retransmission consent" rules); and prohibitions against carrying some sporting events ("sports blackout rule").

It's tempting to attempt to fix one part of video laws—like retransmission consent, which is the subject of the most intense debates today—but that may only result in more market distortions.[23] Comprehensive video reform requires addressing all of the following regulatory obligations.

Network Non-duplication & Syndicated Exclusivity

Broadcasters had a relatively stable competitive environment in the 1950s, with the same three national networks—NBC, ABC, and CBS—and a few local independents broadcasting mostly

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[20] Charles B. Goldfarb, "A Condensed Review of Retransmission Consent and Other Federal Rules Affecting Programmer-Distributor Negotiations," *CRS Report for Congress*, July 9, 2007.

[21] David Weinstein, *The Forgotten Network: Dumont on the Birth of American Television* (Philadelphia, PA: Temple University Press, 2004). Further, as an early television scholar said, "If local programming and control are to be encouraged, it might be more efficient to subsidize local stations directly than to restrict their competitors." Franklin M. Fisher, "Community Antenna Television Systems and the Regulation of Television Broadcasting," 56 *The American Economic Review* 320, 329 (1966).

[22] Megan Mullen, *Television in the Multichannel Age* 85 (Blackwell Publishing: 2008).

[23] Adam Thierer, "Video Marketplace Deregulation: The Battle Over Spectrum Policy and Retransmission Consent Reform," Mercatus Center at George Mason University, *Mercatus Research*, June 19, 2012, http://mercatus.org/publication/video-marketplace-deregulation-battle-over-spectrum-policy-and-retransmission-consent.

via local affiliates in FCC-created local geographic zones.[24] In these early years of broadcast television, the FCC made a conscious choice to pursue "localism": rather than permit many broadcasters to compete regionally or nationally, the FCC opted to have a few broadcasters in each small market.[25] But in the mid-1950s, "cable" companies began setting up broadcast receivers and connecting receivers to households that could not receive adequate broadcast signals because of buildings or geography interfering with their broadcast signal reception.

At first, broadcasters tolerated or welcomed these cable upstarts—more households receiving broadcast signals meant more advertising revenue.[26] However, within a few years, cable companies were capturing broadcast signals from far-away transmitters and importing those signals via microwave and wire into their local city.[27] A rural California cable company, for instance, might capture and transmit popular Los Angeles stations, which had previously been inaccessible to rural households.[28] Producers of local broadcast content, particularly independents not affiliated with the major networks, couldn't compete with the imported signals from cities.[29] The FCC soon realized that "distant signal importation" threatened the viability of many small-market broadcasters and the FCC's localism vision.[30]

To protect local broadcasters from competition, the FCC crafted rules in 1966—like network non-duplication and syndicated exclusivity—that kept localism intact.[31] Network non-duplication and syndicated exclusivity requires a cable operator to blackout certain programs from non-local broadcast stations if the local broadcaster has an exclusive arrangement with a network to carry that programming.[32] Today, when multichannel video program distributors (MVPDs)—the largest of which are cable and satellite operators—and broadcasters are at impasse over carriage payment, the MVPD cannot negotiate with other broadcasters to provide customers content in the interim.[33] If a Washington, D.C. cable company, for instance, couldn't

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[24] Thomas W. Hazlett, "If a TV Station Broadcasts in the Forest…: An Essay on 21st Century Video Distribution", working paper (2011): 6, http://www.americantelevisionalliance.org/wp-content/uploads/2011/05/TV-Future-TWH-5-19-111.pdf. DuMont was a fourth national network but folded in 1955.

[25] Thomas W. Hazlett, "If a TV Station Broadcasts in the Forest…: An Essay on 21st Century Video Distribution", working paper (2011): 6, http://www.americantelevisionalliance.org/wp-content/uploads/2011/05/TV-Future-TWH-5-19-111.pdf.

[26] "In its early form CATV was not viewed as competitive with 'local' and 'free' television broadcasting; in fact, it was arguably a positive factor to those stations whose signal was made available in theretofore unserved areas." Charles O. Verrill, Jr., "CATV's Emerging Role: Cablecaster or Common Carrier?, 34 Law and Contemporary Problems 586, 588 (1969).

[27] Franklin M. Fisher, "Community Antenna Television Systems and the Regulation of Television Broadcasting," 56 Am. Econ. Rev. 320, 324 (1966).

[28] See Thomas W. Hazlett, "If a TV Station Broadcasts in the Forest…: An Essay on 21st Century Video Distribution", working paper (2011): 33, http://www.americantelevisionalliance.org/wp-content/uploads/2011/05/TV-Future-TWH-5-19-111.pdf.

[29] Megan Mullen, *Television in the Multichannel Age* 65-66 (Blackwell Publishing: 2008).

[30] Megan Mullen, *Television in the Multichannel Age* 65 (Blackwell Publishing: 2008).

[31] See FCC, In the Matter of: Amendment of Subpart L, Part 91, to Adopt Rules and Regulations to Govern the Grant of Authorizations in the Business Radio Service for Microwave Stations to Relay Television Signals to Community Antenna Systems, 2 FCC 2d 725, 746 (1966).

[32] Megan Mullen, *Television in the Multichannel Age* 66-67 (Blackwell Publishing: 2008).

[33] Thomas W. Hazlett, "If a TV Station Broadcasts in the Forest…: An Essay on 21st Century Video Distribution", working paper (2011): 34, http://www.americantelevisionalliance.org/wp-content/uploads/2011/05/TV-Future-TWH-5-19-111.pdf ("FCC rules that limit 'distant signals' resemble cartel enforcement devices, limiting cross-

reach a deal with the D.C. NBC affiliate over retransmission consent, explained below, the cable company cannot negotiate with Baltimore's NBC affiliate and provide NBC content to D.C. customers in the interim because of network non-duplication rules. Until the impasse is resolved, customers generally lose the ability to watch certain channels.

Must Carry

Must carry is a requirement from the same 1966 FCC proceeding[34], codified in the 1992 Cable Act, that a local cable distributor carry every local broadcast station that requests carriage.[35] As a mandated part of cable's bundle of channels, it is a policy clearly at odds with a free market. Must carry ensures that local broadcasters are not dropped by distributors, which would result in the loss of needed advertising dollars. Today, must carry is mostly utilized by low-value or niche broadcast channels, like home shopping programming, since there is not sufficient consumer demand for carriage of those channels on MVPDs. For non-broadcast networks that cannot take advantage of must carry, programmers pair unprofitable, niche channels—like VH1 Classic—with popular ones—like MTV—to gain cable carriage. As standalone broadcast channels, however, there is generally not enough customer demand to include certain channels. Popular broadcast networks—like NBC, ABC, Fox, and CBS—and their affiliate broadcasters, in contrast, do not elect must carry. Instead, they have leverage to withhold their signals from cable and satellite companies and request payment via retransmission consent agreements, discussed below.

Compulsory Licenses

Gaining copyright permissions was difficult in the early years of cable because of the numerous parties involved in the production of programming. Television programmers had license agreements with local broadcasters but not with cable companies, who were small and geographically disbursed. Therefore, programmers in the 1960s complained to courts that cable companies were violating their copyright protections since cable companies were not paying to transmit the programs. In 1968, the Supreme Court resolved the dispute declaring cable systems mere "extended antennas" for broadcast signals, thus not engaging in public performances of copyrighted material.[36] Cable companies, therefore, could continue transmitting content for free. Congress responded a few years later with the 1976 Copyright Act and granted cable operators a compulsory license to transmit programs airing in distant (non-local) TV markets in return for a fee established by the Library of Congress.[37]

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market competition among stations for viewers. While premised on the idea of copyright protection, they actually achieved something quite distinct: protection of local broadcast stations.").

[34] The FCC's must carry rules were overturned in court in 1985. See Quincy Cable TV, Inc. v. FCC, 768 F.2d 1434 (DC Cir. 1985).

[35] See FCC, In the Matter of: Amendment of Subpart L, Part 91, to Adopt Rules and Regulations to Govern the Grant of Authorizations in the Business Radio Service for Microwave Stations to Relay Television Signals to Community Antenna Systems, 2 FCC 2d 725, 746 (1966); 47 USC § 534.

[36] *Fortnightly Corp. v. United Artists*, 392 U.S. 390 (1968); *United States v. Southwestern Cable Co*. 392 U.S. 157 (1968).

[37] 17 USC § 111(c).

As compulsory licenses, they essentially place a "duty to deal" upon content owners. Compulsory licensing is an attempt to lower the transactions costs to cable companies and programmers. Rather than cumbersome negotiations with all non-local broadcasters and networks, cable operators can receive the copyright licenses simply by paying royalties into a government-administered fund that pays out to the programmers. Section 111 of the Copyright Act provides for the compulsory licensing of non-local content to cable companies and Section 119, added in 1988, extends the royalty-and-licensing scheme to satellite television providers.

Retransmission Consent

Retransmission (retrans) fees—which MVPDs pay to local broadcasters—might be the most controversial part of today's video marketplace because they have increased in the past few years beyond most expectations. The contractual disputes, haggling over the price of broadcast signals, are disruptive to consumers since television viewers lose popular channels while negotiations drag on.

The retransmission consent regulatory regime was created in the 1992 Cable Act at the behest of the broadcasters, who had unsuccessfully sought the rule since the late 1950s.[38] Cable companies, in the 1970s and 1980s, ate into broadcast television's market share as consumers mothballed their rabbit ear antennas in favor of cable subscriptions. Cable's competitive advantage arose because operators had begun offering cable channels, like HBO and ESPN, in addition to broadcast channels. In the 1980s, broadcasters anxiously noted that cable companies had two sources of income: from advertisers on new cable programs and from cable subscribers. Local broadcasters, however, had only one source of income—advertising support—because broadcast licensees were essentially prohibited from offering subscription services since their inception.

To gain a second stream of income, broadcasters lobbied Congress for the creation of a brand-new property right, known as the retransmission right. In the 1992 Cable Act, Congress created retransmission rights for broadcasters. While cable carriage of non-local signals is covered by the compulsory license, broadcasters of local signals elect either must carry or retransmission consent every three years.[39] MVPDs today must pay broadcasters who elect retransmission consent for the right to retransmit local broadcast signals, the most valuable of which is programming from broadcast networks ABC, NBC, Fox, and CBS.

Market dynamics have changed substantially since 1992. The early 1990s was a relatively stable negotiation environment since cable providers had a local franchise or de facto monopoly for pay television and broadcasters had exclusive rights to network programming. Broadcasters and cable had near-parity in bargaining power since each needed the other. Therefore, money rarely changed hands. Cable systems lost bargaining power, however, in the late 1990s as cable was deregulated and satellite companies began competing away cable customers.[40] If a cable

[38] Patrick R. Parsons, *Blue Skies: A History of Cable Television* 157 (Temple University Press: 2008).

[39] 47 USC § 325(b)(3).

[40] Charles B. Goldfarb, "A Condensed Review of Retransmission Consent and Other Federal Rules Affecting Programmer-Distributor Negotiations," CRS Report for Congress CRS-10 (July 9, 2007) ("As a result [of

company didn't pay adequate retrans fees for a broadcast channel, it risked losing customers to satellite companies who had many of the same channels and nation-wide coverage. With competition among MVPDs intensifying, broadcasters gained the upper hand and could extract retrans payment as the only seller of network shows and sporting events.

Further weakening MVPDs' position was network nonduplication and syndicated exclusivity regulations, described previously. The weakened position of pay-TV distributors meant payments to broadcasters rose quickly. Total retransmission fees were negligible in the 1990s, but rose to $11 million in 2001[41] and then ballooned to around $3.30 billion in 2013.[42]

It is important to note that most television programming deals today operate outside the retrans system since retrans does not cover non-broadcast programming like MTV, ESPN, Bravo, and hundreds of other channels. "Today, more than 500 non-broadcast television channels are distributed by MVPDs nationwide without any need for government compulsory licensing," observes Preston Padden, a former Disney and News Corp. executive. [43] As Padden noted in congressional testimony,

> the success of the marketplace "rights aggregator" model in facilitating the distribution of the programs on non-broadcast channels demonstrates that there is no longer any need for government Compulsory Licensing of broadcast programming. Just like the nonbroadcast channels, broadcast stations easily could aggregate the rights in the programs on their schedule and then negotiate with MVPDs.[44]

There are occasional disputes and blackouts that occur when a content company cannot strike a deal with a cable or satellite operator. This is what occurred in 2012 in carriage spats between AMC and Dish[45] as well as Viacom and DirecTV.[46] There are no special rules that either side

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MVPD competition], programmers have more options available to them to reach audiences and are able to negotiate with distributors from a position of strength . . . .").

41 Katerina Eva Matsa, "Time Warner vs. CBS: The high stakes of their fight over fees," Pew Research, August 21, 2013, http://www.pewresearch.org/fact-tank/2013/08/21/time-warner-vs-cbs-the-high-stakes-of-their-fight-over-fees/.

42 SNL Kagan, Press Release, "SNL Kagan Releases Updated Industry Retransmission Fee Projections," November 22, 2013, http://www.snl.com/InTheMedia.aspx. Further, retransmission's ostensible purpose—to provide revenue to local broadcasters—largely isn't even accomplished today since the national broadcast networks require "reverse retrans," where the local broadcaster remits a portion of their retransmission payments to the network. Richard Greenfield, "The Disequilibrium of Power: How Retransmission Consent Went So Wrong and How to Fix It," *AllThingsD*, August 27, 3013, http://allthingsd.com/20130827/the-disequilibrium-of-power-how-retransmission-consent-went-so-wrong-and-how-to-fix-it.

43 Preston Padden, *Testimony Before U.S. Senate Committee on Commerce, Science and Transportation*, July 24, 2012, http://siliconflatirons.com/documents/publications/policy/PaddenTestimony.pdf.

44 Id.

45 William Launder & Suzanne Vranica, "The Plot Thickens for AMC As Blackout Crimps Growth," *Wall Street Journal*, Aug. 20, 2012,http://online.wsj.com/news/articles/SB10000872396390444233104577595771359471812.

46 Brian Stelter, "DirecTV and Viacom Settle Dispute Over Fees, Restoring Service," *New York Times*, July 20, 2012, http://mediadecoder.blogs.nytimes.com/2012/07/20/directv-and-viacom-settle-dispute-over-fees-restoring-service/?_php=true&_type=blogs&_r=0.

could rely on in those instances. But, in both cases, these contractual disputes were resolved in fairly short order and programming continued. This is what would occur for broadcast programming in a free marketplace. Contractual carriage disputes and even occasional blackouts will continue but will be resolved.[47] There is no reason special carriage rules need apply to some content companies simply because some of their properties are broadcast stations.

Media Ownership

The regulatory landscape is further complicated by a complex web of media ownership restrictions that artificially limit transactions and the contours of media markets. Even though media combinations are already covered by antitrust laws,[48] media properties—particularly broadcasters—were singled out for special regulation by both Congress and the FCC. These rules include:[49]

- **National TV Ownership Rule (TV Audience Cap)**: Networks' ownership of affiliated broadcast stations was first capped by the FCC in 1941, set at three broadcast stations.[50] Over the years, the FCC's cap permitted more ownership of stations.[51] In the 1996 Telecommunications Act Congress permitted networks to own TV stations with a combined national audience reach of 35 percent.[52] In 2004, Congress raised the cap to 39 percent.[53]
- **Dual Television Network Rule**: Adopted in 1946, and modified at the direction of Congress in the 1996 Telecom Act, the rule prohibits any of the top four traditional TV networks (CBS, NBC, ABC, and Fox) from affiliating with or acquiring each other.[54]
- **Local TV Multiple Ownership Rule**: Adopted in 1964, the complex rule prevents a firm from owning more than two TV stations in a designated market. Further, a firm can't own two stations if the commonly-owned stations are two of the top four stations in the market or the combination would leave fewer than eight independently owned stations.[55]

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47 Adam Thierer, "CBS, Time Warner Cable & TV Blackouts: What Should Washington Do?" *Technology Liberation Front*, August 12, 2013, http://techliberation.com/2013/08/12/cbs-time-warner-cable-tv-blackouts-what-should-washington-do.

48 See, e.g., United States v. RCA, 358 U.S. 334 (1959) ("The prohibitions of the Sherman Act apply to broadcasting."); NBC v. United States, 319 U.S. 190, 223 (1943).

49 *See* Federal Communications Commission, "Review of the Broadcast Ownership Rules," http://www.fcc.gov/guides/review-broadcast-ownership-rules; Federal Communications Commission, "Rules Adopted in the Quadrennial Review Order," http://transition.fcc.gov/ownership/rules.html.

50 See Broadcast Services Other than Standard Broadcast, 6 Fed. Reg. 2282, 2284-85 (May 6, 1941).

51 See Stuart Minor Benjamin, "Evaluating the Federal Communication Commission's National Television Ownership Cap," 46 *Wm. & Mary L. Rev.* 439 (2004).

52 Pub. L. No. 104-104, 110 Stat. 56.

53 Consolidated Appropriations Act, 2004, Pub. L. No. 108-199, § 629, 118 Stat. 3, 99-100 (2004) (amending section 202(c) of the 1996 Telecommunications Act).

54 47 CFR 73.658(g). See FCC In the Matter of Amendment of Section 73.658(g) of the Commission's Rules – The Dual Network Rule, MM Dkt. No. 00-108, 16 FCC Rcd 11114, 11115-16 (2001) ("[A]ffiliation is prohibited . . . if the multiple network combination is created by a merger among ABC, CBS, Fox, or NBC . . . .").

55 47 CFR 73.3555(b).

- **TV-Radio Cross-Ownership Ban**: Adopted in 1970, the rule limits the number of radio stations that can be owned by a TV station owner in the same market, using a sliding scale based on the number of broadcast stations in the market.[56]
- **Broadcast-Newspaper Cross-Ownership Ban**: Adopted in 1975, the rule prohibits a newspaper owner from also owning a television or radio station in the same local market.[57]
- **Cable Ownership and Affiliated Channel Caps**: The Cable Act of 1992 directed the FCC to create rules limiting the number of customers reached by a cable system and limiting the number of affiliated channels a cable provider could carry.[58] The FCC tried imposing a 30 percent cap on the market share of a cable operator but that was struck down by the courts.[59] The vertical rule places a cap of 40 percent on the amount of affiliated programming cable operators could put on their own systems.[60]

A decade ago, the FCC made an attempt to reform many of these rules during the tenure of Chairman Michael Powell.[61] The effort was met with a vociferous opposition of some media access organizations, however, which mounted major grassroots efforts to thwart changes.[62] As a result, few of the rules were reformed and subsequent efforts to reform even individual rules have gone nowhere.[63] Meanwhile, each new proposed media combination has met with a similar backlash[64] and these rules are invoked as a means of stopping the evolution of media markets.

II. Legislative Reform Proposals in the 113th Congress

Several bills have been introduced in this session of Congress recently to address the rapidly-changing video marketplace. Some take a more comprehensive approach to video reform but most others only narrowly address one part of the complex web of rules. Bill sponsors are also noted.

H.R. 3720 – *Next Generation Television Marketplace Act* (Scalise-Gardner)

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56 47 CFR 73.3555(c).

57 47 CFR 73.3555(d).

58 47 USC 533(f). When a cable operator has an "attributable interest" in a network, the FCC imposes carriage restrictions. For example, Comcast merged with NBC Universal in 2011 and now has attributable interests in MSNBC, CNBC, Bravo, and other NBC programming.

59 Comcast Corp. v. FCC, 579 F.3d 1 (DC Circuit 2009).

60 47 CFR 76.504.

61 Federal Communications Commission, *In the Matter of 2002 Biennial Regulatory Review – Review of the Commission's Broadcast Ownership Rules and Other Rules Adopted Pursuant to Section 202 of the Telecommunications Act of 1996*, FCC 03-127, June 2, 2003, p. 4, http://hraunfoss.fcc.gov/edocs_public/attachmatch/FCC-03-127A1.pdf, cited hereafter as FCC, *Media Ownership Proceeding*.

62 Adam Thierer, *Media Myths: Making Sense of the Debate over Media Ownership* (Washington, D.C.: Progress & Freedom Foundation, 2005): 2-3, http://www.pff.org/issues-pubs/books/050610mediamyths.pdf.

63 Gautham Nagesh, "FCC Withdraws Proposal to Relax Media-Ownership Rules," *Wall Street Journal*, December 16, 2013, http://online.wsj.com/news/articles/SB10001424052702303949504579262803786617112.

64 Adam Thierer, "A Brief History of Media Merger Hysteria: From AOL-Time Warner to Comcast-NBC," Progress & Freedom Foundation, *Progress on Point* 16.25, Dec. 2, 2009, http://www.pff.org/issues-pubs/pops/2009/pop16.25-comcast-NBC-merger-madness.pdf; Adam Thierer, "A Media Morality Play," *Forbes*, December 15, 2009, http://www.forbes.com/2009/12/14/media-merger-antitrust-opinions-contributors-adam-thierer.html.

Of all of the pending video bills, only the Scalise-Gardner bill attempts comprehensive reform by peeling away the decades' worth of regulatory detritus. The bill asks all sides to give a little through repeal of several sections of the Copyright Act and the amended 1934 Communications Act.

Under the bill, broadcasters and broadcast networks would need to give up retrans and must carry rules but they gain the elimination of compulsory licensing requirements of the Copyright Act of 1976, which essentially forced a "duty to deal" upon them. They have to let cable operators and other video distributors retransmit local stations but the bill allows them to get full compensation for their content through marketplace bargaining.

The Next Generation Television Marketplace Act repeals seven sections of the Communications Act and eliminates various FCC regulations that distort the television market, including regulations about channel positioning, network nonduplication, syndicated exclusivity, and sports blackouts. The bill also eliminates FCC restrictions on the number of stations a person can own in the same market, the radio-television cross-ownership prohibitions, and the limitations newspaper owners face when controlling a television station.

The measure also repeals must-carry requirements, which force MVPDs to carry even low-value local broadcast signals.[65] It also repeals the requirement MVPDs pay broadcasters for retransmission rights.[66] The bill frees cable companies from Section 532 of the Communications Act, which requires cable operators to set aside 10% or more channel capacity for unaffiliated programmers or affiliated minority programmers. That section also gave the FCC authority to decide what are reasonable rates and terms between programmers and cable operators. The bill prohibits all federal and state franchising authorities from regulating MVPDs' rates and the retransmission of broadcast signals.

The Copyright Office reported in its 2009 SHVERA report that "fundamental shifts" in television viewing "call into question the appropriateness of the [compulsory] licensing systems."[67] The report went on to say that "the current distant signal licenses have served their purpose but are no longer necessary, and that Sections 111 and 119 of the [Copyright] Act have outlived their original purposes."[68] The Copyright Office's "principal recommendation is that Congress should abandon Sections 111 and 119 of the [Copyright] Act."[69] In 2010, Congress directed the Copyright Office to explore ways to phase-out these compulsory licenses.[70] Scalise-Gardner does just that: it repeals Section 119 and amends 111 so that market transactions can take place between MVPDs and distant broadcast networks. It also repeals Section 122, which

65 See 47 USC § 534.
66 See 47 USC § 325.
67 U.S. Copyright Office, SHVERA § 109 Report 19 (2008), http://www.copyright.gov/reports/section109-final-report.pdf.
68 U.S. Copyright Office, SHVERA § 109 Report 56 (2008), http://www.copyright.gov/reports/section109-final-report.pdf.
69 U.S. Copyright Office, SHVERA § 109 Report 85 (2008), http://www.copyright.gov/reports/section109-final-report.pdf.
70 Satellite Television Extension and Localism Act of 2010, Sec. 302.

permits satellite carriers to retransmit local broadcast signals on a royalty-free basis and without authorization from the copyright holders.

S.1680 – *Consumer Choice in Online Video Act* (Rockefeller)

Senator Rockefeller's bill, released in late 2013, proposes to "promot[e] the development of online video distribution platforms and fair competition" amongst all television distributors through increased oversight by the FCC. Unfortunately, the Act carries over many television regulations into the nascent Internet video industry and gives the FCC substantial abilities to shape online video competition. Significantly, the bill designates a new class of businesses called online video distributors (OVDs)—like Netflix and Redbox Instant—and essentially repurposes ISPs' networks for OVDs' benefit.

The bill lays out principles for competition and gives the FCC generous discretion to enforce those principles. For example, it's "unlawful . . . [for a designated distributor or an ISP] to engage in unfair methods of competition or unfair or deceptive acts or practices, the purpose or effect of which are to hinder significantly or prevent an [OVD] from providing video programming to consumers…," including over the Internet or any device. The bill delegates rulemaking to the FCC to determine what "unfair methods" are, what "hinders significantly," and what is deceptive.

Further, the bill instructs the FCC to prevent a distributor from "unduly or improperly influencing the decision of any other entity to make a television set or other [CPE] incompatible with the services provided by any [OVD];" "unduly or improperly using its own [CPE] to discriminate against or otherwise favor its own services" over any OVD; "unduly or improperly influencing the decision of any other entity to sell, or the prices, terms, and conditions of sale of, video programming to any [OVD]"; and "providing an incentive to any entity in an attempt to deny video programming to an [OVD]." All of the operative words in these sections are left to the discretion of the FCC. An aggressive FCC could use these provisions to radically shape commercial contracts and television competition.

The bill provides the FCC a review process to review any contract between MVPDs, programmers, and OVDs. All of these contracting costs, ironically only encourages vertical mergers (subject to existing media ownership restrictions). Mergers between traditional distributors, online distributors, and programmers would substantially lower transaction costs this bill imposes. Absent a merger, most firms face severe regulatory risks since the FCC is injected into nearly every agreement between content producers and distributors.

Broadcasters are penalized in this bill because they will be required to negotiate with OVDs under rules a future FCC will issue. Broadcasters also won't be allowed to place any restriction on an OVD's distribution to subscribers. The bill blesses the existence of antenna rental services, like Aereo, as long as they only serve local broadcasts to the respective local area, and exempts those services from paying retransmission fees.

The bill essentially implements net neutrality on Internet Service Providers (ISPs) when they deal with OVDs. ISPs can't block, degrade, unreasonably discriminate against OVDs and can provide no transmission benefits to affiliated OVDs. ISPs are also prohibited from usage-based billing that deters competition from unaffiliated OVDs. During disputes in this new television market, the FCC may establish prices, terms, and conditions of sale of programming to OVDs.

In addition to cable and satellite companies, the bill introduces another regulatory silo: non-facilities based MVPD (NFB MVPD). If an OVD provides programming reasonably equivalent to a MVPD, the OVD can elect to be treated as a non-facilities based MVPD. This election brings many of the existing television regulations onto this new market participant but exempts the NFB MVPD from others. The FCC can decide what MVPD regulations should apply to NFB MVPDs, guided by its public interest standard. There are some requirements, though.

NFB MVPDs must allow reasonable amount of time for candidates for federal office and, if one allows a candidate to use its facilities, it must allow all eligible candidates to use its facilities. NFB MVPDs are exempted from complying with "basic tier and tier buy-through" requirements. NFB MVPDs may also carry non-local broadcasts. NFB MVPDs are exempt from network non-duplication, syndicated program exclusivity, and sports blackout rules. NFB MVPDs are also exempt from any franchising authority. NFB MVPDs cannot be required to carry local broadcasts as a condition of carrying non-local broadcasts. NFB MVPDs that carry local signals must carry, upon request, noncommercial educational broadcast signals in the same local area. NFB MVPDs have channel reservation requirements. They must reserve between 3.5% to 7% of channel capacity for educational and informational programming. They must also make channel capacity available to each national educational programmer upon reasonable prices and terms. Finally, NFB MVPDs carrying any broadcast signal is considered a "cable system" and thus subject to compulsory licensing requirements and royalty payments. Oddly, NFB MVPD-subscribing households cannot be considered in the FCC's determination of whether a traditional cable system is subject to effective competition in that franchise area.

H.R. 3719 – *The Video Choice Act* (Eshoo)

Rep. Eshoo's bill limits itself mostly to retrans disputes, which are disruptive for consumers. In a retrans negotiation impasse, the bill allows the FCC to permit the MVPD's interim carriage of the broadcast station pending conclusion of the impasse.

The bill also contains an anti-tying—or a la carte—provision. A broadcaster who grants retrans can't enter into an agreement with an MVPD that in any way conditions carriage of retrans programming—which is popular—on carriage of other, less popular programming. As for cable operators, they must offer subscribers a separate tier (called the retrans consent tier) consisting only of broadcast signals. This tier is subject to rate regulation, same as the basic cable service tier. A cable operator can't require purchase of any tier, other than the basic cable service tier, to receive the retrans consent tier. In telecom-speak, this is a buy-through prohibition.

The Video Choice Act focuses on important consumer issues—the disruptiveness of retrans disputes and the relatively high cost of cable packages. However, the bill attempts to remedy the symptoms of flawed video markets, not the causes. Retrans fights are complicated by the fact that network nonduplication and syndicated exclusivity rules prevent cable companies from contracting with other broadcasters at impasse. And cable packages are expensive bundles in part because the FCC and Congress have mandated the carriage of broadcast content, PEG channels, and non-affiliated content in every cable package. This bill only adds more complexity—including price controls of the retrans consent tier—to television markets.

S. 1721 – *Furthering Access and Networks for Sports Act ("FANS Act)* (Blumenthal-McCain)

In November 2013, Sens. Blumenthal and McCain introduced the Furthering Access and Networks for Sports Act. In short, the Act eliminates the FCC's sports blackout rules. Sports leagues currently have a limited antitrust exemption under the Sports Broadcasting Act, in place since 1961.[71] The bill would once again extend antitrust laws to leagues and distributors who prohibit distribution in the home territory of the home team.

For leagues to enjoy the current antitrust exemptions of the Sports Broadcasting Act, the league would have to prohibit any television licensee from deliberately removing sports games from a cable or satellite distributor during distribution contract negotiations. A league would also have to make a game available, for a fee or otherwise, over the Internet when a game is not available via television through broadcasters or pay TV.

Removing the sports blackout rules are beneficial as the rules prevent bargaining between pay-TV operators and major sports leagues. Removing the limited antitrust exemption sports leagues currently enjoy is also commended since the exemption is a special-interest concession.[72] Conditioning the exemption on the leagues' efforts to make games available to MVPDs during retrans negotiations, however, only threatens the leagues with an ill-conceived antitrust exemption. Rather than use the exemption to induce leagues to make programming widely available, the antitrust exemption should be simply be eliminated.

S. 1912 **–** *The Television Consumer Freedom Act* (McCain)

Sen. McCain for years has attempted to bring some a la carte channels to the television market. This Act withholds some regulatory benefits if a distributor does not make its content available a la carte. The bill rescinds benefit of the statutory compulsory license fees for MVPDs if they don't offer retransmitted channels to consumers on an a la carte basis. Again, this piecemeal legislation has the potential to distort television markets further. A simpler solution is to remove the requirement that MVPDs carry retransmitted broadcasts on their basic tiers.

To further promote a la carte programming, the bill also rescinds regulatory benefits to broadcasters. The bill provides that a broadcaster may not elect retrans fees or avail itself to network nonduplication and syndicated exclusivity rules if the station is not made available to MVPDs on an a la carte basis. Finally, program vendors—like Viacom and Time Warner—can only offer program bundles to distributors if they also offer programming on an a la carte basis. Bundling programs is generally economically efficient[73] so a requirement to unbundle is counterproductive.

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71 15 USC 1291.

72 We would, however, predict little impact from removing the exemption since antitrust law has changed considerably since the time the exemption was granted. It is unlikely the antitrust agencies could support a lawsuit against the leagues under current economic theories of harm.

73 David S. Evans & Michael Salinger, "Why Do Firms Bundle and Tie? Evidence from Competitive Markets and Implications for Tying Law," *22 Yale J. on Reg*. 37 (2005).

Conclusion

Regulatory reform is needed to clear out the regulatory detritus of the past half century, both because it limits market opportunities for existing media providers and also threatens to spread and limit opportunities for future content creators and distributors. It is discouraging that most of the bills Congress is contemplating only offer marginal improvements or actually burden the marketplace with more regulations. Only a comprehensive reform along the lines of the Scalise-Gardner "Next Generation Television Marketplace Act" can address this regulatory thicket. Such a legislative solution would declutter the modern media legal landscape and give media innovators the freedom to experiment. By contrast, the Rockefeller bill represents the most significant attempt to expand regulation of the video marketplace and would set back needed liberalization efforts. The other measures currently pending in Congress only narrowly address needed reforms, and often do so by adding greater complexity to the current regulatory system.

Repealing outdated analog era video marketplace regulations will lead to even more experimentation with new business models, technologies, and methods of content creation and delivery. We already see much innovation in this marketplace despite all the red tape that exists.[74] As noted, many alternative video delivery platforms exist today. Broadcast and cable giants have made strides in recent years, too. CBS is a good model for how content can be re-purposed online in creative ways on a firm's own digital platform. Likewise, Walt Disney, has effectively utilized the combination of its ABC and ESPN properties to offer consumers a seamless sports experience across broadcast, cable, and Internet platforms. Meanwhile, cable companies like Time Warner Cable are adapting to consumers' demand for video to be delivered to multiple devices. Finally, innovation from online platforms – such as Internet giants like Amazon, Apple, Google, and Microsoft, among others -- continues at a healthy clip.

A deregulated market is not a nirvana, of course. Great content and great delivery platforms don't happen by magic or the good intentions of activists or policymakers. That content and those platforms come about because new markets and monetization mechanisms develop to facilitate them. Comprehensive liberalization of America's video marketplace can help ensure more media content is developed and distributed, thereby prolonging today's Golden Age of Television.

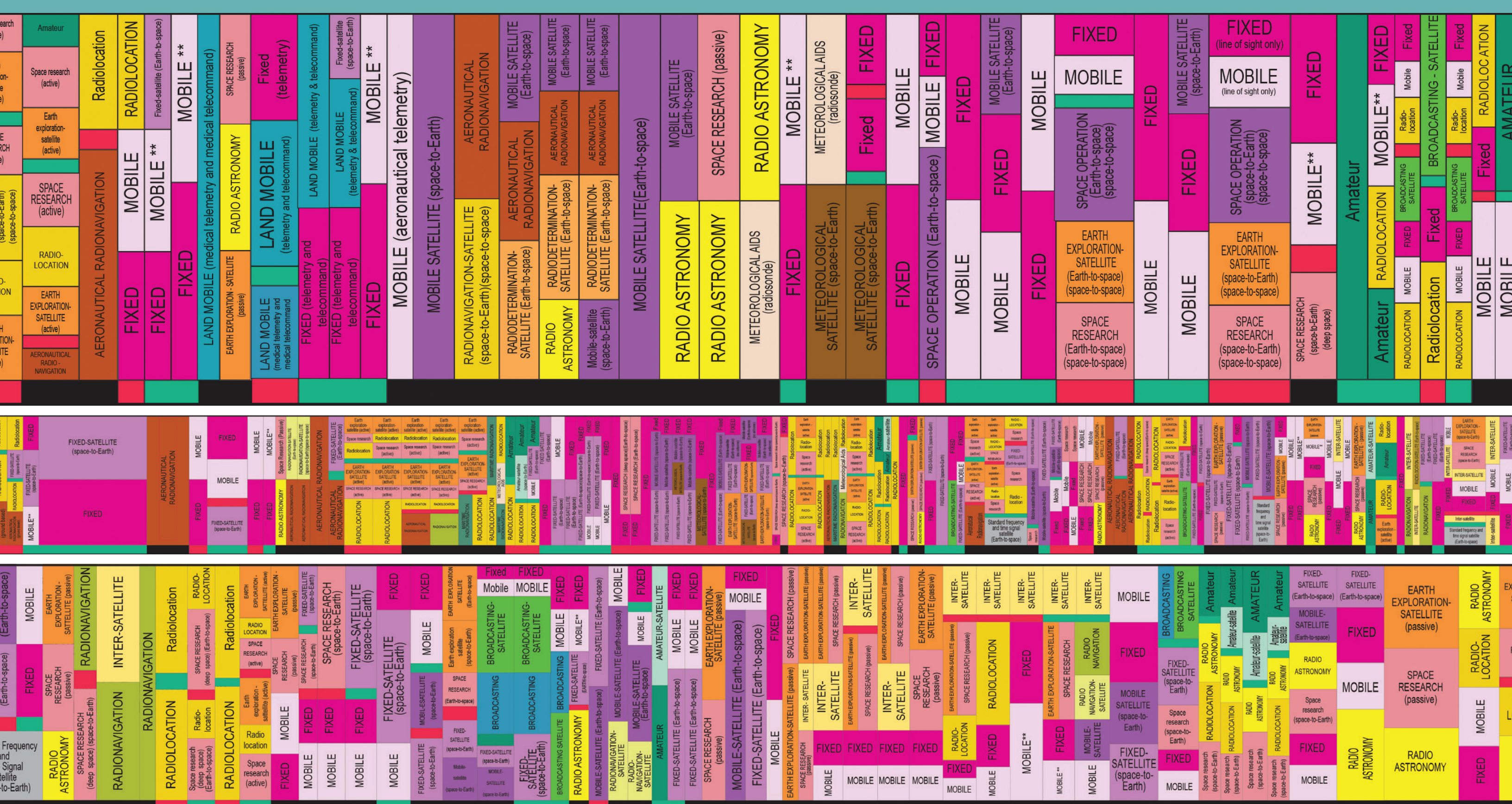
[74] Adam Thierer, "Television: From Vast Wasteland To Vast Wonders," *Forbes*, May 16, 2011, http://www.forbes.com/sites/adamthierer/2011/05/16/television-from-vast-wasteland-to-vast-wonders.

THE HAMILTON PROJECT

DISCUSSION PAPER 2014-01 | MARCH 2014

Unlocking Spectrum Value through Improved Allocation, Assignment, and Adjudication of Spectrum Rights

J. Pierre de Vries and Philip J. Weiser



MISSION STATEMENT

The Hamilton Project seeks to advance America's promise of opportunity, prosperity, and growth.

We believe that today's increasingly competitive global economy demands public policy ideas commensurate with the challenges of the 21st Century. The Project's economic strategy reflects a judgment that long-term prosperity is best achieved by fostering economic growth and broad participation in that growth, by enhancing individual economic security, and by embracing a role for effective government in making needed public investments.

Our strategy calls for combining public investment, a secure social safety net, and fiscal discipline. In that framework, the Project puts forward innovative proposals from leading economic thinkers — based on credible evidence and experience, not ideology or doctrine — to introduce new and effective policy options into the national debate.

The Project is named after Alexander Hamilton, the nation's first Treasury Secretary, who laid the foundation for the modern American economy. Hamilton stood for sound fiscal policy, believed that broad-based opportunity for advancement would drive American economic growth, and recognized that "prudent aids and encouragements on the part of government" are necessary to enhance and guide market forces. The guiding principles of the Project remain consistent with these views.

THE HAMILTON PROJECT

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THE HAMILTON PROJECT

Unlocking Spectrum Value through Improved Allocation, Assignment, and Adjudication of Spectrum Rights

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MARCH 2014

NOTE: This discussion paper is a proposal from the authors. As emphasized in The Hamilton Project's original strategy paper, the Project was designed in part to provide a forum for leading thinkers across the nation to put forward innovative and potentially important economic policy ideas that share the Project's broad goals of promoting economic growth, broad-based participation in growth, and economic security. The authors are invited to express their own ideas in discussion papers, whether or not the Project's staff or advisory council agrees with the specific proposals. This discussion paper is offered in that spirit.

BROOKINGS

Abstract

Technological developments have continued to increase the importance of radio spectrum, with citizens, companies, and government users increasing their use of wireless-enabled services of all kinds, from smartphone apps to satellite navigation. Since technology places limits on the coexistence of multiple radio systems, usage rights must be allocated among various competing uses. Currently, the management of the wireless spectrum in the United States (and in many other countries) is heavily constrained by government regulation. That makes it difficult for spectrum players—whether they are wireless service providers, citizens using unlicensed devices, or government users—to reach mutually agreeable, efficiency-enhancing agreements through direct negotiation with one another.

This Hamilton Project discussion paper describes the importance of moving toward a more economically efficient system for managing the use of wireless spectrum, and proposes concrete policy steps to move us closer to such a system. In particular, it sets forth three pillars of a reformed policy regime: (1) reduce ambiguity about the responsibilities of receivers to tolerate interference by defining harm claim thresholds that state the signal levels that must be exceeded before one operator can claim harmful interference by another, (2) reduce the drawbacks of excessive band fragmentation by introducing band agents that could represent large groups of licensees in negotiating changes in operating rights with neighbors, and (3) move adjudication from the current ad hoc and politically charged process to a more fact-based procedure that can resolve spectrum-related disputes in a timely fashion using judges with expertise in spectrum policy, either in the FCC and/or in a newly created Court of Spectrum Claims.

All three proposals reform the legacy spectrum policy framework by empowering individual spectrum licensees to develop win-win solutions without having to invoke time-consuming regulatory processes. Taken together, these reforms promise to move more spectrum management from a model more closely controlled by regulators to one authorizing end users to make more-flexible, win-win uses of spectrum. Based on our rough estimates, we conclude that these reforms could result in a total of a $10 billion per year in additional consumer surplus.

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Chapter 1: Introduction

The operation of wireless devices has become one of our nation's most valuable forms of economic activity. The wide range of devices using radio frequencies—also commonly referred to as wireless spectrum, or simply "spectrum"—includes cell phones, Wi-Fi networks, GPS devices, terrestrial and satellite TV, air traffic control systems, and even garage door openers. Because there are technological limits on the ability of multiple radio systems to coexist, usage rights must therefore be managed among various uses, industries, and competing interests. At present, the United States' spectrum policy framework largely constrains how wireless devices can be used. This discussion paper addresses the challenge of reforming our legacy policy framework and moving toward a more economically efficient use of wireless spectrum, proposing a set of policy steps to do just that.[1]

The wireless spectrum is separated into frequency bands. A receiving system in one band can tolerate a certain amount of wireless energy transmitted in neighboring bands before the quality of its service is degraded by a neighbor's "interference." The degree of interference that can be tolerated by any given system is also influenced by the characteristics of its own receiving and transmitting equipment. These considerations constantly change as technology and business models evolve. As with any other limited resource, more-efficient use of spectrum rights can lead to economic and social welfare gains.

Technological developments have underlined the importance of spectrum. Between 2009 and 2012, annual investments in U.S. wireless networks rose more than 40 percent—from $21 billion to $30 billion, according to a White House (2013) report—and will likely continue to rise in the future. The U.S. Department of Defense (DoD), moreover, is forecasting exponential growth in its spectrum requirements, with data use forecasted to grow roughly six times between 2000 and 2020 (DoD 2013). Given the importance of all these technologies, maximizing the efficient use of spectrum is a critical policy goal.

Over the past few decades, policymakers have sought to expand wireless services by providing access to frequencies that had previously been controlled by government or private users and could be transitioned relatively easily to more economically efficient uses. But there are few remaining opportunities for easily clearing additional spectrum. Today's great spectrum policy challenge is thus to maximize the value that can be derived from bands already in use. This challenge in turn requires a new framework for the decentralized management of the wireless spectrum.

The Federal Communications Commission (FCC), the independent federal agency responsible for regulating spectrum not used by the federal government, has already started to move away from its legacy command-and-control model of regulation, which greatly restricts how users can operate wireless services. As an alternative model, the FCC has begun to embrace approaches that offer more flexibility by approximating property rights in some cases, and allowing spectrum use by all comers using approved devices (i.e., leaving spectrum as a "commons") in others. There is, however, an important frontier that neither the FCC nor the National Telecommunications & Information Administration (NTIA), the entity managing federal spectrum, has fully explored: how to manage and adjudicate rights in wireless spectrum so that large bands of spectrum are not left underused. As we explain later in this discussion paper, the primary reason for such inefficiencies is a lack of clarity concerning interference prevention between neighboring spectrum users and an inadequate system for allowing trades and resolving disputes between users. The result is that economically efficient spectrum deals are not completed.

The recent case of the company LightSquared serves as an example of the issues that our proposed reforms attempt to address. LightSquared filed for bankruptcy in 2012 following the FCC's ruling that the company would not be allowed to deploy the terrestrial mobile network it had planned in the band adjacent to the one used for GPS operations. If this network had been deployed, its proponents argued, it would have created $120 billion in consumer value (Bazelon 2011). Opponents claimed that it would have cost the aviation community at least $70 billion (Federal Aviation Administration [FAA] 2011). The dispute boiled down to the implications for LightSquared of rules developed almost a decade earlier, and the rights of the myriad GPS users to protection from harmful interference from transmissions in neighboring bands. As the case unfolded, it underscored the challenges LightSquared faced in reaching any accommodation with the many and various interests in the GPS band. It also underscored the difficulty of overcoming the unpredictability of the U.S. regulatory process for deciding harmful interference claims.

To meet today's spectrum policy challenges (discussed in detail in sections II and III), including dealing with conflicts like that between LightSquared and the GPS industry, this discussion paper outlines three policy reforms that would form the pillars of a new framework for spectrum policy. These reforms would:

1. Reduce the ambiguity about the responsibilities of receivers to tolerate interference by *defining harm claim thresholds*, which would govern what in-band and out-of-band interfering signal levels must be exceeded before a system can claim that it is experiencing harmful interference (subsection IV.A);

2. Overcome the drawbacks of excessive band fragmentation by *introducing band agents*, entities that could represent large groups of licensees in negotiating changes in operating rights with neighbors (subsection IV.B); and

3. *Transform adjudication* from the current ad hoc and politically charged process to a more fact-based procedure that could resolve spectrum-related disputes in a timely fashion using judges with expertise in spectrum policy, either in the FCC and/or in a newly created Court of Spectrum Claims (subsection IV.C).

All three recommended reforms are based on a recognition that today's regulatory regime makes it difficult for spectrum players to reach mutually agreeable, efficiency-enhancing agreements through direct negotiation with one another. Moreover, all three aim to decentralize spectrum management by allowing players to find productive arrangements without government regulators as gatekeepers. Taken together, these reforms promise to move spectrum management from central regulatory control to greater empowerment of end users, enabling more-flexible, win-win uses of spectrum and providing economic benefits of a roughly estimated $10 billion per year in additional consumer surplus (section V).

Chapter 2: Background

As wireless technologies have proliferated over the past several decades, the demand for access to spectrum has increased markedly. During that period, however, regulators have not fundamentally questioned whether there are now more-efficient strategies for overseeing spectrum and managing interference issues. In particular, regulators have often failed to act on the possibility that the benefit from increasing the allowed transmitted signal strength (leading to faster data transfers, for example) is greater than the adverse impact of the increased signal strength on the party experiencing interference.

A. KEY PLAYERS IN THE SPECTRUM LANDSCAPE

Understanding the status quo of spectrum policy requires understanding the key players involved. The FCC and the NTIA in the U.S. Department of Commerce are the government bodies directly involved in the regulation of spectrum. The FCC regulates the use of wireless spectrum by private firms, individuals, and by nonfederal public agencies. The NTIA oversees the multifarious federal government uses, including military radar systems, weather observation, and aviation, to name a few. In many cases, such as satellite services and aviation, oversight is shared between the FCC and the NTIA. Congress oversees the operations of the NTIA and the FCC, and plays an active role in shaping the spectrum rights landscape.

Because there are so many different services that use spectrum, there are many different actors with stakes in how spectrum rights are managed. Large telecommunications companies like AT&T and Verizon are prominent holders of rights to the "licensed" portion of the wireless spectrum. Other notable licensees include broadcasters, satellite network operators, point-to-point microwave services, and amateur radio operators. Players in the "unlicensed" portions of the wireless system, where operation is controlled by equipment regulation rather than by licenses, are more diverse, and include technology companies like Google and Microsoft, manufacturers like Cisco and Qualcomm, wireless internet service providers, and public interest organizations. More recently, the cable industry has become an important stakeholder in unlicensed allocations; Comcast, for example, has deployed nearly 350,000 Wi-Fi access points (Nagel 2013).

Because there are so many different services that use spectrum, there are many different actors with stakes in how spectrum rights are managed.

B. MANAGING INTERFERENCE

The more wireless systems can operate concurrently, the greater the value of spectrum use. Because two radio systems that operate at the same time, place, and frequency—in other words, that "use the same spectrum"—tend to degrade each other's performance, government regulators have long overseen radio operations. Traditionally, they have used command-and-control regulation to closely prescribe how radios could be used.

Since radio systems can degrade each other's performance, "interference" is a critical concept in spectrum policy (see box 1). The amount of service degradation a receiver experiences is a combination of the strength of the unwanted signals delivered by the adjacent service, and the receiver's ability to pick out its desired signal from the surrounding unwanted signals. The responsibility for harmful interference is therefore shared between transmitters and receivers.

BOX 1.

Interference

Interference is defined in the FCC Rules as "the effect of unwanted [radio] energy . . . upon reception in a radiocommunication system, manifested by any performance degradation, misinterpretation, or loss of information which could be extracted in the absence of such unwanted energy" (FCC Not dated [b], 47 Code of Federal Regulations [CFR] § 2.1). Such effects are unavoidable; systems are expected to be designed to tolerate interference unless it rises to the level of "harmful interference." For its part, the FCC defines harmful interference as, "interference which endangers the functioning of a radionavigation service or of other safety services or seriously degrades, obstructs, or repeatedly interrupts a radiocommunication service operating in accordance with [the ITU] Radio Regulations" (FCC Not dated [b], 47 CFR § 2.1).

It is important to appreciate that the Communications Act of 1934 sets out the goal of maximizing the value of radio operations—not minimizing interference to any particular spectrum licensee. The impression that the regulatory goal is to minimize mere interference per se may have arisen due to a now-superseded statute of the Radio Act of 1912 that stated that private and commercial stations would be subject to regulations "for the purpose of preventing or minimizing interference with communication between stations in which such apparatus is operated" (Radio Act of 1912, section 4). Under the 1934 Act, the FCC must prevent interference where it deems it necessary, permitting it to "provide flexibility of use [as long as] such use would not result in *harmful* interference among users" (Communications Act of 1934, section 47.303; emphasis added). The statutory imperative is thus not to minimize any interference, but rather to prevent harmful interference. While the definition of harmful interference is broad, it is by definition considerably more stringent than mere interference.

Since the strength of radio signals generally decreases with distance, two wireless systems can operate simultaneously at the same frequencies if they are well separated geographically. This leads to the issuance of licenses based on geographical operating assignments. In practice, these licenses can be organized either by transmitter location or, as they increasingly have been, by designating geographic operating areas. The regulator seeks to limit the effect of one operation on another by imposing operating rules that limit, for example, the transmit power and the amount of signal power that an operator may deliver outside its assigned geographic area and frequencies.

Two wireless systems can operate simultaneously in the same area by using different frequencies. Each transmitter broadcasts on its designated frequencies, and their respective receivers tune to those frequencies, filtering out signals on other frequencies. If the filtering does not reject signals on other frequencies sufficiently well, the device may be unable to operate as designed. Interference can be mitigated by spacing out services in frequency or by using more-frequency-selective, and thus expensive, receivers. Now that spectrum is more crowded and the demand for it is increasing, however, spacing out services is increasingly ineffective. There have been numerous cases where poor receiver performance has precluded or delayed the introduction of valuable new services (NTIA 2003, section IV; FCC TAC Sharing Working Group 2011, appendix C). In many cases today, unlike in the past, the most cost-effective approach is to expect more from receivers by requiring better filters.

Given the reality that filters are imperfect, operation in one frequency band can degrade operations in an adjacent band. In economic terms, radio interference is a negative externality, not unlike pollution. Indeed, unwanted interference can be viewed as a kind of pollution to the licensee of a frequency band who must contend with unwanted interference. Interference inflicts, in other words, a cost on the licensee that it must mitigate or manage (whether by using filters or other methods to manage interference). As Nobel laureate Ronald Coase famously explained, all harm is reciprocal—e.g., one person's harm is another person's benefit, and vice versa (see box 2).

C. SPECTRUM MANAGEMENT PARADIGMS

Since the 1990s the FCC has begun to move away from a command-and-control model of regulation, seeking to provide individual operators with more discretion. Traditionally, regulators have specified not only which stations may operate in a given spectrum range, but also the services that spectrum operators should offer and the technology that they should use. For example, television stations are obligated to broadcast using a particular technology standard. Recently, the FCC has grown increasingly reluctant to specify the service to be offered or the relevant technology to be used.

Two alternative models are beginning to replace the legacy command-and-control model of regulation: (1) exclusive, tradable, and flexible use licenses assigned by auction (e.g., for mobile cellular services); and (2) open access or "unlicensed" regimes that allow unlicensed flexible use (e.g., Wi-Fi, Bluetooth, cordless phones, smart meters, and garage

BOX 2.

Command and Control, Contracts, and Coase

Ronald Coase is known as one of the founders of the Law and Economics movement and is a Nobel laureate, recognized for his work on property rights in "The Problem of Social Cost." This article, published in 1960, built on Coase's earlier work on spectrum policy in "The Federal Communications Commission" (1959). In both articles, Coase explained that, with established property rights and low transaction costs, parties can contract—through what is now called Coasian bargaining—to reach efficient outcomes (that is, win-win solutions that make both parties better off).

door openers). Proponents of each approach have spent considerable energy debating the relative merits of the two approaches despite the fact that they are being implemented side by side, and that both provide viable alternatives to the legacy command-and-control regime.

There are significant opportunities to reform the legacy command-and-control model of regulation. The framework for these opportunities was laid out in a classic article in 1959 on spectrum regulation by Nobel laureate and property rights pioneer Ronald Coase. In that article, Coase called for a move away from command-and-control regulation and toward a system where parties could negotiate between themselves.

Given the well-known frailties of regulatory processes, facilitating such "Coasian bargaining" should be a core policy goal. This transition away from the command-and-control model, however, has only just begun. For instance, only about 20 percent of the highly sought-after 400–3700 megahertz (MHz) band has so far been dedicated to either of these new regimes; the remaining 80 percent is still subject to command-and-control management, leaving plenty of room for more spectrum to be transitioned to either the licensed or unlicensed models of regulation.

Chapter 3: The Failings of Current Spectrum Regulation

The current system of spectrum regulation has three serious shortcomings. First, the FCC and the NTIA fail to define the rights and responsibilities of spectrum access with enough clarity to promote the most efficient coexistence of wireless systems by facilitating bargaining between neighboring spectrum users. Second, the high level of fragmentation among rights holders creates significant transaction costs and an increased likelihood of market failure that can prevent coordination that could enable the more-efficient and more-intensive use of spectrum. Third, the FCC's inability to resolve conflicts through effective adjudication leads to paralysis and lost opportunities. These flaws have a common theme: the current regulatory regime does not give spectrum operators the ability to reach mutually agreeable, efficiency-enhancing agreements through direct negotiation with one another. We will now discuss each concern in turn.

A. INSUFFICIENTLY DEFINED RIGHTS

Claims of harmful interference between systems are at the heart of disputes about whether a user's rights have been violated, or, alternatively, whether a user has lived up to its responsibilities to tolerate reasonable levels of interference.[2] The lack of clarity from the FCC and NTIA about the rights and responsibilities of radio operation constitutes perhaps a basic shortcoming of spectrum regulation today.

A key problem arises when a signal in a particular band interferes with the signal in an adjacent band operating at a similar frequency. Wireless systems in one band that cannot tolerate reasonable signal levels in an adjacent band and are nonetheless protected against interference by limits imposed in the adjacent band are reaping benefits (say, by using cheaper receivers) and imposing costs on operators in adjacent bands (say, through restricted transmit levels). This state of affairs prevents the addition of new wireless services that could foster innovation, improve public safety, and create jobs.

A failing of current spectrum policy is that it focuses on transmitters and fails to address the important role of receivers. Harmful interference has no meaning as a concept, however, outside the context of a specific receiving system. The ability of a radio system to tolerate interference depends not only on the design of the receiver, but also on the relative strength of desired and undesired signal transmissions; the received signal strength, in turn, depends not only on the power of the transmitted signal, but also on the distance between the transmitter and the receiver, and on intervening obstacles. Where the use of filters or other solutions can manage against interference effectively, it is important that policy provides the proper incentives for such solutions.

To return to Coase, consider the famous example from his 1959 article as to how neighbors (in that case, a doctor and a confectioner) can cooperate to manage interference concerns. In that case, the confectioner's loud equipment threatened to constitute a nuisance to the doctor. The critical point raised by Coase is that the relevant harm is reciprocal: avoiding disturbance to the doctor by silencing the confectioner causes harm to the confectioner's business, and allowing the confectioner to make noise disturbs the doctor. Similarly, radio systems with an inadequate ability to tolerate interference can harm the interests of neighboring transmitters—the converse of the conventional assumption that it is always transmitters that harm receivers. As Coase suggested in the case of the doctor and the confectioner, the ideal solution is to define the respective rights of the two parties—whether the doctor has the right to quiet or the confectioner has the right to make noise—so that the parties can find the optimal balance between themselves, allowing for any number of creative solutions (say, the doctor paying the confectioner for noise proofing or delineating operating hours).

To appreciate how spectrum policy can create perverse incentives rather than incentives for creative problem solving, consider its ill-fated initiative to grant new licenses to "low-power" FM stations for local broadcasts in underused parts of the spectrum (FCC 2003). The broadcasters responded to this initiative by suggesting that the relevant standard for judging interference was whether a single listener, owning the lowest-quality receiver on the market, faced *any* interference. The broadcasters' position prevailed, favoring the use of technologically backward equipment at the expense of more-dynamic and more-intensive use of spectrum. Unfortunately, the low-power FM case is not an anomaly and represents a widespread phenomenon of privileging legacy receiver technology over a more-intensive use of spectrum (De Vries 2009; De Vries and Sieh 2011).

The FCC's legacy regime, which ignores the role of receivers, handles interference issues by using the model outlined in the low-power FM case. As in that case, the FCC looks at interference on a case-by-case basis, examining how receivers are affected by signals in an adjacent band and asking what burden the neighbor is creating through its transmissions. Using this approach, the remedy is almost invariably for the neighbor to reduce its transmit power, move its transmitter farther away from the band boundary, or, in a few cases, for the neighbor to purchase additional filters for the receivers affected by its transmission system. Stated differently, the FCC traditionally views all transmitters as the cause of interference and all affected receivers as innocent "victims." Indeed, a 1987 FCC Report and Order stated, "[s]ub-standard receivers do not cause system interference" (FCC 1987, section 7.25).

The FCC's current regulatory regime is vague about the rights and responsibilities of spectrum operators regarding harmful interference. In particular, the relevant definitions (see box 1) are very general and require case-by-case interpretation, a time-consuming process that only well-heeled parties can afford (see Lazarus 2009; Weiser and Hatfield 2008b). In its decisions on spectrum rights, the FCC traditionally issues what might be called rulings "for this day only," declining to adopt any guidance or clarification as to what would constitute harmful interference in other cases. Since spectrum negotiations frequently hinge on responsibilities to mitigate interference, the lack of such guidance about what constitutes harmful interference prevents more-intensive and more-dynamic use of spectrum.

These problems are exacerbated by a lack of user-to-user negotiating authority. At present, there are cases where conflicts between existing neighbors could be agreed upon, but the FCC and NTIA are currently required to mediate and manage those conflicts, creating opportunities for rent-seeking, strategic delay of the relevant approvals, and other potential mischief. As there is no provision for direct negotiation between parties, the government's involvement always looms large. Under current rules, for example, the FCC must approve most changes to the defined set of rights through a notice-and-comment rule-making process, which, at a minimum, adds unnecessary delay to any spectrum-related transaction.[3]

B. FRAGMENTED SPECTRUM RIGHTS

A second challenge for spectrum regulation is to overcome the collective action problem that stems from band fragmentation. Fragmentation refers to the sharing of control of a band among a large number of operators, and sharing a band among multiple uses (known as "services" in spectrum parlance). Such fragmentation is not an accident and arises from decisions made during prior decades, when facilitating the flexible and intensive use of spectrum was not a core policy goal. One reason for the level of fragmentation is that the FCC has traditionally used small geographic area licenses in mobile spectrum license auctions to facilitate participation by smaller, regional operators. Another reason is that the FCC, assuming a world of fixed technologies, has combined a variety of different services in one band because it has deemed that they could coexist successfully. Fragmentation also arises from permitting unlicensed use, where, by definition, operations cannot be controlled by licensees since there are none. Finally, fragmentation can arise from ineffective control of assignments (e.g., the NTIA's weak oversight of the more than 240,000 frequency assignments to federal agencies and government departments, as documented in Government Accountability Office [GAO] 2011).

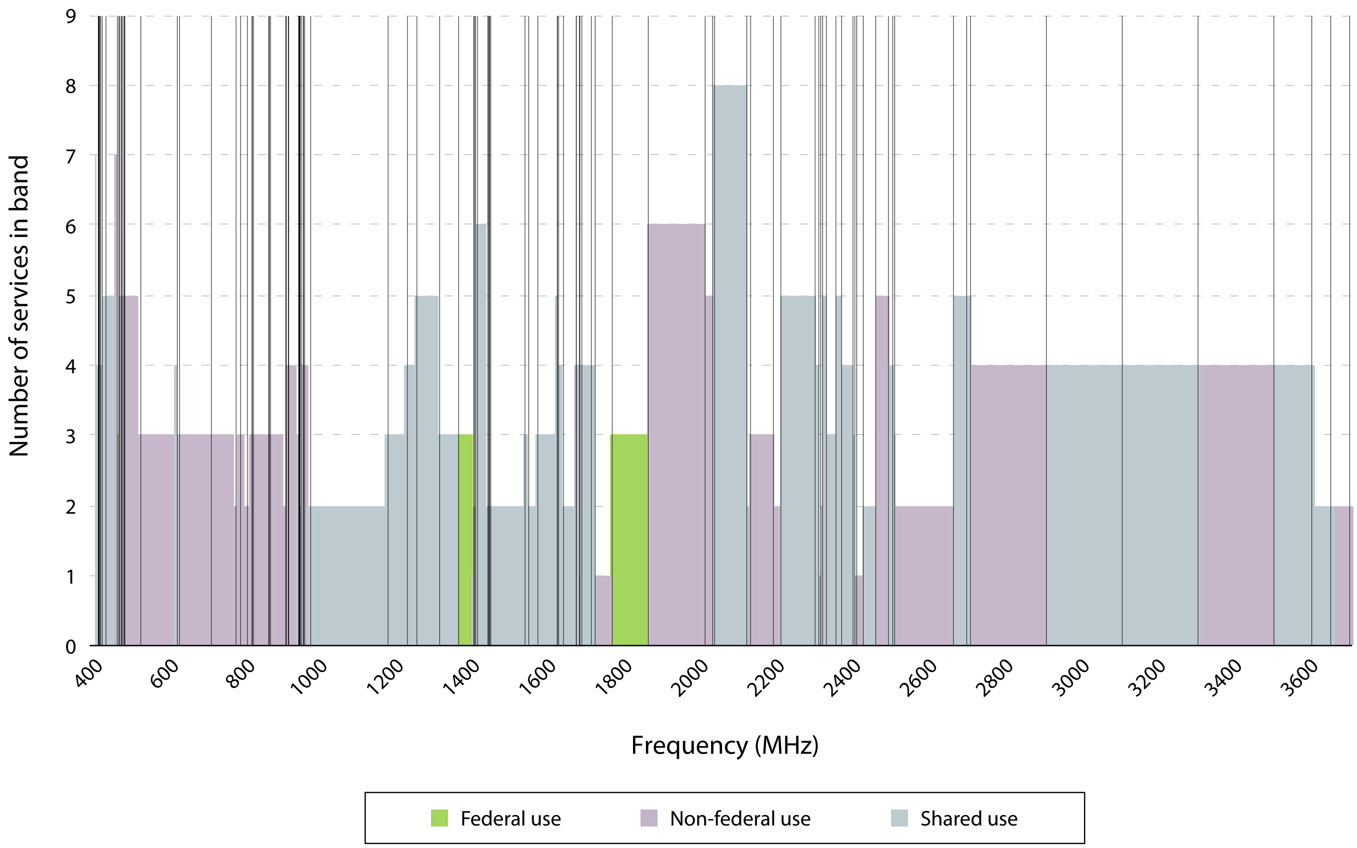
The FCC's current regulatory regime is vague about the rights and responsibilities of spectrum operators regarding harmful interference.

Figure 1 illustrates the degree of fragmentation in the 400–3700 MHz frequency range by plotting the number of service allocations in each band. One can see that most bands are shared by at least two services, and often are shared between federal and nonfederal uses. Many bands are shared among four or more services. Figure 2 charts the number of licenses per band, for bands where that information is available. Note that while there is wide variation in the license count, bands with more than a thousand licenses are quite common.

Fragmentation threatens efficient spectrum allocation because it makes private negotiations more difficult. That is, private

FIGURE 1.

Fragmentation of Bands, Measured by Number of Services



Source: FCC 2014b; authors' calculations.

Note: Vertical black lines represent band boundaries. Where the bands are very narrow, band boundaries pack into thick lines.

negotiations are likely to fail where many parties are involved, particularly if no structure for coordinating among them exists. As Coase makes clear, the opportunity for efficient bargaining outcomes can be frustrated in situations with high transaction costs or where property rights are not well-defined. The transaction costs concern explains why a government must use its eminent domain power to overcome the collective action costs and holdout risk that would ensue were it forced to negotiate with scores (or hundreds) of landowners individually to construct, say, an airport.

To illustrate how fragmented and difficult to manage interests can come into existence, consider the case of Nextel and public safety operators (see De Vries 2009, section 4.1 and references cited therein; FCC 2004). Not only were assignments given to various commercial, governmental, and public safety land mobile radio (LMR) users, but the licensees themselves were quite small, as licenses were assigned to individual municipal police and fire service providers and local commercial operators. Consequently, when interference issues between Nextel's cellular service and individual public safety (narrowband) LMR services arose, the FCC was forced to get involved and develop an extensive process to reallocate spectrum rights in order to manage this conflict. Stated differently, because the rights assigned to individual public safety agencies were so fragmented, the FCC needed to establish a nationwide process to resolve the matter, which was quite challenging, time-consuming, and costly.

The recent case of one prominent auction provides a clear reminder that fragmentation is not simply a function of the total number of licenses, and can be managed effectively if the parties are able to negotiate. In the 2006 Advanced Wireless Services (AWS-1) auction, 104 bidders won 1,087 licenses across the United States in various bands of spectrum. Despite the creation of 922 frequency blocks and six market areas as a result of that auction, ensuing negotiations in this band—used for commercial mobile operations—appear to have addressed any fragmentation concerns. In other words, despite the number of licenses and licensees, the impact of fragmentation in this case was low because there were relatively few boundaries between licenses where problems needed to be resolved. Notably, under the rules set by the FCC, geographical license areas abutted only a few others, with at most two adjacent frequency blocks; the number of parties to each negotiation was small (unless there was a geographically large license in one block and many small licenses in the adjacent one). Furthermore, each block was controlled by a single licensee, reducing coordination problems. Consequently, even with a large number of distinct licenses, the structure of the bands made negotiation and transactions relatively easy to manage; there have been extensive secondary market transactions leading to better post-auction rationalization of the spectrum holdings, including deals between Verizon and T-Mobile, Verizon and a cable company consortium, and various smaller AT&T and Verizon deals to purchase AWS-1 spectrum licenses. The number of licenses and different uses alone does not determine whether fragmentation issues will arise.

C. INEFFICIENT ADJUDICATION

A third challenge in spectrum regulation concerns the inefficiency of the current adjudication regime. Invariably, conflicts in how spectrum is being used will emerge between neighbors. A system of adjudication is important as a means of resolving such conflicts, and as a means of providing a framework to encourage more-effective conflict settlement.

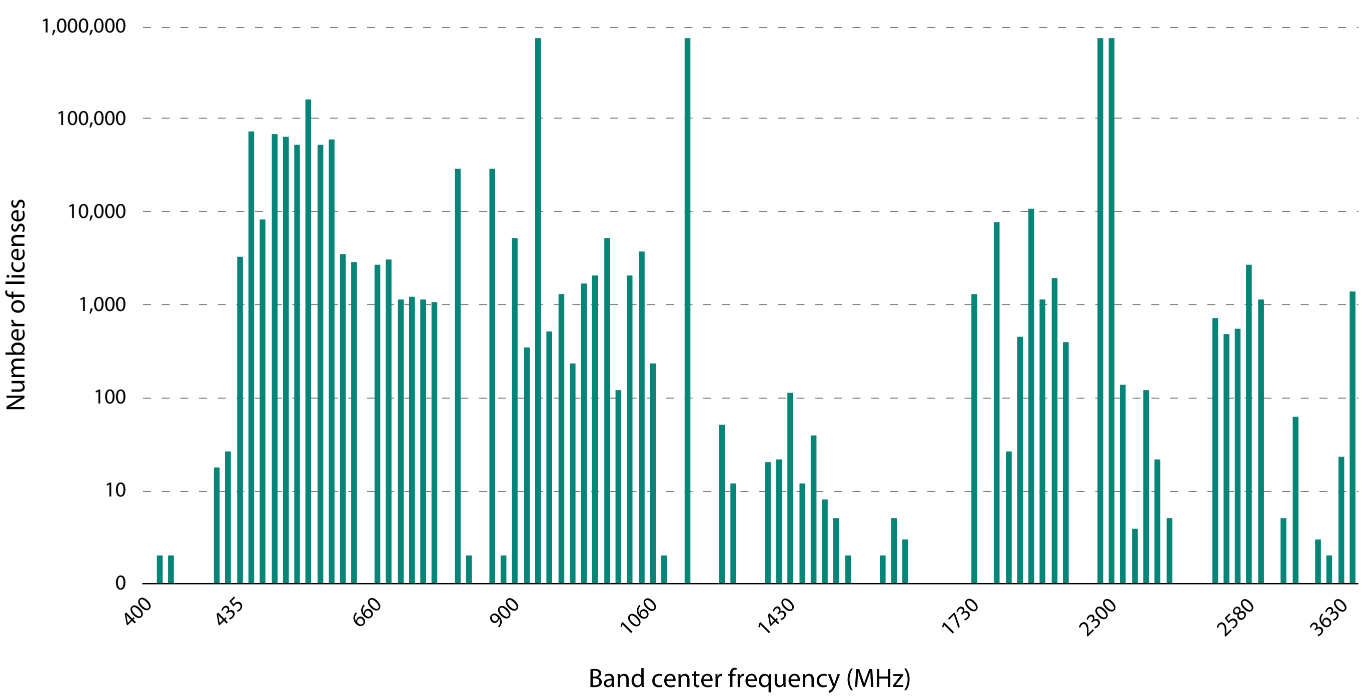
The NTIA, to the extent its processes are visible to the public, does not devote sufficient resources to conflict resolution, preferring to make such generous (and thus inefficient) assignments of exclusive frequencies and geographic areas to its clients that conflicts are precluded. To be sure, federal agencies coordinate among themselves to avoid intersystem interference where many of their services share a band, but since how such spectrum rights are managed is not visible, it is impossible to judge the efficiency of the resulting arrangements.

For its part, the FCC currently has little to no ability to resolve conflicts, as its adjudication process is unpredictable and ad hoc. In most cases, the FCC usually resorts to delay and politics or notice-and-comment rule making when adjudication would have been more appropriate and efficient. In summary, the current state of adjudication in spectrum disputes is at best inefficient.

To take two examples, consider the Comcast network management case and Sirius Satellite Radio and XM's violation of their Special Temporary Authorizations. In both cases, the FCC failed to use an adjudication process to settle high-profile disputes. Rather, as Weiser (2009) explains, the FCC styled the proceeding involving Comcast's network management processes as an adjudication even though it did

FIGURE 2.

Fragmentation of Bands, Measured by Number of Licenses



Source: FCC 2014b; authors' calculations.

Note: Each bar represents a single band, but is not representative of the bandwidth of the band. A bar is not drawn where a license count is not specified in the source data.

not use any judicial process: the actual proceeding mirrored the agency's rule-making processes and did not operate as a true adjudication. The proceeding also evoked the all-too-familiar complaints by dissenting commissioners that they were forced to vote on an Order without the benefit of sufficient time to evaluate its substance.

In the Sirius case, there were longstanding complaints that satellite radio providers were violating the terms of their licenses. Rather than conduct a vigorous enforcement proceeding, the FCC took action and entered into a consent decree with the two companies only once they were on the brink of receiving approval to merge with one another. The FCC's failure to treat seriously the longstanding complaints about Sirius's and XM's behavior is emblematic of the agency's lack of commitment to effective adjudication and enforcement. The agency rarely asks administrative law judges (ALJs), or other independent arbiters, such as independent judges, to find facts. In practice, the vast majority of enforcement decisions are determined by negotiations between the agency and the rule-breaking parties. As FCC Commissioner Tate (2005–2008) put it, Sirius Satellite Radio "failed to comply—knowingly and repeatedly—with the specifications for its FM modulators and the terms of its Special Temporary Authorizations . . . for more than five years" (Sirius Satellite Radio Inc. 2008). This conclusion, unfortunately, was not the result of an enforcement process: it came as a condition of Sirius's approval to merge with XM Radio.

The approach outlined above reflects the FCC's institutional priorities (Weiser 2009). The FCC employs only two ALJs and they rarely are given assignments to handle adjudicative proceedings. Indeed, when ALJs are given assignments, the FCC often maintains a high level of involvement and micromanagement of the proceeding, undermining the ALJs' authority. As for the Enforcement Bureau, its processes are often managed with a level of political oversight and a lack of commitment to neutral determination of complaints. Consequently, it is not empowered to act effectively on complaints and has failed, according to a 2008 GAO report, to either resolve many complaints or explain why no action was taken.

The reality of enforcement at the FCC, in the spectrum context and others, is that the agency rarely uses anything approaching true adjudication. As a formal matter, the FCC charges its Enforcement Bureau with investigating instances where parties are using radio frequencies that they are not authorized to use. But limits of the agency's capabilities, both in terms of personnel and equipment, mean that the agency is rarely successful in redressing such cases. Moreover, even as a formal matter the FCC's authority in this area is limited and its general practice is to confiscate the equipment. In short, the FCC has not developed the capacity to conduct the sort of adjudication handled by courts or even by many administrative agencies. This makes it no surprise that the agency fails to use any such system even for cases where it would seem to be the natural response.

Chapter 4: Toward a Reformed Spectrum Policy Framework

We propose three sets of reforms to address the challenges outlined in section III. We propose that the FCC and NTIA (1) define the rights provided to licensees more effectively (i.e., establish harm claim thresholds) and allow for the modification and transfer of such rights without delays created by regulation; (2) create a mechanism to address collective action problems that follow from overly fragmented spectrum rights (i.e., band agents); and (3) establish an adjudication venue that backstops negotiations and provides a forum for dispute resolution (including cases in which the U.S. government is a party). Implementing any one of these proposed reforms would improve spectrum management, but there is a powerful synergy between them and they reinforce one another in important ways. If implemented, they could unlock considerable social welfare value and, in the case of underused government spectrum, make it easier for it to be shared and/or auctioned at a benefit to the U.S. Treasury.

A. ENHANCING RIGHTS USING HARM CLAIM THRESHOLDS

We propose that the FCC establish harm claim thresholds—in-band and out-of-band interfering signals that must be exceeded before a system can claim that it is experiencing harmful interference—to address the issue of spectrum rights ambiguity, and the related issue of the modifiability of those rights. In defining operating rights in spectrum, the goal of the government is not to develop complete clarity on the nature of the relevant rights. Indeed, as Hazlett and Oh (2013) have argued eloquently, it is not possible or desirable to remove all ambiguity from the relevant rights to use spectrum. Rather, the challenge for policymakers is to capture the necessary complications in defining property rights in spectrum while keeping matters as simple as possible.

Our proposal calls on the FCC and NTIA to adopt a statement in a service's rules that defines the signal levels it needs to tolerate before it can bring a harmful interference claim.[4] This would establish a field strength profile due to neighbors' signals that is defined both inside and outside an assigned service's designated frequencies. Under a system of harm claim thresholds, the relevant threshold must be exceeded at more than a specified, small percentage of locations and times in a measurement area before the affected operator can bring a claim against the neighbor.

Under this model, manufacturers and operators would be allowed to determine for themselves whether and how to build receivers that can tolerate such interference, or even determine that they will choose to ignore these limits and risk adverse results in adjudication (see subsection IV.C). As such, harm claim thresholds do not mandate receiver performance standards.

> Implementing any one of these proposed reforms would improve spectrum management, but there is a powerful synergy between them and they reinforce one another in important ways.

The harm claim threshold model is not one-size-fits-all. A frequency assignment's harm claim threshold can be customized to reflect the current and expected performance of systems in its assignment and in those next to it. Thus, different bands will have different harm claim thresholds.

Harm claim thresholds would also apply to interactions between government and private parties. This requires the establishment of a mechanism for reaching an appropriate model for interference limits that could enable other operators to share swaths of spectrum now controlled by the government. In return for agreeing to such sharing, the government would receive funds for agreeing to modified interference limits and authorizing new users of spectrum in blocks previously assigned to the government (President's Council of Advisors on Science and Technology [PCAST] 2012). Both the government agencies and the new users of spectrum would need, as a condition of agreeing to this sharing, the ability to bring an action to enforce those limits and protect their right to operate as agreed upon.

Benefits

Three features of a harm claim thresholds approach shape the benefits that can be derived from it. First, the model does not require that the FCC define the performance levels of individual receivers per se. Instead, it proposes that the FCC should stipulate that receivers must be expected to tolerate a certain degree of interference. Second, our model creates incentives for operators to upgrade their receivers or bargain with their neighbors to avoid the necessity of doing so. Finally, any given user who would like to use its spectrum more intensively and would be willing to purchase the right to create more noise for its neighbors is able to do so. Consequently, this framework enables more-sophisticated and more-efficient means of sharing spectrum use between different parties.

Harm claim thresholds allow markets to dictate the detailed solutions to problems of interference. By establishing harm claim thresholds rather than attempting to mandate receiver standards, our proposal delegates decisions about system design, including receiver performance, to manufacturers and operators. For example, they can invest in high-performance receivers that tolerate high levels of adjacent band noise even when their own received signals are weak. Alternatively, manufacturers and operators can deploy more basic receivers, but invest in increasing the level of their own received signals by deploying more transmitters. Finally, they may choose to use a system design that experiences some degradation even when interference is below the threshold; perhaps this degradation will be sufficiently rare as to be tolerable, or their business model is such that fluctuations in performance are acceptable.

Harm claim thresholds allow markets to dictate the detailed solutions to problems of interference.

In all events, the establishment of harm claim thresholds should facilitate bargaining between neighboring users, allowing wireless system operators to find and adjust the optimum level of mutual interference. In the wake of any such adjustments, the FCC would function as a recorder of spectrum interference levels, putting other parties on notice of the relevant changes rather than serving as a gatekeeper. In cases where a party did not agree to an adjustment and could claim an adverse impact, that party would have the right to bring an action against the purported interfering party.

Though the harm claim threshold approach has yet to be implemented, a recent experience suggests that it would be effective. A resolution that emerged organically from the negotiations that led to the compromise between AT&T and Sirius XM offers a powerful case for the harm claim threshold proposal. As detailed in a 2012 Order on Reconsideration (FCC 2012), the FCC established that operators in one band would be required to work with other operators in another band to address problems where ground power level targets exceeded stated levels (essentially, de facto harm claim thresholds) and harmful interference occurred in receivers. Earlier attempts by the FCC to encourage negotiation failed, seemingly because of a divergence of interests among half a dozen parties. The need for access to additional spectrum led AT&T to broker a deal with Sirius XM, and eventually to buy out license holders who were adversely affected by the compromise. While a compromise interference limit was eventually found, it would appear that resolution was complicated by the absence of an interference baseline, such as a preestablished harm claim threshold.

Implementation

Harm claim thresholds will need to be phased in and refined over time. The harm claim threshold values for an assignment can be chosen by a regulator to reflect the status quo and protect incumbents. For example, if the receivers in an allocation are very susceptible to interfering signals in frequencies outside their band, the harm claim threshold can be set very low. In such a case, little or no operation will be permissible in the adjacent band without the consent of receivers, and incumbents will not be required to replace existing receivers.

If the regulator believes that better receiver performance is in the public interest but will not be achieved by market negotiation, it can give notice that harm claim thresholds will be increased in the future. The time period for compliance could be chosen to give incumbent operators sufficient time to upgrade their receivers. Conversely, if the status quo is that there is already strong signal operation in the adjacent band, the harm claim threshold for the new assignment could be set high enough that the incumbent in the adjacent band will not be deemed to be causing harm.

There may be cases where the initially assigned harm claim threshold is not economically efficient. For example, there might be net social gain if the threshold were increased, allowing increased transmit power and thus better service in the adjacent band. The FCC should allow parties to adjust the limit by negotiation among affected neighbors. If the FCC deems that there is no prospect of such negotiations being concluded successfully, it could put incumbents on notice that the harm claim threshold level will be increased stepwise over time.

Establishing harm claim thresholds requires additional care where receivers are not controlled by a license holder. This scenario applies to a number of services such as GPS, FM radio, and satellite weather receivers. One possible solution for cases where receivers are not coupled to a transmission license is to require that manufacturers self-certify that a receiver is fit for the purpose in its envisaged use. Such a model could ensure that such receivers operated successfully given the prescribed harm claim thresholds. Such self-certifications could function as an express warranty, and perhaps be enforced under a false advertising remedy. This could be done by individual companies, or collectively through an industry-certified seal of approval. To further enforce such a model, the FCC could also require the manufacturer to submit a testing protocol that allows for validation, as happens now in the European Union (European Parliament and Council 1999).

Unlike the imposition of mandatory receiver performance requirements, where there are doubts about the FCC's statutory authority, we believe that the FCC can add harm claim thresholds to operating rules without additional legislation. Notably, harm claim thresholds do not supersede existing rules and definitions (e.g., FCC Not dated [b], 47 CFR § 2.1; also see box 1) but rather provide additional clarity to them. We also believe that parties could be allowed to modify initial entitlements, with the FCC acting as a recorder of spectrum rights, so to speak, rather than reviewing each such proposal through a rule-making process. In so doing, the FCC would build on its existing rules that allow parties to agree to maxima different from those specified by the FCC.[5]

B. THE FRAGMENTATION CHALLENGE AND THE ROLE OF BAND AGENTS

To address the problem of fragmentation among spectrum rights holders, we propose that the FCC facilitate the establishment of band agents. These agents would operate as entities that can represent and bind large groups of licensees in negotiating changes in operating rights with neighbors. In short, the band agent would be a mechanism to solve the collective action problem associated with large groups, like fragmented spectrum rights holders.[6] Ultimately, band agents allow for a fragmented set of interests to be represented by a single voice.

In the spirit of Schlager and Ostrom's 1992 typology of property rights, one can recognize a variety of radio operating rights in existing regulation, including the right to operate a transmitter ("operation"), the right to determine which transmitters may operate at a given time/place ("management"), the right to determine who will have various rights ("exclusion") and the right to transfer (by assignment, sale or lease) any of the above rights ("alienation"). Our proposal recognizes the right to change operating parameters (e.g., a transmit power ceiling), beyond the initial values determined in FCC rules: the right of "alteration."

Band agents would hold only one type of right—the "alteration" right to negotiate the contours of the operating right to use spectrum in particular bands (and adopt or not adopt protective measures). Using this right, the band agents could bargain efficiently with other parties for changes in operating rights, and these changes—and any side payments that result from the negotiation—would be binding on the licensees they represent.[7] All of the other rights remain vested in their current users. The system would thus operate along the lines of shareholder voting on a proposed merger, whereby a sufficiently large fraction of licensees could authorize an agent to act on behalf of them without requiring individual approval of every single licensee (which would raise holdout cost concerns). Even with a band manager in place, the licensees could still transfer their licenses and determine which transmitters may operate within their license area.

This proposal builds on an established framework for allowing facilitation across various interests in spectrum regulation. The current framework employs both band managers, who are responsible for managing the interference between operators in a band, and frequency coordinators, who facilitate the establishment of operating assignments that minimize in-band interference.[8]

Building on these two models, band agents would possess the ability to negotiate adjustments to operating rules in a given band. They would be able make or accept payments as well as bind the operators in that band. As a point of contrast, while a band manager may, for example, be able to resolve interference between some or all operators in its band, it cannot negotiate changes that are binding on all licensees in its band to reflect an agreement with a neighboring operator.[9]

The most effective way to enable the development of band agents is to establish a framework for voluntary coordination with backstop procedures for when parties cannot agree. In so doing, the FCC would encourage private institutions to spring up to manage this important function. This approach is likely to be superior to detailed upfront implementation mechanisms, because a more-prescriptive and rigid approach risks not taking account of information known only to market participants, let alone risk not being able to change in the face of dynamic conditions.

Public interest concerns and permanent legacy assignments call for the need for "trusted intermediaries" to act on behalf of a range of rights holders. In terms of establishing such intermediaries, our rule of thumb is that every "allotment" of spectrum—in other words, every subdivision of an allocation that refers to a service associated with a specific group of users or providers, such as frequency blocks auctioned separately in a cellular allocation—that has a degree of fragmentation among rights holders should have at least one, or at most a few, band agent(s) so that negotiations can proceed across block boundaries.

Band agents for unlicensed bands would be assigned by a regulator who would designate a small number of band stewards or "stamp holders" who would be able to authorize the use of an unlicensed band.[10] For the stewards to function efficiently as band agents, they would have to have the power not only to agree to changes to the operating rules in their band among themselves and with neighbors, but also to accept (or make) side payments that could be distributed to affected parties (say, to upgrade equipment). Band stewards could also emerge organically in unlicensed bands coordinated by database managers, provided the FCC gave them the power to allow devices controlled by them to operate at higher power levels than the rules permit if the affected neighbors agree to those signal levels. For example, a whitespace database manager could negotiate an agreement with a TV broadcaster whereby devices affiliated with the manager would be allowed increased transmit power if payments are made to the broadcaster.

Benefits

The existence of band agents would facilitate mutually beneficial rearrangements of operating rights among parties within bands and across band boundaries. Such deals often cannot be struck under the status quo because of collective action problems such as a single hold-out blocking an agreement that would be beneficial to the whole, or because negotiations among a large number of parties can be prohibitively expensive and time-consuming.

For example, band agents would allow for more-efficient negotiations among parties within bands where there are multiple licensees in multiple service allocations, such as the 2050–2110 MHz band, where there are 10,800 licenses divided among eight different service types. If these interests were represented by a handful of band agents representing the different services (e.g., TV broadcasting auxiliary service, local TV, cable relay, and Earth exploration satellite), more-efficient rearrangements of rights within the band and with mobile telephony neighbors would be possible.

Band agents would also be useful to consolidate interests in unlicensed bands where changes need to be negotiated within and across allocations, such as the ongoing matter involving Globalstar (Lung 2013). At present, the FCC is forced to address such matters by operating as a de facto band agent for unlicensed operators and by operating as the regulator and adjudicator of spectrum property rights.[11] Band agents could far more effectively negotiate changes in unproductive operating rules that cannot be changed under the current regime because of the opposition of fragmented stakeholders that are unable to reap the financial benefits of change (e.g., U-PCS; see Hazlett 2008, 114; Hazlett and Oh 2013). On the federal side, band agents representing federal wireless operations could provide a mechanism for federal users to be exposed to the costs of their radio use, creating a financial benefit for trading away those rights.

Band agents could also take the FCC out of its frequently conflicted position of acting on behalf of a group of licensees while simultaneously refereeing conflicts between these licensees and others. For example, when interference issues arose between Nextel's cellular service and individual public safety LMR services that were assigned to individual municipal police and fire service providers and local commercial operators, the FCC was forced to get involved and develop an extensive process to reallocate spectrum rights in order to manage this conflict. If a band agent had been available to act on behalf of public safety, the FCC would not have been both advocate and judge. (The recent creation of FirstNet to hold the license of the new 20 MHz broadband public safety band is recognition of the need for such consolidated control.)

Implementation

We recognize that the introduction of band agents into spectrum policy is a notable change and would need to be phased in. As discussed above, the current levels of fragmentation are an intended consequence of political considerations (e.g., small geographic licenses to serve local constituencies), industry structure (e.g., local control of public safety operations, ancillary services associated with local broadcasting licenses), or regulatory choice (e.g., allowing for unlicensed uses of spectrum). In many cases, policymakers may not wish to undo those decisions. Consequently, and because the band agent model needs to be proven out and refined, we believe that a partial and incremental introduction of band agents is a sensible and important first step.

As we note above, the concept of band agents is not completely foreign to spectrum policy. Rather, band agents can be thought of as band managers or frequency coordinators with additional powers. The concept of band managers is well established in spectrum regulation; such managers are typically responsible for managing the interference between operators in a band. Frequency coordinators, by contrast, facilitate the establishment of operating assignments that minimize in-band interference, playing more of a facilitator role and lacking any formal authority themselves (Williams 1986). In the 800 MHz band, for example, the FCC has certified specific associations to coordinate the choice of frequencies for LMR systems before it will accept license applications.[12] Building on these two models, band agents would possess the ability to negotiate adjustments to operating rules in a given band, meaning that they would be able to make or accept payments as well as bind operators in that band.

The band agent model could be implemented in several possible ways, depending on the existing circumstances in a given band (see box 3 for a summary). Different situations will require different solutions to achieve the single goal of enabling a small number of agents to act on behalf of many principals in search of win-win deals with neighbors.

We propose, as a first option, the appointment of the band agent in the same way that shareholders appoint managers to act on their behalf. Under this model, the FCC would reallocate (e.g., recognize a transfer of) the alteration rights of individual licensees—say, the next time a license was renewed—to the band agent. Under such a model, the FCC would need to determine the voting rights of the affected spectrum licensees, who would become, in effect, band shareholders.

Moving forward, the FCC could include collective action clauses in new licenses; these clauses would be similar to those that allow a supermajority of bondholders to agree to a debt restructuring that is legally binding on all holders of the bond, including those who vote against the restructuring. It could also add overarching conditions to all licenses in a given band that would lead to a consolidation of interests in the same way that oil and gas property rights can be unitized if a supermajority of rights holders agree.

A second option for developing band agents is to build on existing institutions, such as frequency coordinators. The LMR bands, for example, are in dire need of delegated management as the FCC is currently embroiled in deciding minor technical details as a result of the absence of decentralized management.[13] The existing 800/900 MHz frequency coordinators could be provided with additional authority to negotiate operating arrangements.[14] At present, frequency coordinators cannot negotiate effectively since they do not hold licenses, and their rights would need to be augmented to enable them to do so. Although there are more than a handful of coordinators—about ten per band—that is still significantly fewer than the tens of thousands of current licenses.[15]

For federal government spectrum rights, either a single entity or individual departments and agencies could act as band agents. At present, the NTIA is nominally the band manager for spectrum dedicated to the federal government. In practice, however, the NTIA operates at best like a frequency coordinator, because it cannot control federal departments and agencies, especially powerful ones like the DoD and FAA. Moreover, federal agencies are not authorized to negotiate commercial arrangements that enable more-efficient uses of spectrum.

BOX 3.

Ways to Introduce Band Agents

1. Licensees appoint the band agent in the same way that shareholders appoint managers to act on their behalf.

2. The FCC and NTIA build on existing institutions, such as frequency coordinators, band managers, and federal agencies, by extending their powers.

3. The FCC auctions alteration rights. In licensed bands, alteration rights may be separated from, or included with, other spectrum rights. In unlicensed bands, the FCC assigns stamp holder rights, or allows spectrum sharing database operators to act as agents.

A single band agent for federal allocations could be seen as an alternative to, or a variant of, the Government Spectrum Ownership Corporation (GSOC, aka the GSA for Spectrum) proposed by Lenard, White, and Riso (2010). Just like the GSOC, a single federal band agent would be able to negotiate changes in spectrum rights with the private sector. The federal band agent would take on many responsibilities currently borne by the NTIA; the agent may or may not be the NTIA itself.

Given the extent to which spectrum is shared between federal and nonfederal users—a trend that is likely to continue and is being encouraged by the Obama administration—it makes sense to assign band agent powers to a single federal agent or, where appropriate, give the specific departments and agencies that use wireless spectrum the additional powers necessary to negotiate commercial agreements (see, e.g., Strickling 2013).

In general, the fundamental incentive for band agents will be to share in the benefit of gains from trade as rights are transacted among neighbors.

Third, band agent rights could be assigned by auction. This is, indeed, what happens currently in the case of exclusively assigned flexible use rights, such as commercial mobile spectrum licenses; however, one can envisage a situation where the rights to alter operating parameters are auctioned separately from rights to operate transmitters within those parameters. Such an approach could even work in unlicensed allocations. At one level a band agent in an unlicensed band would seem to be an oxymoron; after all, by definition an unlicensed band allows anyone to operate a compliant device without third-party permission. However, the FCC could use an auction to assign a small number of band stewards or "stamp holders" who would be able to authorize the use of an unlicensed band (De Vries 2011). A system for such stewards could also work for decoupled receivers—in other words, in cases where licensees do not control the design, sale, or operation of receivers used with their system, including TV, GPS, FM radio, and satellite weather receivers—which have many of the same cross-allocation coordination challenges of unlicensed bands.

It will be critical to establish effective incentives for band agents to operate effectively. In general, the fundamental incentive for band agents will be to share in the benefit of gains from trade as rights are transacted among neighbors. The details of how a share of this benefit is paid to the band agent will depend on the implementation; the incentive structure will vary among the options we described above. If the band agent receives benefits at the end of the process based on the creation of new wealth (through win-win transactions), it has a direct incentive to strike the best possible deal. If it were acting on behalf of licensees as a manager would for shareholders, the usual panoply of management incentives could be used, including fixed remuneration and/or a share in the proceeds of a successful negotiation. If the agent acted as a market-maker, bringing together licensees across band boundaries, it might charge a fixed fee or a percentage of the net benefit of striking a deal.

We recognize that a band holder regime is vulnerable to a variety of difficulties. For example, there is the well-understood challenge of aligning the interests of an agent with those of its principals, like the interests of a company's managers with the interests of its shareholders. In arranging a trade of spectrum rights, there may well be relative winners and losers within the group represented by a band agent; the agent faces an invidious challenge in dividing up the spoils. Finally, if the gains are very large, the greed of all the parties may preclude them from striking a deal. Our working assumption based on the pervasive use of principal/agent arrangements and market makers is that the benefits will exceed the costs, and that difficulties can be resolved—but this will have to be worked out as this concept is developed.

The FCC has considerable discretion as to how it might catalyze the emergence of band agents. The FCC's support for frequency coordinators provides a precedent for how the agency could support the development of these new entities. In such an approach, the FCC could put in place the mechanisms that band agents would need, such as authorization for licensees to cede some rights, the power for agents to negotiate changes in operating parameters, and the power for agents to make or accept payments on behalf of licensees.

The creation of band agents for federal operations is inherently more challenging than the creation of band agents for private licensees. Most notably, given the inability of government agencies to accept remuneration from private entities (e.g., as part of a deal to alter spectrum operating rights), there are powerful limits in terms of what can be done to create a win-win solution. Developing strategies to encourage the federal government to use its spectrum assignments more productively is an area for further research and, ultimately, more legislative action. Legislation would be required, for example, to create a GSOC to enable federal agencies to benefit from win-win solutions or allow agencies to act as band agents.

C. REFORMING SPECTRUM ADJUDICATION

We propose the development of an effective adjudication regime that moves adjudication from the current ad hoc, politically charged, and notice-and-comment driven process to a more-fact-based process.[16] This regime will also be afforded the resources to adjudicate spectrum-related disputes in a timely fashion by judges with sufficient expertise in spectrum policy. Our proposal to achieve this goal is two-fold.

First, we propose that the FCC employ either ALJs or administrative judges, as opposed to the traditional ALJs, to develop factual findings in spectrum disputes. The key difference is that such judges are not a formal part of a federal government–wide system for selecting such officials. Indeed, the FCC does not actually have many ALJs on staff and those in place lack the specialized expertise that would enable more-effective adjudication in this area, making the administrative judges model an appealing alternative.

In practice, the resolution of spectrum disputes is very likely to turn on specialized knowledge of how wireless services operate and how to assess violations of a threshold level of tolerable harm. Rather than ask generalist judges to learn such details, Congress could empower specialized adjudication of spectrum disputes. For the FCC, the development of a specialized adjudication function would involve building a capacity it does not currently have. To do so, it would need to hire up and train those who could manage this system (including technical advisers, which could rotate from other parts of the agency).

Second, even with the FCC acting as an expert adjudicator, we propose that Congress establish a Court of Spectrum Claims that could hear cases in this field. Such a body would be housed within the existing Court of Claims, the court that hears cases involving claims against the U.S. government. It would consist of specialized decision makers who could hear cases in the spectrum field.

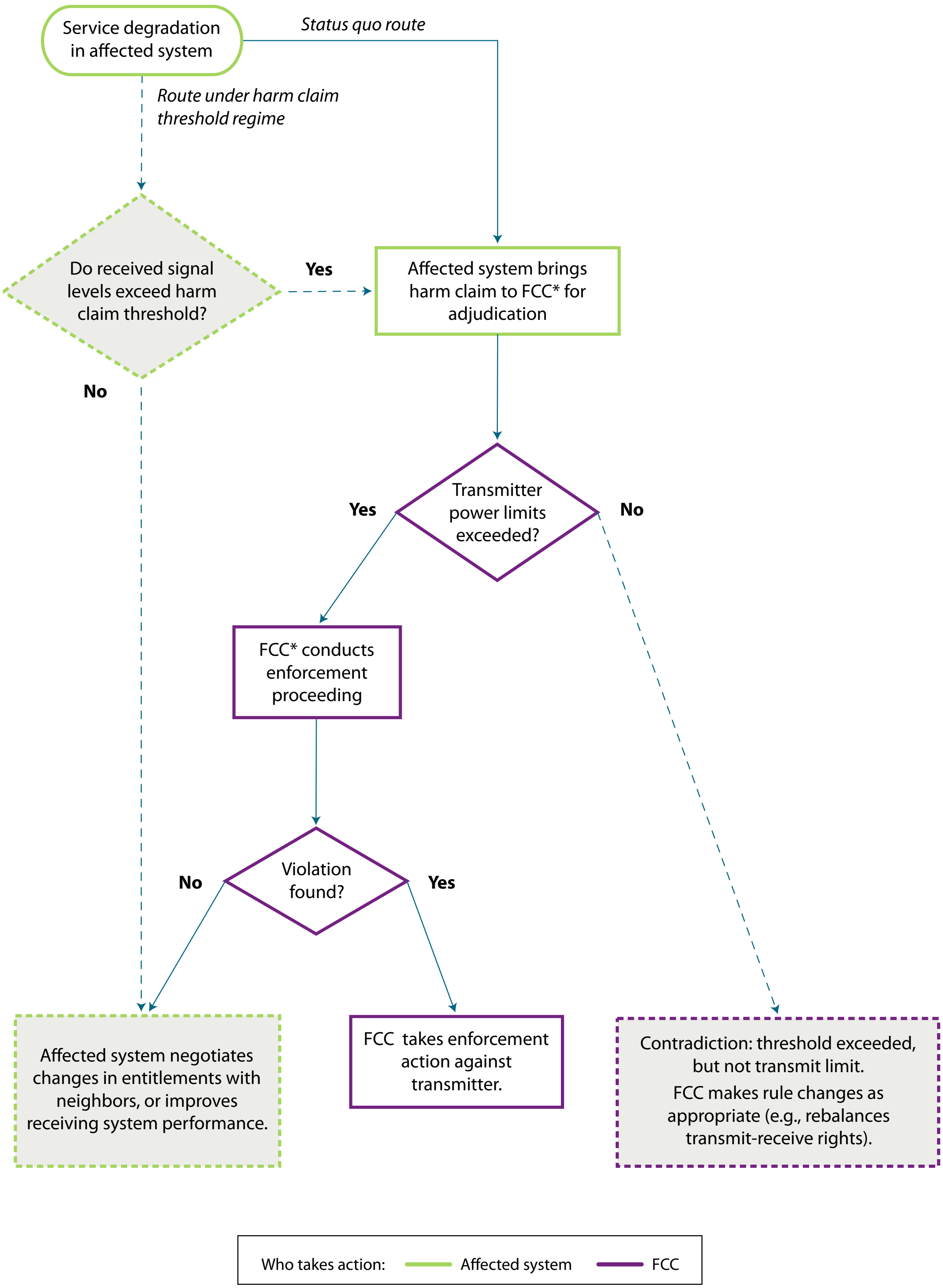
There are two underlying reasons why such a body should be established. First, such a body would provide an alternative and a check against the FCC's possible failure to operate effectively in this area. Second, even if the FCC were operating effectively (and the establishment of such a body would greatly enhance that likelihood), the FCC is not set up to handle disputes involving the federal government as a party. The number of spectrum disputes involving the federal government (and agencies like the DoD) may well increase as the initiative to encourage spectrum sharing between federal and nonfederal users gains traction. The establishment of a specialized court outside of the FCC would enable the U.S. government to sue or be sued when appropriate. We also recommend that a Court of Spectrum Claims be allowed to hear disputes between two private parties, ending the FCC's monopoly on hearing such claims and providing a choice of forum. In all events, appeals from either the FCC or the Court of Spectrum Claims would proceed to the Court of Appeals for the District of Columbia to promote uniformity of decisions in both forums.

Under our proposed framework for reform, the basic path of spectrum rights adjudication would change radically. To set the template for adjudications, the FCC would need to conduct rule-making to establish the set of harm claim thresholds. (The NTIA would need to develop a parallel process for government spectrum shared with private parties.) In the wake of these rules, parties could alter the relevant property rights through contracting and Coasian bargaining that would refine the relevant thresholds. If a dispute later arose (as to where the initial or refined entitlements were breached), the parties could either resolve the matter through an agreement or subject the matter to formal adjudication (either at the FCC or at the Court of Spectrum Claims.). As is often the case in civil litigation, the mere threat of litigation (and opportunity for discovery) could aid the parties in moving to a settlement.

Under our model, adjudication would come into play when a harm claim threshold is exceeded. In such cases, a plaintiff could bring a claim by alleging that a party has exceeded its allowable transmit power. Regardless of whether the adjudicative body is the FCC's Enforcement Bureau (as it would be at present) or another body (such as a Court of Spectrum Claims), there would be three separate questions that would determine the issue of liability for the interference in question: (1) Was the harm claim threshold exceeded in the first place? (2) Did the plaintiff suffer harm by the criteria in 47 CFR § 2.1 (FCC Not dated [b]; also see box 1)? (3) Was the influencing system operating outside its allowed transmitter parameters? If the FCC determined that the first two showings were made, but the influencing system was operating properly, the underlying rules are to blame, and the FCC would need to revise them by adjusting the relevant harm claim threshold and/or guidance on operating parameters. This interactive dynamic is why the

FIGURE 3.

Enforcement Process



Note: A decision tree for making enforcement decisions as described in the text. Grey shading and dashed boxes show the steps added to the current status quo by harm claim thresholds.

* If adjudication were reformed as we recommend, some of the adjudication roles currently played by the FCC under the status quo might be taken over by an independent adjudicator.

establishment of harm claim thresholds both depends on and feeds into the role of a vibrant adjudicative framework.

After liability is established, the next question is what remedy is appropriate for a violation. A showing of actual harm (e.g., service degradation), while not necessary to establish liability, would be relevant in selecting the proper remedy. Similarly, a greater or lesser showing of fault would influence the selection of the remedy. Where an affected system is not yet operating, for example, an immediate injunction would not be necessary or appropriate. Moreover, extraordinary circumstances that explain the violation of the harm claim threshold and attendant operating parameters—say a change in weather—could also militate for a more-lenient remedy. As the Supreme Court has explained in the context of patent law, relevant remedial decisions must result from the exercise of sound discretion and not be issued automatically when any violation is shown.[17]

To see how the process outlined above would work in practice, consider figure 3. This representation underscores that the use of harm claim thresholds makes clear that an affected system bears some responsibility to mitigate the effects of interference, as shown by the unshaded boxes on the left-hand side. Consequently, unlike under the current model (where the presence of interference is prima facie evidence), the harm claim threshold model looks at both sides of the boundary.

As we see it, adopting harm claim thresholds without a reformed system of adjudication will fail to realize the promise of introducing harm claim thresholds. After all, instituting a more-calibrated system of defining the right to use spectrum invites disputes and will only be effective with a regime suited to settling such disputes. As for the case of spectrum shared between the federal government and private licensees, neither side is likely to accept a harm claim threshold as valid unless it knows that claims will be enforced. Moreover, with respect to the band agent proposal, the negotiation of regimes for managing spectrum among a wide variety of players could easily lead to disputes and thus be greatly aided by an effective adjudication framework.

Chapter 5: Cost/Benefit Analysis

The principal benefit of our proposed reforms is to enable the more-dynamic and more-intensive use of spectrum. In so doing, our reforms will give rise to a series of benefits to consumers and producers. These benefits include lower costs, faster innovation, and more-rapid growth of wireless services. The Treasury will benefit considerably from such improvements, but mostly through the downstream impact of increased tax revenue.[18] Finally, by removing the FCC from its current prescriptive and case-by-case oversight role, our proposal will also restrict opportunities for rent seeking and market distortion by reducing the FCC's role in spectrum management.

We attempt to quantify these benefits by estimating the number of megahertz of spectrum—the "amount" of spectrum—that could benefit from these reforms. We then multiply this with a dollar-per-megahertz estimate of additional consumer surplus that would be generated.[19] This is an admittedly imperfect measure, since both the dollar-per-megahertz value estimate and the number of megahertz are subject to many uncertainties. Many of the benefits of our reforms, particularly regarding improved adjudication, cannot be easily tied to per-band valuations. However, we believe this provides a reasonably defensible lower bound on monetary benefits.

Any new regulatory regime also has costs. Though there are unintended consequences of action and change (just as there are unintended consequences of inaction), we estimate the costs of our proposal that can reasonably be anticipated.

A. BANDWIDTH MADE AVAILABLE BY REFORMS (MHZ)

Freeing up guard bands using harm claim thresholds

Using harm claim thresholds will have a variety of benefits, including facilitating the more-intensive use of spectrum, enabling the deployment of new services, and reducing the costs of negotiations. Since these are difficult to quantify, we focus on ways in which the institution of harm claim thresholds would reduce the reliance on wide frequency buffers—known as "guard bands"—that are placed between different kinds of services. We take this approach because there are conventional ways to value the spectrum bandwidth represented by guard bands.

To appreciate the role of implicit guard bands, consider the high-profile LightSquared/GPS case we discussed above. As we explained, LightSquared's planned use of the spectrum was precluded in that case by the interference that such service was projected to cause to GPS devices (Knapp and De La Torre 2012). Notably, GPS receivers were designed on the assumption that the adjacent band would be relatively quiet, allowing some receivers to "listen" to frequency ranges wider than their assigned bands to achieve greater location accuracy. As a result, such receivers could not reject the higher signal levels that terrestrial LightSquared transmitters would have generated in the adjacent band once they began operating. The type of implicit guard band at issue in cases like LightSquared is readily apparent. There are also less obvious cases of implicit guard bands, such as the "duplex gaps" between the base-to-mobile and mobile-to-base parts of certain spectrum allocations, and bands that serve to protect mobile handsets.[20]

We recognize that estimating the number of bands that can benefit from harm claim thresholds and use spectrum more effectively is uncertain. The number will depend at least in part on the degree to which harm claim thresholds incentivize improved receiver performance, which in turn will lead to more services being deployed in a given bandwidth. There are, at the very least, a number of cases where 10–40 MHz in implicit guard bands can be significantly reduced over time. For the purposes of the calculation, we will conservatively assume this number to be 200 MHz, but it could be as high as 600 MHz.

Estimating fragmentations and bandwidth benefits of band agents

As noted previously, fragmentation leads to economic inefficiencies and less-intensive use of spectrum than would be possible if a mechanism such as band agents were in place to overcome coordination issues. To provide a bird's-eye view of the benefits of having a band agent to reduce fragmentation, we analyzed the data in the FCC Spectrum Dashboard and Table of Federal Allocations in the frequency range 400–3700 MHz.[21] We counted the number of distinct services in federal and nonfederal allocations using the taxonomies of the Spectrum Dashboard and the Table of Federal Allocations.

There are a number of different possible measures one could use to capture the extent of license fragmentation. First, if one considers a band that contains four or more services to be fragmented, then 46 percent (1532 MHz) of this spectrum meets the criterion (see figure 1). (This count does not include bands with many unlicensed devices.) Second, if we focus on the number of licenses per band (see figure 2) rather than on the number of services, we can refine the fragmentation criterion to four or more services as well as seven hundred or more licenses, leaving 19 percent of nonfederal spectrum (277 MHz) bands as fragmented.[22] Finally, if we posit that difficulties are only likely to arise at boundaries between fragmented bands and count bands containing four or more services where either or both adjacent bands are similarly fragmented, 40 percent (1317 MHz) of the 400–3700 MHz frequency range could be considered as fragmented.[23] In summary, approximately 1000 MHz of the 400–3700 MHz frequency range is significantly fragmented.

Building on the above analysis, we have identified half a dozen large contiguous band regions, each more than 20 MHz wide, where four or more services occur on either side of all internal band boundaries (see table 1). Our estimates for the amount of fragmented spectrum in 400–3700 MHz ranged from 277 MHz to 1532 MHz, depending on fragmentation criteria. The rough inventory in table 1 lists six bands, ranging from 45 MHz to 610 MHz, for a total of 1154 MHz. Not all of them will prove amenable to defragmentation in the short to medium term. We assume that only 400 MHz could be governed more effectively. However, the total could in fact be more than 1000 MHz.

B. ESTIMATES OF SOCIAL SURPLUS ($ PER MHZ PER YEAR) AND INCREMENTAL VALUE ($ PER YEAR)

First, we must reiterate the challenges of coming up with a meaningful estimate of the economic benefits that would flow from our proposal. We are not, for example, estimating the value of the sharing of government spectrum that would result from our proposal. We are also not assigning any specific value to the benefit that comes from facilitating the rollout of new services and new technologies, or to the value of the time saved in negotiations among a range of parties. We do not venture such an estimate because it is difficult, if not impossible, to ascribe the lost value in such cases. Caveats aside, we have sought to develop a rough estimate of the spectrum bandwidth in megahertz that would be realized as a result of our proposals.

To estimate dollar per megahertz value, we start with the value of an allocation to commercial cellular service as a baseline, since that is the currently most highly financially valued measurable use of spectrum. The auction value of such licenses is of the order of one dollar per megahertz per capita (see, e.g., Bazelon and McHenry 2012, figure 1), or roughly $300 million

TABLE 1.

Large Band Regions with Four or More Allocations on Either Side of Band Boundaries

Band Region (MHz)	Bandwidth	Allocations
406–460	54 MHz in seven contiguous bands	Amateur, aviation, federal fixed and mobile, general aviation air-ground, industrial/business radio, maritime, low power auxiliary, paging and radiotelephone, personal locator beacons, public safety radio, radiolocation, remote pickup, rural radiotelephone, space research
1215–1300	85 MHz in two contiguous bands	Amateur, federal aeronautical radionavigation, earth exploration-satellite, federal earth exploration-satellite, radiolocation, radionavigation-satellite, space research, space research radiolocation
1850–2110	260 MHz in four contiguous bands	AWS-2, broadband PCS, cable antenna relay, earth exploration satellite, local television transmission, fixed microwave, mobile satellite service, space operation, TV broadcast auxiliary
2200–2300	100 MHz in two contiguous bands	Earth exploration-satellite, fixed, mobile, space operation, federal and non-federal space research
2345–2390	45 MHz in two contiguous bands	Aviation, fixed, mobile, radiolocation, WCS
2690–3300	610 MHz in four contiguous bands	Aviation, federal aeronautical radionavigation, federal and non-federal earth exploration-satellite, federal and non-federal radiolocation, maritime, maritime radionavigation, meteorological aids, radiolocation, radio astronomy, space research

Source: FCC 2013b; FCC 2014b.

Note: AWS = Advanced Wireless Services; PCS = Personal Communications Service; WCS = Wireless Communication Service.

per megahertz for the United States, as the U.S. population is slightly over 300 million. The economic literature suggests that the annual consumer surplus is a multiple of the auction value; we conservatively assume that the multiple is one; in other words, we assume that an auction price of $300 million per megahertz leads to additional consumer surplus of $300 million per megahertz per year.[24] We then posit that the value generated by implementing our reforms is a small fraction of this baseline value.

We estimate that clarifying the interference rights and responsibilities would lead to more-productive use of the implicit guard bands. We estimate that this improvement will be worth at least a few percent of the bands' value if they were to be used for wireless broadband service, our baseline value assumption. For the purpose of calculation we will conservatively assume this percent increase in value to be 2 percent.

The value of fragmented bands in their current state is not known, and it is unlikely that the full value of commercial mobile broadband use will be realized for them if their band agents could negotiate effectively. We will therefore assume that reducing fragmentation would increase consumer surplus by some fraction of the baseline cellular service value. For the purpose of calculations, we will make the conservative assumption of 5 percent. We have not been able to devise a method to quantify the value of improved adjudication on a dollar-per-megahertz basis, so we will ignore adjudication for the purposes of this cost/benefit calculation.

To estimate the incremental value that could be gained by implementing the reforms we propose, we combine the quantities derived above:

- Baseline value for consumer surplus associated with highest value use (cellular): $300 million per megahertz per year
- Harm claim thresholds
  - Incremental consumer surplus obtained by reducing guard bands through the use of harm claim thresholds: 2 percent of baseline value, or $6 million per megahertz per year
  - Guard bands amenable to reform: 600 MHz
  - Incremental consumer surplus due to reform: $3.6 billion per year
- Band agents
  - Incremental consumer surplus obtained by improved ability to find highest use by using band agents in fragmented bands: 5 percent of baseline value, or $15 million per megahertz per year
  - Fragmented bands amenable to reform: 400 MHz
  - Incremental consumer surplus due to reform: $6 billion per year

Adding these estimates yields a potential increment in consumer surplus of $9.6 billion per year.

C. COSTS

The establishment of harm claim threshold levels constitutes a major undertaking. It would entail costs for both stakeholders and the government entities (the FCC and the NTIA, if it followed suit). The harm claim threshold is a new concept that will need to be tested and refined over time. There is the risk, if not the likelihood, that the initial value of a harm claim threshold will not be set to the exact value that maximizes social welfare. Some imprecision in setting the initial value for the harm claim threshold is inevitable, and can be corrected by market transactions among the parties. But we believe that the inefficiencies in the current regime are so great that the benefit will be substantial and outweigh the costs imprecision even if obstacles to Coasian bargains preclude reaching the optimal solution.

There are also costs of retraining staff and adopting new equipment. The implementation of harm claim thresholds will increase the number of field measurements that will have to be made, although measurements will only be necessary when a claim of harm is being made. There are currently about 600–1,200 technicians in the cellular and public safety industries able to make such measurements. If one assumes conservatively that implementing harm claim thresholds will roughly double this population, about one thousand technicians will have to be trained to make such measurements, at a cost of about $5,000 per person.[25] This yields a total cost of around $5 million. More staff will also need more equipment. About 3,000 high-quality spectrum analyzers are sold per year in the United States, at prices up to $15,000 each. Assuming sales double, this cost will approach $45 million per year.

Perhaps the most easily identifiable cost of a band agent regime is the need to create new institutions: the agents represent a new layer of management. Since licensees will cede some of their powers to band agents, there is the potential cost of inefficiency in any principal–agent arrangement: the agents may not always act in the best interests of the licensees. However, we believe that since band agents will be introduced to remedy severe collective action problems in fragmented bands (e.g., hold-outs and free-riders blocking the successful conclusion of socially beneficial negotiations), the net result will be positive. The incremental surplus gain may be reduced from such inefficiencies, but it is highly unlikely that the overall outcome from the reform will be worse than the status quo.

Investing in the appropriate infrastructure to establish a more-effective adjudication process is an ambitious undertaking. For all intents and purposes, the FCC engages in very little to no such adjudication at present. Developing this capability, or building a new institutional structure for such adjudications, would bring important benefits but also entail significant costs. Like the costs associated with establishing harm claim thresholds, there would be the cost of a need to hire and train personnel. The benefits of the ability to expedite decision making going forward as well as to facilitate agreements of a kind that would not be made in the absence of an effective adjudication backstop could be considerable, even if these benefits are difficult to quantify at present. Such an adjudication system will be critical to enabling protective arrangements for shared spectrum situations that can provide the government with additional revenue and enable the more-efficient and more-intensive use of spectrum—as acknowledged by the Commerce Department Advisory Committee.

Chapter 6: Questions and Concerns

Do these proposals threaten national security by reducing the amount of spectrum available for the military?

No. None of these proposals sets out to reallocate military spectrum assignments to other uses without the federal government supporting such moves. They are intended to increase the value and efficiency of all radio operations, civilian and military.

Could the use of harm claim thresholds have changed the outcome in the LightSquared/GPS case?

Yes. Consider, for example, an alternative course where the FCC had instituted harm claim thresholds in 2003. Those thresholds could have provided that all deployed GPS receivers would enjoy protection and LightSquared would have been precluded from operating in a fashion that would cause harmful interference to them. Alternatively, the thresholds could have stated that the thresholds in the lower part of the Mobile Satellite Service (MSS) band, farthest away from GPS, would be increased ten years later in 2013 to levels that would allow LightSquared to deploy terrestrial transmitters without being deemed to be causing harm (i.e., creating harmful interference) to terrestrial GPS receivers. Yet another possibility would have been to set the harm claim threshold low, and to set an especially low harm claim threshold above a certain altitude and around airports in order to protect aviation applications. Under such a regime, LightSquared would have been obligated to upgrade all aviation equipment to tolerate its signals as part of an agreement to change the relevant harm claim thresholds. Under the latter two cases, moreover, at least the lower 10 MHz of spectrum that LightSquared had access to could be used for terrestrial services, generating an estimated consumer surplus of $300 million per year (assuming auction value of $1 per megahertz per person, a U.S. population of 300 million, and an annual consumer surplus equal to the auction value).

What are some potential challenges with the band agent approach?

We recognize that there are challenges to the successful operation of a band agent regime; we note two major challenges here in order to stimulate discussion. Band agents, by definition, represent the interests of a diverse group of principals. After a successful renegotiation of rights, the principals as a group will necessarily be better off (otherwise the negotiation would not have succeeded). However, there are likely to be winners and losers within the group. The band agent could arrange for transfer payments to compensate the losers, but it is likely that there will still be some scenarios in which some of them will not be satisfied. This may be one reason why it will be useful to have more than one band agent in a given band; dissatisfied principals in one group will have the option to defect to another band agent for subsequent negotiations. A second difficulty occurs when the gain negotiated by the band agent is very large: when the pie to be divided is very large, the risk of strategic behavior rises greatly, with individual licenses positioning for a greater share of the rewards. Finally, there are potential conflicts of interest between the principals as a group and the agent; the agent may, for example, prefer the continuance of a status quo that funds its functions, rather than a change that would be to the benefit of the principals.

How many band agents can there be per band?

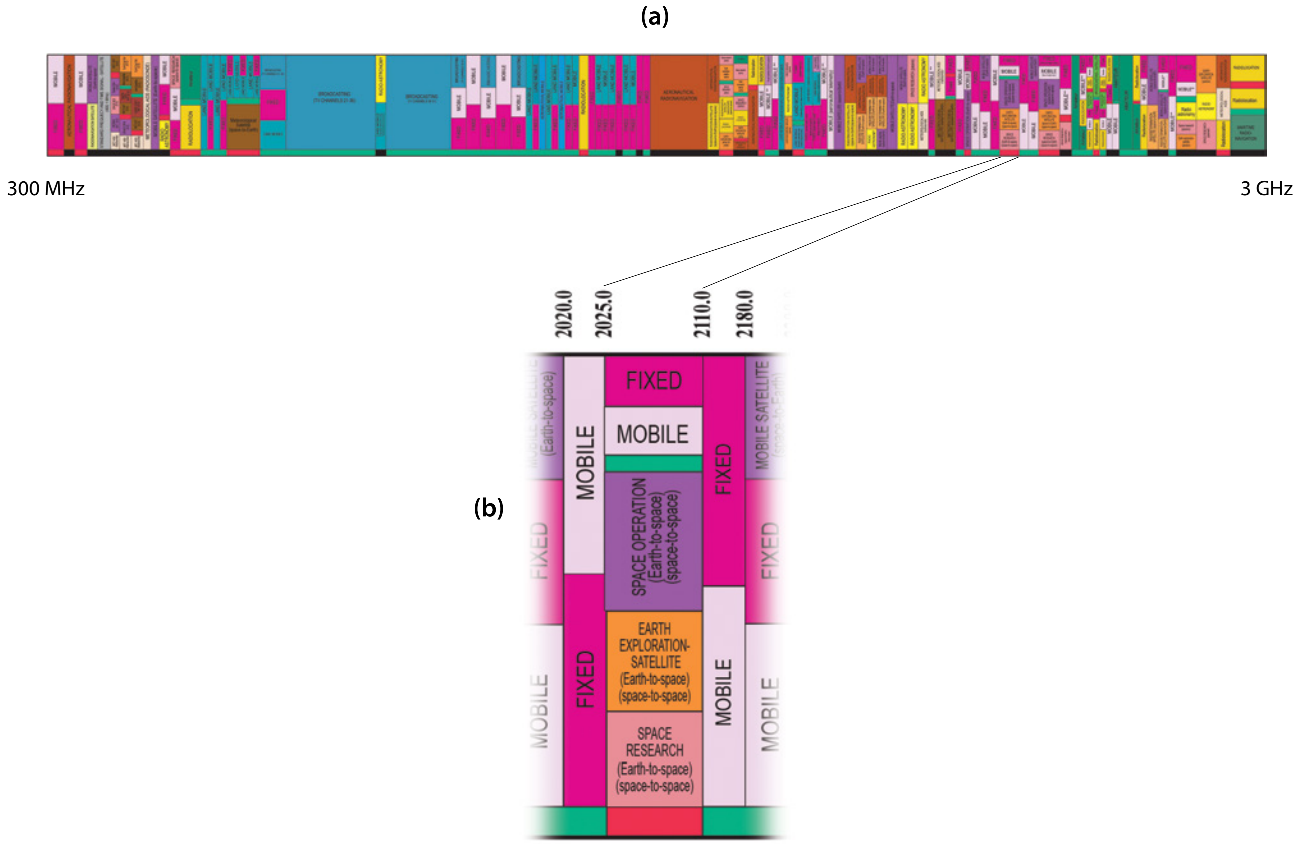
Under our model, there does not need to be just one band agent in a frequency band. For example, each different allocation in a band might be represented by its own agent; in the 2025–2110 MHz band, say, there might be agents representing licensees in the Cable Antenna Relay, Earth Exploration Satellite, Local Television Transmission, Space Operation Service, and the TV Broadcast Auxiliary services, respectively (see Figure 4 (a)). In a single-allocation band with multiple interests, each might be represented by an agent; in the 800 MHz land mobile radio (LMR) bands, for example, there might be agents representing the petroleum, electrical utility, railroad, fire alarm, and forestry industries.

Does the lack of disputes between major wireless carriers suggest that adjudication is unnecessary?

One misleading claim about the current system of spectrum regulation is that the lack of disputes between major wireless providers suggests that adjudication is unnecessary. It might well be true that "interference issues between wireless carriers are always resolved in the field without FCC intervention." To the extent that is the case, it is so because the FCC's processes are not reliable, the relevant parties are relatively few and well known to one another, and the associated technologies are common among those parties. By contrast, in spectrum bands with greater numbers of operators, or where an incumbent

FIGURE 4.

(a) U.S. frequency allocations, 300 MHz–3 GHz (b) 2025–2110 MHz



Source: U.S. Department of Commerce 2011.

operator is sharing access to spectrum with another provider, the likelihood of disputes emerging—and not being resolved easily, as they are between cellular providers—is great. The cellular case is the exception that proves the rule: the often-large license areas and repeated interactions in many settings by nationwide operators create considerable incentives for cooperative behavior (Weiser and Hatfield 2008a, 588–91). In other contexts, where there is no perceived benefit to the incumbent in allowing additional spectrum usage by the adjacent band user, the incentive is to delay or slow the process, or to attempt to use politics to affect the outcome based on safety of life arguments that politicians readily understand for the incumbent licensee.

You seem to be double counting bands as increasing in value, simultaneously, from both the band agent and harm claim threshold proposals. Do you think this is appropriate?

One might argue that this estimate includes double counting since some bands that are currently fragmented are also “quiet” bands that would be counted as candidates for amelioration by using harm claim thresholds. We believe that our marginal value estimates of a few percent are so low that the benefits would be additive, and thus it is plausible to add these estimates. However, even counting only half of the benefit still yields a substantial value estimate.

Chapter 7: Conclusion

When auctions for spectrum licenses and modern unlicensed deployments began in earnest around twenty years ago, there were relatively many accessible opportunities to tap into unused or deeply underused swaths of spectrum. To satisfy future demand by wireless services for more access to spectrum and for more-efficient uses of spectrum over the next twenty years, policymakers will need to look to a new horizon for different kinds of policy reforms.

Policymakers should take on the reforms outlined in this discussion paper if they indeed wish to take a step toward the next great policy frontier and toward ensuring more-effective and more-efficient use of spectrum. After the FCC implements the pending incentive auctions in the TV band, it will not have any obvious opportunities for shifting large swaths of spectrum from less-efficient to more-efficient uses (Weiser 2008). Unless the FCC decides that such an alternative opportunity is available, it should begin pursuing these initiatives.

This discussion paper suggests a set of complementary spectrum policy reforms—to address band fragmentation, the lack of defined interference rights, and the absence of an effective adjudication framework—that will facilitate more-intensive use of spectrum by existing and emerging wireless services. We recognize that these reforms will not be easy to implement, and that it will take time to refine them and phase them in. But we are convinced that they will give rise to considerable benefits over time. We estimate that such reforms can provide economic benefits of nearly $10 billion per year in additional consumer surplus. This is only a rough estimate that does not capture any of the revenue the federal government will gain as a result of the spectrum-sharing initiatives that these reforms will make possible, the many dynamic benefits that will come from a heightened level of flexibility in spectrum use, or the unquantifiable benefits of more-efficient institutions. Consequently, the case for moving ahead with these spectrum policy reforms seems quite compelling.

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Endnotes

1. By "economically efficient," we mean using resources more effectively, which enables society to be better off as a whole.
2. For example, FCC (Not dated [b], 47 CFR § 2.102(f)) requires that "stations of a service shall use frequencies so separated from the limits of a band allocated to that service as not to cause harmful interference to allocated services in immediately adjoining frequency bands." In so doing, the rules recognize the possibility of interference between services in adjoining bands.
3. For cases in point of such resolutions, the cases of Wireless Communication Service (WCS)/SiriusXM and Sprint/DISH in Advanced Wireless Services (AWS)-4 provide notable examples of this very situation. See FCC (2012) regarding the WCS, satellite radio dispute; and FCC (2013d) regarding the AWS-4 dispute. The rules for cellular mobile radio systems allow parties to negotiate changes in field strength limits at their geographical boundaries (FCC Not dated [b], 47 CFR § 27.55). Cellular/Personal Communications Service (PCS) systems would not be able to operate up to the edge of their licensed areas without such agreements. There are mutual benefits and harms that lead to good faith negotiations among the parties.
4. In so doing, we elaborate on earlier work on this topic. See, e.g., De Vries (2013); FCC TAC Receivers and Spectrum Working Group (2013); and President's Council of Advisors on Science and Technology (PCAST; 2012, section 3.2).
5. FCC (Not dated [b], 47 CFR 27.55 (a)) allows the field strength at the geographical border of a license area to exceed the value specified in the rule if adjacent affected service area licensee(s) can agree to a different value.
6. In developing the concept of a band agent, we are not introducing an entirely new idea into the world of spectrum regulation. Congress recognized the limits of fragmented and individualized public safety licensees when it established FirstNet, an independent authority within NTIA that holds the license to the entire 20 MHz of public safety broadband spectrum. FirstNet can in effect negotiate on behalf of, and bind, public safety spectrum users.
7. Cf., FCC (2013a, 7): "The band manager would also be able to bargain with high power licensees for increased rights, e.g., higher power limits, as a market alternative to administrative provisioning, at least for low-power uses that do not spread across a great many licensees. . . . The 'band manager' concept could take different forms, and would appear to fall within the current secondary market rules."
8. In the 800 MHz band, for example, the FCC has certified specific associations to coordinate the choice of frequencies for LMR systems before it will accept license applications.
9. For example, a 700 MHz Guard Band Manager has the authority to manage interference between operators to whom it subleases spectrum; the 800 MHz band Transition Administrator is responsible, among other things, for facilitating issue resolution and administering the alternative dispute resolution process in that band.
10. A system for such stewards could also work for decoupled receivers—i.e., in cases where licensees do not control the design, sale, or operation of receivers used with their system, including TV, GPS, FM radio, and satellite weather receivers; decoupled receivers have many of the same cross-allocation coordination challenges of unlicensed bands.
11. In effect, the FCC is both the representative of the interests in an unlicensed band and the adjudicator between these interests and those of its neighbors, creating a clear conflict of interest and the potential for confusion between the two roles. Whether or not the FCC can manage that conflict effectively (say, by having different internal constituencies represent each role), this situation is clearly suboptimal.
12. See FCC (Not dated [a]) for a list of frequency coordinators.
13. For example, the FCC is forced to decide on waiver rules for train coupler transmitters. See FCC (2013c), 3.
14. See FCC (2014a) for a list of frequency coordinators: nine below 800 MHz, and ten at 800/900 MHz.
15. For example, as of September 2013, the FCC Spectrum Dashboard listed more than 28,000 licenses in the 809–849/854–894 MHz band.
16. Indeed, even when the FCC styles a matter as an adjudication it often uses its traditional notice-and-comment procedure to reach an ultimate judgment. In the XM/Sirius case noted above, for instance, the FCC did not ever actually find facts and reach a judgment.
17. See *eBay Inc. v. MercExchange, L.L.C.* (2006), which holds that a four-factor test must be applied before granting a request for an injunction for a possible violation of the Patent Act.
18. Unlike auctions for using wireless spectrum transitioned from other uses, our proposed reforms do not lend themselves to many immediate and directly quantifiable monetary benefits to the U.S. Treasury. The principal exception to this is that our proposed initiatives would give rise to such revenue opportunities to the extent that the federal government shares spectrum and receives payments from private entities as a result of them. In short, the benefits from such spectrum sharing between the federal government and commercial entities could be substantial, but are difficult to quantify.
19. Consumer surplus is the monetary gain obtained by consumers because they can obtain something for less than the highest price they would be willing to pay; it is a measure of the welfare that is created by a particular market structure.
20. For example, 10 MHz below and 20 MHz above the 1.9 GHz Broadband PCS cellular band used by mobiles, and similarly, the 20 MHz below the 2.1 GHz is mobile cellular receive band.
21. The Spectrum Dashboard covers the range 235–3700 MHz. We based our analysis on data downloaded from FCC (2014b).
22. We exclude bands that contain federal services from this analysis since we do not have data on the number of federal assignees, reducing the total spectrum inventory to 1492 MHz.
23. The upper 33.5 MHz of the 2400–2483.5 MHz band is included in the first count (ignoring boundaries) since it contains five services according to the Spectrum Dashboard inventory; however, since none of its neighbors are fragmented, this sub-band is excluded from the second count.
24. Rosston (2003) compares incremental consumer surplus of $30 billion to $50 billion per year for cellular licenses auctioned for $30 billion, for a multiple of around 1.3x; Hazlett, Muñoz, and Avanzini (2012, table 1) indicates consumer surplus of $170 billion to $210 billion a year for licenses auctioned for $50 billion, for a multiple in the three to four times range.
25. We assume four days of training at $1,250 per day.
26. Strategic behavior is when parties take actions designed to maximize their long-term rewards by not revealing their true interests and, in many cases, by holding out from entering into an otherwise win-win agreement. Such behavior can be seen as a particular form of a transaction cost and, if not managed or overcome, can thwart socially valuable solutions.
27. Weiser and Hatfield (2008b, 588 n. 218), quoting James D. Young, president, U.S. Tower Operations, Crown Castle International.

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Highlights

In a new Hamilton Project discussion paper, Philip J. Weiser of the University of Colorado Law School and Silicon Flatirons Center, and J. Pierre de Vries of the Spectrum Policy Initiative, Silicon Flatirons Center, propose three major reforms to the regulatory structure of the wireless spectrum. While each of these proposals stands on its own, they integrate to form a package of policy proposals that transform the regulation of the wireless spectrum.

The Proposal

Define harm claim thresholds to reduce the ambiguity over responsibilities for interference harm. Authors J. Pierre de Vries and Philip J. Weiser explain how a system of harm claim thresholds could generate default spectrum rules that are clear enough to facilitate more bargaining between rights holders to reach the economically efficient trade-off between the rights of transmitters and receivers.

Introduce band agents to overcome the drawbacks of excessive fragmentation. To address the collective action problems created by fragmentation among spectrum rights holders, the authors propose that the Federal Communications Commission and National Telecommunications and Information Administration facilitate the establishment of band agents that can represent and even bind large groups of fragmented licensees.

Reform spectrum adjudication to improve the reliability and efficacy of dispute resolution. To advance important spectrum policy reforms, it is important to move adjudication from the current ad hoc, politically charged, and notice-and-comment-driven process to a more fact-based process. The authors put forth proposals that would resolve spectrum-related disputes in a timely fashion using judges with expertise in spectrum policy, in the Federal Communications Commission and/or in a newly created Court of Spectrum Claims.

Benefits

Complementary spectrum policy reforms that address the lack of defined interference rights, band fragmentation, and the absence of any adjudication framework would facilitate more intensive use of spectrum by both existing and emerging wireless services. Such reforms could provide economic benefits of nearly $10 billion per year in additional consumer surplus.

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FINAL REPORT

ASSESSMENT OF THE ECONOMIC VALUE OF UNLICENSED SPECTRUM IN THE UNITED STATES

February 2014

TELECOM ADVISORY SERVICES, LLC

AUTHOR

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EXECUTIVE SUMMARY

For more than fifty years, ever since the publication of Coase's seminal paper (1959) on spectrum management, there has been a debate over the most effective way of allocating the frequency spectrum. One specific issue of the policy debate relates to the management of unlicensed spectrum, which covers the frequency bands for which no exclusive licenses are granted. While the debate has been useful so far in terms of highlighting the large range of beneficial effects of unlicensed spectrum - such as triggering technological innovation, complementing cellular networks, and the like - limited research quantifies its economic value. In the few studies that exist, researchers concur that the economic value generated by keeping a portion of the spectrum unlicensed is significant. However, the studies completed so far do not consistently measure the same areas of impact: some estimate residential Wi-Fi value (Thanki, 2009; Cooper, 2012) while others focus on Wi-Fi tablets (Milgrom et al, 2011); some mention Wireless Internet Service Providers that rely on Wi-Fi (Thanki, 2012), but their economic contribution is not quantified[1].

We recognize that valuing unlicensed spectrum is a difficult task since, contrary to licensed spectrum that supports a few homogeneous services, unlicensed bands are used by numerous heterogeneous devices and services (Bayrak, 2008). Furthermore, since many of the services that rely on unlicensed spectrum are not sold, it is difficult to estimate the consumers' willingness to pay as it has been done in the case of licensed spectrum (Hazlett, 2005). Finally, unlicensed spectrum is being used by technologies and services that are growing at a rate that renders obsolete any research completed two years ago: for example, Wi-Fi traffic in the United States is growing at 68% per annum, while Wi-Fi households, currently at 63%, are forecast to reach 86% by 2017. As such, estimates of value conducted in 2009 might not be relevant any more.

That said, if we were to add the different economic value estimates of all four studies completed so far (controlling for double counting and using the latest estimates), the resulting total economic value of unlicensed spectrum in the United States reaches $ 140.20 billion (see table A).

[1] The research evaluated in this report addresses only the studies focused on the United States. Additional similar work has been conducted in the United Kingdom by Indepen, Aegis and Ovum (2006), and Williamson et al (2013).

Table A. United States: Prior Research on the Economic Value of Unlicensed Spectrum (in $ billions)

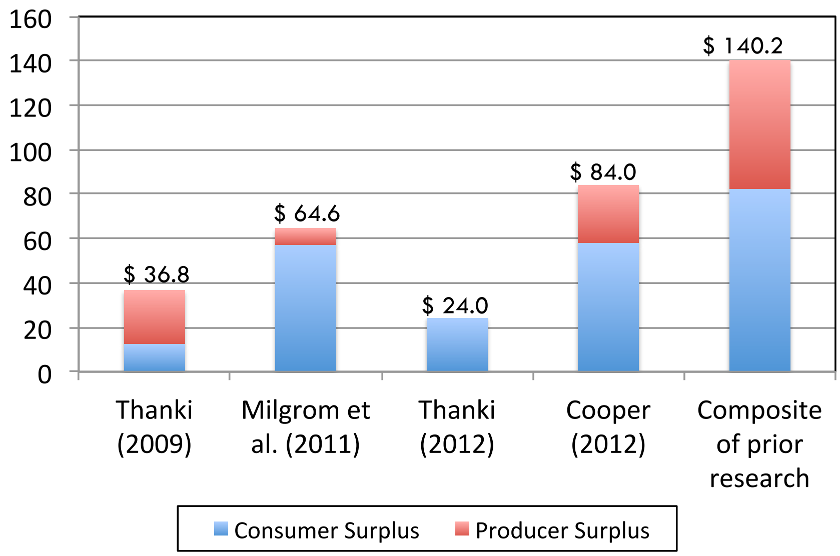
	Effect	Thanki (2009)	Milgrom et al. (2011)	Thanki (2012)	Cooper (2012)	Composite
Wi-Fi Cellular Off-Loading	Consumer Surplus	N.A.	$ 25.0	N.A.	$ 20.0	$ 25.0
	Producer Surplus		N.A.	$ 8.5	$ 26.0	$ 26.0
	Return to Speed		$ 12.0	N.A.	(*)	$ 12.0
	New Business Revenue		N.A.	N.A.	N.A.	N.A.
	Subtotal		$ 37.0	$ 8.5	$ 46.0	$ 63.0
Residential Wi-Fi		$4.3 - $ 12.6	>$ 12.6	$ 15.5	$ 38 0	$ 38.0
Wi-Fi Only Tablets	Producer Surplus	N.A.	$ 7.5	N.A.	N.A.	$ 7.5
	Consumer surplus		$ 7.5		N.A.	$ 7.5
	Subtotal		$ 15.0		N.A.	$ 15.0
Hospital Wi-Fi		$ 9-6 – $16.1	N.A.	N.A.	(*)	$ 16.1
Clothing RFID		$ 2.0 - $ 8.1	N.A.	N.A.	(*)	$ 8.1
Wireless Internet Service Providers		N.A.	N.A.	(*)	N.A.	N.A.
Total		$ 16.0 - $ 36.8	$ 64.6	$24.0	$ 84.0	$ 140.2

(*) Referenced but not quantified
N.A. Not addressed
Source: Compiled by TAS

Despite this large number, all researchers mention in their studies that they may have underestimated these figures, which should be updated to capture the ever-increasing number of applications running on unlicensed bands.

The understandable limitations of the existing research on the economic value of unlicensed spectrum prompt the need to produce up-to-date, rigorously developed evidence to support the policy debate further. In this sense, the following study stands as a progression of analyses that were started by Thanki in 2009 and have been gradually extended and updated since (see figure A). It should be noted, however, that none of the prior studies claims their estimates represent the whole value of unlicensed spectrum.

Figure A. Unlicensed Spectrum Economic Value in The United States: Prior Studies (in $ billions)



Note: The composite constructed based on prior research does not account for economic growth that took place after the studies were completed.
Source: Compiled by TAS

This study first summarizes all economic benefits of unlicensed spectrum and formalizes a methodology for estimating its total economic value. Along those lines, unlicensed spectrum should be considered a critical production factor that generates value across four dimensions:

- Complementing wireline and cellular technologies, thereby enhancing their effectiveness;
- Providing an environment conducive to the development of alternative technologies, thus expanding consumer choice;
- Similarly, enabling the launch of innovative business models; and
- Expanding access to communications services beyond what is economically optimal by technologies operating in licensed bands

It should be mentioned, however, that these four dimensions could be interrelated and overlapping. For example, unlicensed spectrum can stimulate innovation resulting in new products and services, which could, in turn, contribute to the enhancement of existing wireline and cellular technologies, thereby increasing competition.

In addition to its intrinsic value, unlicensed spectrum generates "spill-over" value in other domains. In the first place, as pointed by Milgrom et al. (2011) unlicensed spectrum has a direct positive impact on the value of licensed bands. A reduction in the supply of licensed spectrum caused by maintaining or expanding unlicensed bands can yield an increase in the price per MHz of licensed spectrum. Beyond increasing the unit value of MHz as a result of restricted supply, the reduction of licensed spectrum bands acts as a stimulus for the development of technologies and services that complement licensed spectrum by increasing its capacity. Most importantly, technologies operating in unlicensed bands have the ability to off-load data traffic from cellular networks, which allows service providers to maximize revenues while controlling capital expenditures. In addition, by increasing broadband speed, traffic off-loading to Wi-Fi sites also raises broadband's consumer surplus. In fact, it has been argued that, considering the amount of traffic channeled through Wi-Fi, one could suggest the latter to be the preferred platform for data communications, while cellular networks become the off-loading technology (Garnett, 2011).

This study's approach to measuring the economic value focuses first on the surplus generated from the adoption of the technologies operating in the unlicensed network bands. The underlying premise is that the unlicensed spectrum resource generates a shift in both the demand and the supply curves (utilized to measure economic surplus) resulting from changes in the production function of services as well as the corresponding consumers' willingness to pay. On the supply side, the approach measures changes in the value of inputs in the production of wireless communications. The most obvious example is that of Wi-Fi, which positively contributes to wireless carriers' CAPEX and OPEX since they can control their spending while meeting demand for increased wireless traffic. From an economic theory standpoint, this allows the wireless industry to increase its output, yielding a marginal benefit that exceeds the marginal cost, resulting in a shift in the supply curve by a modification in the production costs. Additionally, since the demand curve is derived from the utility function, as consumers see the benefits of – and increasingly rely on - technologies enabled by unlicensed spectrum at a stable price, their willingness to pay will also increase, consequently shifting the demand curve. The sum of producer and consumer surplus represents the most important component of economic value creation.

However, beyond the concept of economic surplus, the study also measures any direct contribution of technologies, applications, and computer-mediated transactions that run on unlicensed spectrum bands to the nation's GDP. By quantifying their contribution to GDP, we consider the economic growth enabled by unlicensed spectrum. However, in measuring GDP contribution, we strictly consider only the revenues added "above and beyond" what would have occurred had the unassigned spectrum been licensed[2]. Table B presents the formalization of each value creation effect and underlying rationale.

[2] It should be mentioned that the "GDP contribution" metric might be subject to some distortions. For example, if the price of Wi-Fi service falls while quality remains stable, the imputed "contribution to GDP" decreases, while consumer welfare increases.

Table B. Approaches to Measure Economic Value of Unlicensed Spectrum

	Economic Effect	Quantification	Rationale
Wi-Fi Cellular Off-Loading	Value of free Wi-Fi traffic offered in public sites	Consumer surplus	Price paid if traffic transported through the cellular network minus the price of paid Wi-Fi service equals the willingness to pay
	Total cost of ownership (cumulative CAPEX and OPEX) required to accommodate future capacity requirement with Wi-Fi complementing cellular networks	Producer surplus	Since mobile broadband prices do not decline when traffic is off-loaded to Wi-Fi, the gain triggered by cost reduction is producer surplus
	Contribution to GDP derived from an increase in average mobile speed resulting from Wi-Fi off-loading	GDP contribution	While speed increase could be considered consumer surplus, recent research finds economic efficiency spillovers
	Sum of revenues of service providers offering paid Wi-Fi access in public places	GDP contribution	These revenues would not exist without the availability of unlicensed spectrum
Residential Wi-Fi	Internet access for devices that lack a wired port (e.g. tablets, smartphones, game consoles)	Consumer surplus	Price to be paid if cellular network transports all traffic; this equals the willingness to pay
	Avoidance of investment in in-house wiring	Consumer surplus	Price to be paid if in-house wiring equals willingness to pay
Wireless Internet Service Providers	Aggregated revenues of 1,800 WISPs	GDP contribution	These revenues would not exist without the availability of unlicensed spectrum
Wi-Fi Only Tablets	Difference between retail price and manufacturing costs for a weighted average of tablet suppliers	Producer surplus	Availability of manufacturing and retail costs, as well as sales volume
	Difference between willingness to pay for entry level tablet and prices of iPad and Android products	Consumer surplus	Availability of willingness to pay data, retail pricing, and sales volume
Wireless Personal Area Networks	Sum of revenues of Bluetooth-enabled products	GDP Contribution	These revenues would not exist without the availability of unlicensed spectrum
	Sum of revenues of other WPAN standards (ZigBee, WirelessHART)	GDP Contribution	
RFID	RFID value in retailing	Consumer and producer surplus	Benefits to consumers and savings to producers resulting from RFID adoption
	RFID value in health care		

Source: TAS analysis

The compilation of effects outlined above indicates that the technologies operating in unlicensed spectrum bands in the United States generated a total economic value of $222 billion in 2013 and contributed $ 6.7 billion to the nation's GDP (see table C).

Table C. United States: Summary of Economic Value of Unlicensed Spectrum (2013)
(in $ billions)

	Effect	Economic Value			GDP
		Consumer Surplus	Producer Surplus	Total Surplus	
Wi-Fi Cellular Off-Loading	Value of free Wi-Fi traffic offered in public sites	$ 1.902	N.A.	$ 1.902	N.A.
	Benefit of total cost of ownership required to support future capacity requirement with Wi-Fi complementing cellular networks	N.A.	$ 10.700	$ 10.700	N.A.
	Contribution to GDP of increase of average mobile speed resulting from Wi-Fi off-loading	N.A.	N.A.	N.A.	$ 2.831
	Sum of revenues of service providers offering paid Wi-Fi access in public places	N.A.	N.A.	N.A.	$ 0.271
	Subtotal	$ 1.902	$ 10.700	$ 12.602	$ 3.102
Residential Wi-Fi	Internet access for devices that lack a wired port	$ 22.510	N.A.	$ 22.510	N.A.
	Avoidance of investment in in-house wiring	$ 13.570	N.A.	$ 13.570	N.A.
	Subtotal (*)	$ 36.080	N.A.	$ 36.080	N.A.
Wireless Internet Service Providers	Aggregated revenues of 1,800 WISPs	N.A.	N.A.	N.A.	$ 1.439
Wi-Fi Only Tablets	Difference between retail price and manufacturing costs for a weighted average of tablet suppliers	N.A.	$ 34.885	$ 34.885	N.A.
	Difference between willingness to pay for entry level tablet and prices of iPad and Android products	$ 7.987	N.A.	$ 7.987	N.A.
	Subtotal	$ 7.987	$ 34.885	$ 42.872	N.A.
Wireless Personal Area Networks	Sum of revenues of Bluetooth-enabled products	N.A.	N.A.	N.A.	$ 1.739
	Sum of revenues of ZigBee-enabled products	N.A.	N.A.	N.A.	$ 0.267
	Sum of revenues of WirelessHART-enabled products	N.A.	N.A.	N.A.	$ 0.160
	Subtotal	N.A.	N.A.	N.A.	$ 2.166
RFID	RFID Value in retailing	$ 26.26	$ 68.58	$ 94.84	N.A.
	RFID Value in health care	$ 4.03	$ 31.96	$ 35.99	N.A.
	Subtotal	$ 30.29	$ 100.54	$ 130.83	N.A.
TOTAL		$ 76.26	$ 146.13	$ 222.38	$ 6.707

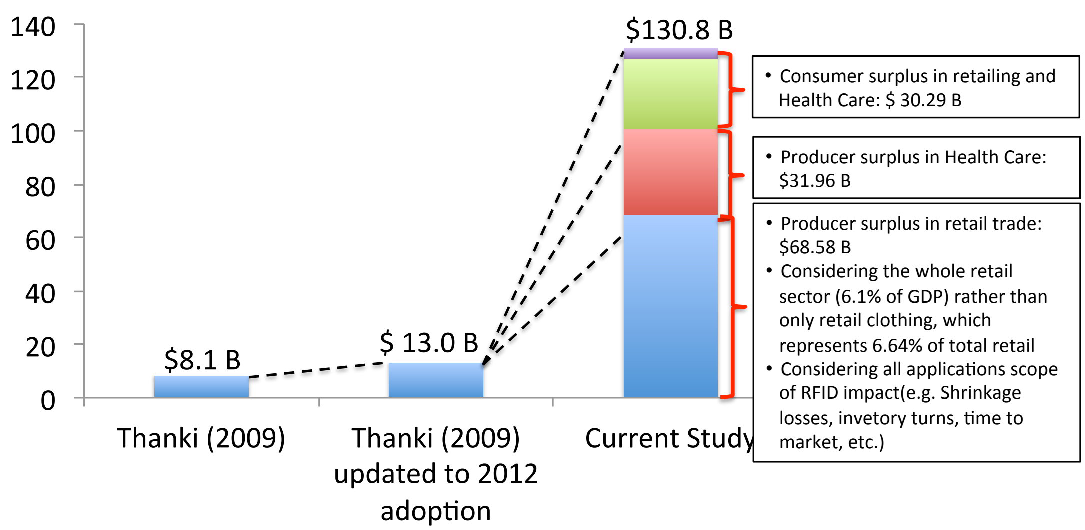
(*) A lower range in Residential Wi-Fi consumer surplus would amount to $ 31.9 billion
Source: TAS analysis

We recognize this number to be significantly higher (close to $ 82 billion more) than the composite generated by aggregating prior research (presented in Table A and Figure A), and, therefore, needs to be explained. The largest source of value ($130.83 billion) resides in the implementation of RFID in the Retail and Health Care industries (all data, sources and calculations of RFID value are included in chapter VIII). Thanki conducted the prior estimate of RFID economic value in 2009, focusing only on retail clothing (understandably so, since retail clothing was an adoption leader of RFID and there was already research on economic impact available at the time). The economic value estimated by Thanki in 2009 ranged between $2.1 and $8.1 billion. However, he recognized that the usage of RFID was "at its infancy". In fact, his model assumed that RFID in retail clothing would reach 60% (high take up scenario) only in 2019.

Several things have happened since 2009. First, adoption of RFID in retail clothing has exceeded Thanki's high uptake scenario (reaching 52% in 2012). If we were to consider only Thanki's original industry (retail clothing), and the acceleration of RFID take-up, the economic value of this technology would increase approximately to $13 billion. Second, the blending of general-purpose networks and RFID has yielded new applications, which has led to their adoption in manufacturing plants, warehouses, and logistics chains. As a result, penetration has increased well beyond retail clothing, reaching the whole retail trade sector. According to a survey by Accenture, more than 50% of US retailers have already adopted RFID. Third, research on the economic value of RFID has greatly expanded since 2009 (Gorshe et al, 2012; Waller et al, 2011). For example, Thanki recognizes that his analysis does not consider the value that might be generated in preventing shrinkage, reducing inventory holdings, and using data for marketing purposes. In conclusion, three trends are at work that greatly enhance RFID economic value beyond the original estimate: more penetration in retail clothing, enhanced adoption in the retail sector as a whole, and more applications.

In addition, beyond retail trade, RFID adoption has expanded in the health care industries, a sector that was not originally considered by Thanki. The impact of all these changes is presented in figure B.

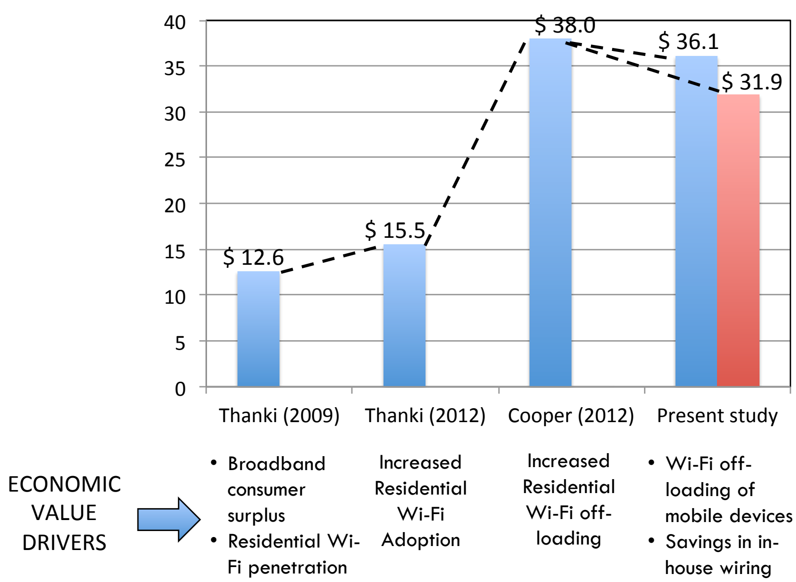
Figure B. Economic Value of RFID: Thanki (2009) Versus Present Study (in $ billions)



To sum up, implementing Radio Frequency Identification in two of the largest sectors of the US economy (retailing (6.1% of GDP) and health care (7.4% of GDP)) results in efficiencies that generate the largest portion of economic surplus ($ 130.83 billion). This estimate does not include all other areas impacted by RFID, such as manufacturing supply chain (Sarac et al., 2009) and livestock tracking.

Residential Wi-Fi also generates a sizable surplus. Thanki's original estimate (2009), based on the extrapolation of consumer surplus (Dutz et al., 2009) and 36% Wi-Fi adoption across households, was ranged between $4.3 billion and $12.6 billion. In 2012, Thanki updated his analysis based on increased Wi-Fi households and estimated its economic value at $15.5 billion. In the same year, Cooper (2012) provided a higher estimate (which he considers to be conservative) of $38 billion. This last author factors in not only the increase in Wi-Fi penetration but also the growth in cellular off-loading. Our approach differs from Thanki's and Cooper's. Rather than extrapolating from fixed broadband consumer surplus research, we quantify savings incurred by consumers as a result of deploying Wi-Fi in their residences (all data, sources and calculations are included in chapter IV). As of 2013, 63% of US households are equipped with Wi-Fi (versus only 36% when Thanki did his study), which has a net effect of providing free access for devices designed for wireless access (tablets, smartphones), generating annual transport savings of $22.5 billion. In addition, residential Wi-Fi services generate $13.6 billion in savings for households that do not require in-house wiring to interconnect PCs, printers, audio equipment, and the like. The sum of these estimates are two and a half times higher than Thanki's 2012 figures, and close to Cooper's (see figure C). To calibrate our results, we replicated Thanki's estimates, multiplying the total number of Wi-Fi households (72,450,000) by an assumed willingness to pay of $36.8 per household per month[3]. This yields a total surplus of $31.9 billion (considered to be a low bound estimate).

Figure C. Economic Value of Residential Wi-Fi: Thanki (2009, 2012), Cooper (2012) Versus Present Study (in $ billions)

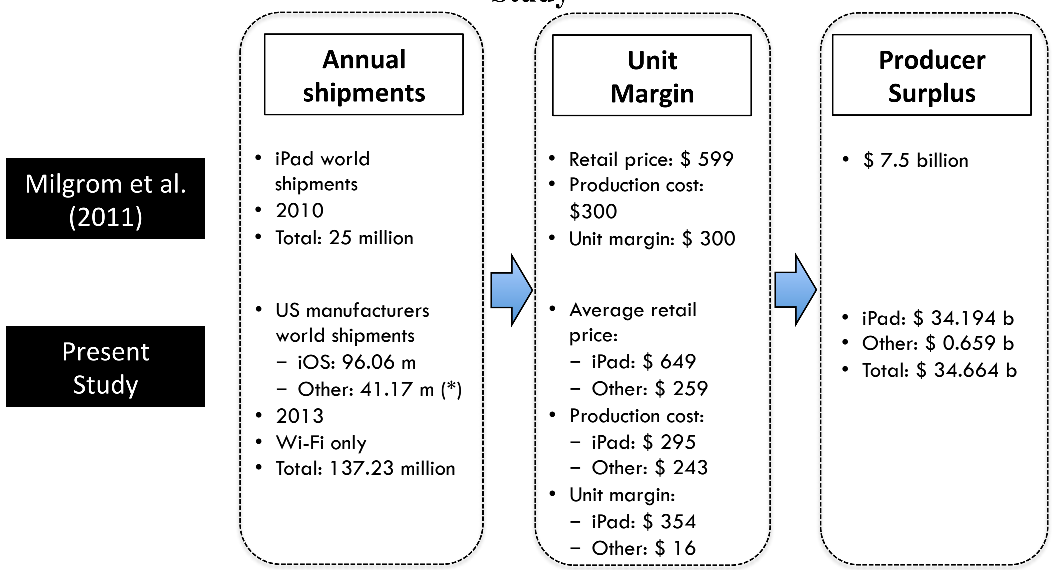


Source: TAS analysis

[3] Thanki estimates the average monthly consumer surplus to be $27.6, which represents 30% of the home broadband value. He also states that there is additional value not captured in his analysis (pp.35). Given the current Wi-Fi adoption and usage patterns, it is reasonable to assume that willingness to pay would amount to 40% of the value, which equals to $36.8 per month.

The producer surplus resulting from the adoption of tablets ($ 34.9 billion) is almost as high as the surplus of residential Wi-Fi and five times the surplus of the iPad as estimated by Milgrom et al. (2011) (all data, sources and calculations are included in chapter VI). While sales of tablets increased from 17.9 million in 2010 to approximately 220 million in 2013[4], the producer surplus per unit declined from $300 for the iPad in 2010 to an average per tablet (iOS or other) of $253 because Apple's competitors' tablet margins are substantially lower than the iPad (see figure D).

Figure D. Producer Surplus of Wi-Fi Only Tablet: Milgrom et al. (2011) Versus Present Study



(*) Other: Google Nexus, Amazon Kindle Fire, HP Touchpad, etc.

Source: TAS analysis

Wi-Fi cellular off-loading also creates economic value (all data, sources and calculations are included in chapter III). This value includes the producer surplus generated by the operators' deployment of carrier-grade Wi-Fi sites to respond to the growth in wireless data traffic ($ 10.7 billion). This figure is higher than Thanki's 2012 $ 8.5 billion estimate due to the increase in the volume of Wi-Fi sites since the author conducted his analysis. Wi-Fi off-loading's second value-creation effect comes from the consumer surplus derived from the utilization of free Wi-Fi sites deployed in public locations ($ 1.9 billion). This is calculated as the cost of the total wireless traffic transported in free Wi-Fi sites (which is 3%) if the consumer would have to pay to a wireless carrier minus the price paid for Wi-Fi provisioned in public places. Our estimate is lower than Cooper's since we have a more conservative estimate of the annual benefit of off-loading for the carriers and because a portion of the consumer surplus assumed by Cooper (and Milgrom et al, 2011) has already been assigned to residential Wi-Fi (see figure E).

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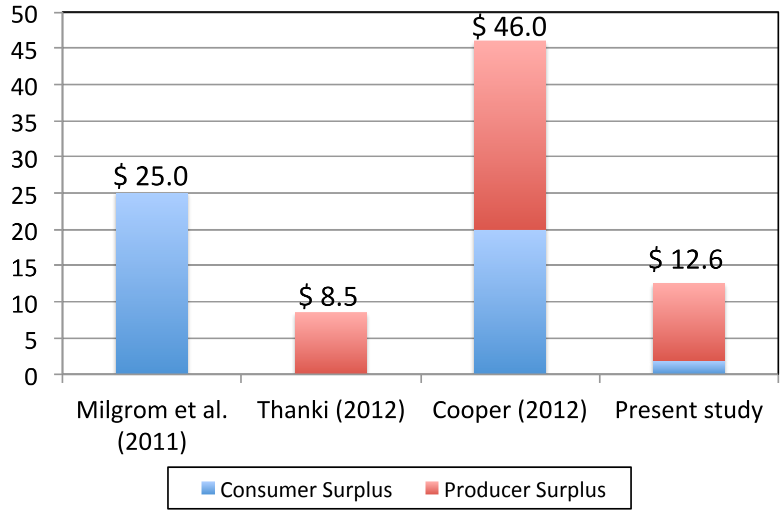
[4] This number was reduced to subtract shipments from manufacturers based overseas, and tablets with cellular connectivity, yielding a total of 137 million units for 2013.

Figure E. Economic Value of Wi-Fi Off-Loading: Thanki (2012), Milgrom et al. (2012), Cooper (2012) Versus Present Study (in $ billions)

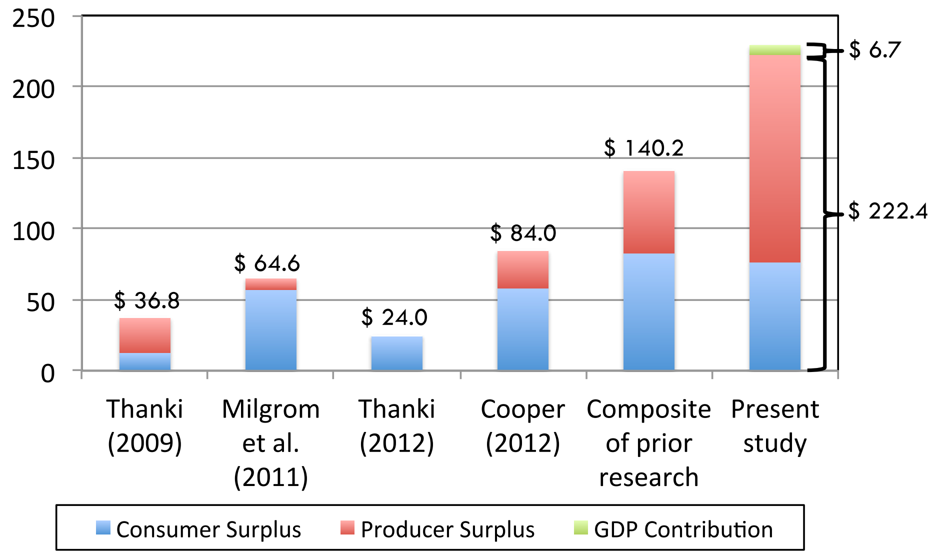


Source: TAS analysis

Finally, unlicensed spectrum fosters the development of new businesses generating revenues that directly contribute to the country GDP ($3.87 billion): companies offering paid Wi-Fi access in public places (e.g. Boingo), Wireless Internet Service Providers (WISPs), Bluetooth-enabled products (e.g. chipsets to enable hands-free wireless calling), ZigBee-enabled products (e.g. home automation), and WirelessHART (e.g. industrial monitoring systems). The spillover impact of faster-than-cellular broadband wireless connections resulting from Wi-Fi off-loading ($ 2.8 billion) also contributes to GDP.

To summarize, we believe that the aggregate economic surplus estimate of $222 billion and $6.7 billion in direct GDP contribution, while considerably higher than prior studies, is accurate since it captures the whole range of applications operating in unlicensed spectrum bands (figure F).

Figure F. Unlicensed Spectrum Economic Value in the United States: Comparison with Prior Studies (in $ billions)



Source: TAS analysis

Furthermore, this number is well above that one estimated by recent studies because it reflects a more detailed analysis of the multiple relatively heterogeneous applications and technologies that rely on unlicensed spectrum.

In light of this value, and the technical characteristics of unlicensed spectrum, the economic rationale for licensing it does not apply. By definition, applications and services relying on low-power, low-propagation transmission, like Bluetooth, ZigBee, and RFID remain private goods, as one person's use of does not usually impact other users (Varian, 2013). Congestion in these cases is hardly a problem. In the case of Wi-Fi, some congestion issues arise, particularly in public places. However, these could be resolved by assigning more bands for unlicensed usage.

This last point leads to the question of whether the current assignment of unlicensed spectrum bands risks, in light of the explosive growth in usage, in becoming a bottleneck of future value creation. Indeed, our estimate of Internet traffic trends indicates that total Wi-Fi traffic in the United States is currently 0.67 Exabytes per month and will reach 5.97 Exabytes by 2017, reflecting a 68.0% growth rate. Wi-Fi households in the US, currently at 63%, are forecast to reach 86% by 2017[5]. According to IDC, tablet worldwide shipments, currently at 221 million, are estimated to reach 386 million by 2017. According to Gorsh et al, while 52% of retailers surveyed had already implemented or piloted RFID within their organization, 23 % are considering launching pilots in the near future[6]. All in all, there are currently 20,339 different unlicensed devices certified for use in the 2.4 GHz band alone, approximately three times the amount in any licensed band[7].

[5] Gillott, I. (2012). U.S. Home Broadband and Wi-Fi Usage Forecast 2012-2017. Austin, TX: iGR.
[6] Gorsh, M, Rollman, M, and Beverly, R. (2012) Item-level RFID: a competitive differentiator. Chicago, Illinois: Accenture.
[7] Wireless Innovation Alliance. Background on Unlicensed Spectrum.

In the context of accelerating adoption of applications operating in unlicensed spectrum, it would be relevant to ask the question whether there is enough spectrum space to accommodate the expected growth. Until 2008, roughly 955 MHz were allocated to unlicensed uses below 6 GHz (Hazlett et al., 2010), although only a small portion of this is in the beachfront spectrum (the 300 MHz to 3 GHz spectrum range). In 2010, the FCC allocated additional unused spectrum between broadcast TV channels. That said, the most used bands remain in the 900 MHz, 2.4 MHz, 5.2/5.3/5.8 GHz, 24 GHz, and above 60 GHz (Milgrom et al., 2011). In fact, the 2.4 GHz and 5GHz bands have become increasingly congested due to the intense Wi-Fi usage.

If future assignment of unlicensed spectrum is not fulfilled, it is plausible to consider that economic value creation would be at risk. This case is similar to the transition from 3G to 4G and the allocation of additional licensed spectrum for mobile broadband. Where do we see the effects that would be most at risk? Our quantification of the risk of not assigning additional unlicensed spectrum assumes that, beyond a certain point of network congestion, application or technology demand stops growing.

In the first place, let us address the so-called return to speed. At the current rate of traffic off-loading, the average speed of mobile traffic in the United States in 2013 was 10 Mbps[8]. Our analysis showed that, even when considering the increasing speed of LTE networks, if all the off-loaded traffic were to be conveyed through cellular networks, the speed would decline to 3.43 Mbps, with the consequent negative impact of $2.8 billion in GDP (see section III.3 for detailed calculations). Over five years, the impact would amount to $ 23.56 billion. The benefit derived from the additional speed resulting from off-loading is what we call the Wi-Fi return to speed. However, if we assume that, due to congestion, the average Wi-Fi speed does not increase to 17 Mbps, as Cisco projects, but stays at current levels (13.32 Mbps), the average speed of all mobile traffic would not change significantly from today, which means that $ 10.6 billion of the Wi-Fi speed return over the next five years would disappear.

Obviously, average speed could decline even further beyond the current level, with the consequent increase in value erosion. According to a study by Williamson et al. (2013), this scenario is highly likely. Once an 80-100 Mbps fiber link is deployed to a customer premise, the last mile is not the bottleneck any more, and the residential Wi-Fi becomes the congestion point. This is because there is a difference between the advertised speed in a typical Wi-Fi router (150 Mbps) and the delivered speed, which is below 70 Mbps[9]. Given that Wi-Fi shares available capacity across devices, if a typical Wi-Fi household is running multiple devices, the service will degrade and be substantially less than what could be handled by a fiber link.

A second area of negative impact under a scenario of limited unlicensed spectrum assignment is service degradation in public places (airports, convention halls, etc.). Research by Wagstaff (2009) and Van Bloem et al. (2011) indicates that in dense device environments, data overheads

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[8] This is calculated by prorating total mobile traffic by Wi-Fi and Cellular speeds according to off-loading factors (see appendix C).

[9] The difference is due in part to the need to assign part of the capacity to the data overheads. In addition, advertised speeds are based on tests that relying on large packets, while the average packet size is much smaller. Finally, range and attenuation are factors to be considered in the reduction of speed. Williamson et al. (2013) estimate that delivered speed is approximately 50% of the advertised.

that are generated to keep the connection running consume between 80% and 90% of capacity. In the context of increasing traffic volumes, Wi-Fi is becoming the contention point in public access networks. Some of this pressure could be alleviated by the upcoming Wi-Fi standard 802.11ac. While it is difficult to quantify the negative impact of this degradation, a large portion has been considered above in the reduction of the so-called Wi-Fi speed return. In addition, no additional assignment of unlicensed spectrum could result in the disappearance of the Wi-Fi service provider industry since, with lower service quality level, these operators could not compete with cellular service provider: an erosion of $271 million direct contribution to the GDP.

A third area of negative impact if additional unlicensed spectrum is not assigned could be an erosion of the benefit to carriers generated by cellular traffic off-loading. With high-density device environments being so prone to contention, if Wi-Fi does not benefit from additional spectrum, cellular carriers would experience service degradation when users roam into Wi-Fi. In other words, Wi-Fi's value of complementarity would be greatly diminished, reducing the $10.7 billion estimated producer surplus.

Following the evidence generated in this study, we conclude that any policies focused on this portion of the spectrum must preserve the value generated so far as well as the capacity to generate economic surplus in the future. Given the emerging body of evidence of congestion within the unlicensed spectrum bands and their estimated economic value, it would highly beneficial to pursue additional research linking up the study of congestion scenarios, the advantage of additional allocation and the risks of not proceeding along this path.

I. INTRODUCTION

The debate over the most effective way of allocating frequency spectrum has been conducted over the past fifty years, in particular since the publication of Coase's seminal paper (1959) on spectrum management. A specific issue of the policy debate relates to the management of unlicensed spectrum, which covers the frequency bands for which no exclusive licenses are granted. Key policy questions addressed in this domain range from whether granting exclusive licenses would deter innovation to if setting spectrum for unlicensed uses would be costly in terms of reduced government revenues to be derived from auctioning frequency rights. Along these lines, research to date has produced a number of very important contributions in support of (Milgrom et al, 2011; Carter, 2003; Cooper, 2011; Bayrak, 2008; Marcus et al, 2013; Crawford, 2011; Benkler, 2012; Calabrese, 2013) and against (Hazlett et al., 2010a; Hazlett et al, 2010b, Nguyen et al, 2010; Bazelon, 2008) the allocation of spectrum for private use. That said, while the debate has highlighted the diverse beneficial effects of unlicensed spectrum - such as triggering technological innovation, complementing cellular networks, and the like - little research assesses the economic value of unlicensed spectrum, particularly the producer and consumer surplus derived from keeping a portion of the spectrum unassigned as well as its GDP contribution[10]. Part of the difficulty in assessing the value of unlicensed spectrum resides on the fact that, unlike licensed spectrum that is used for a few, homogeneous services, unlicensed bands provide the environment for the provision of several heterogeneous services and devices. Furthermore, given the recent history of some of those services, historical data on pricing and use is not readily available. Finally, given the complementarity between applications relying on unlicensed and licensed spectrum, value estimation of the unlicensed portion is non-trivial. Nevertheless, an evidence-based policy debate requires the rigorous quantification of economic value of the unlicensed spectrum.

In 2009, Richard Thanki produced the first paper to determine the economic value of unlicensed spectrum. He estimated that three major applications (residential Wi-Fi, hospital Wi-Fi, and retail clothing RFID) in the United States generated value in the range of $16 and $36.8 billion. At the time, the author acknowledged that these estimates covered only a fraction of the economic value[11] and, consequently, were too conservative.

Two years later, Milgrom et al. (2011) supported Thanki's numbers, but also provided additional estimates for other applications. For example, the authors estimated the economic value of Apple's iPad, a device intimately linked to the use of Wi-Fi, at $ 15 billion. Additionally, the authors quantified other benefits in the United States alone, such as Wi-Fi supported cellular off-loading ($ 25 billion) and the value of Wi-Fi faster data rates of mobile phones ($ 12 billion). Finally, they referenced other non-quantified benefits, such as the usage of Wi-Fi only devices and future applications such as Super Wi-Fi and Advanced Meter Infrastructure.

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[10] This is contrary to research on the valuation of consumer welfare derived from the use of licensed spectrum which has been a fairly standard research practice given the availability of auction data and consumption series (see Hazlett, 2005: Hausman, 1997).

[11] Thanki estimated that the three applications represented 15% of the unlicensed wireless chipsets to be shipped in the US in 2014.

A year later, Thanki (2012) produced a new piece of research, refining his residential Wi-Fi estimate and quantifying other benefits of unlicensed spectrum. He estimated the annual consumer surplus of residential Wi-Fi to be between $118 and $225 per household[12] (a total of $ 15.5 billion for the United States). Additionally, enlarging the original scope of benefits, he assessed the producer surplus derived from carrier savings resulting from Wi-Fi off-loading ($ 8.5 billion for the United States). Finally, he estimated the value generated by enhanced affordability (an assessment mainly focused on emerging markets) and mentioned potential innovation related benefits related to deployment of Wireless Internet Service Providers.

In the same year, Cooper (2012) calculated the economic value by estimating the number of cell sites that the wireless industry would avoid investing in as a result of traffic off-loading (130,000), which would result in annual savings of $26 billion. The author also updated Thanki's residential wireless consumer surplus as a result of the considerable increase in Wi-Fi adoption that took place since 2009, and slightly reduced the Milgrom et al. off-loading consumer surplus estimate to $ 20 billion.

A compilation of the results produced by these four pieces of research reveals the limited available evidence generated to date in support of such a critical policy discussion (see table I-1).

Table I-1. United States: Prior Research on Economic Value of Unlicensed Spectrum (in $ billions)

	Effect	Thanki (2009)	Milgrom et al. (2011)	Thanki (2012)	Cooper (2012)	Composite
Wi-Fi Cellular Off-Loading	Consumer Surplus	N.A.	$ 25.0	N.A.	$ 20.0	$ 25.0
	Producer Surplus		N.A.	$ 8.5	$ 26.0	$ 26.0
	Return to Speed		$ 12.0	N.A.	(*)	$ 12.0
	New Business Revenue		N.A.	N.A.	N.A.	N.A.
	Subtotal		$ 37.0	$ 8.5	$ 46.0	$ 63.0
Residential Wi-Fi		$4.3 - $ 12.6	>$ 12.6	$ 15.5	$ 38 0	$ 38.0
Wi-Fi Only Tablets	Producer Surplus	N.A.	$ 7.5	N.A.	N.A.	$ 7.5
	Consumer surplus		$ 7.5		N.A.	$ 7.5
	Subtotal		$ 15.0		N.A.	$ 15.0
Hospital Wi-Fi		$ 9-6 – $16.1	N.A.	N.A.	(*)	$ 16.1
Clothing RFID		$ 2.0 - $ 8.1	N.A.	N.A.	(*)	$ 8.1
Wireless Internet Service Providers		N.A.	N.A.	(*)	N.A.	N.A.
Total		$ 16.0 - $ 36.8	$ 64.6	$24.0	$ 84.0	$ 140.2

(*) Referenced but not quantified
N.A. Not addressed
Source: TAS analysis

The only consistent series of estimates, albeit reliant on different methodologies, is the one of residential Wi-Fi. Nevertheless, the growth in Wi-Fi household penetration is the central assumption driving an increase in economic value from a low-end estimate of $4.3 billion in 2009 to an estimate of $ 15.5 billion in 2012. A composite sum (which recognizes that there

[12] In the 2009 study, his estimate of annual consumer surplus per household ranges between $114 and $331.

could be some double-counting) of the latest estimates for each of the areas addressed would indicate a total economic value of $ 140.2 billion for unlicensed spectrum in the United States. We believe, however, that even this estimate could be subject to a number of forecasting limitations.

First, in a field that is evolving at such a high speed in terms of the rate of product innovation, consumer adoption, and technological substitution, a 2009 assessment of economic value could vastly underestimate present economic value.

Second, as pointed out by Milgrom et al. (2011), the range of unlicensed spectrum applications has vastly increased over time. In fact, by looking only at applications that currently rely on unlicensed spectrum, one could underestimate its value since some of the benefits cannot yet be foreseen. As an example, to be shown in chapter VI, one of the greatest benefits derived by unlicensed spectrum results from the diffusion of Wi-Fi only tablets. Apple introduced the first version of its iPad, the most successful tablet to date, in April 2010 (eight months after the publication of Thanki's study). By the time Milgrom et al. published their study (October 2011), global annual shipments of tablets reached 70 million. Two years later, this number exceeded 200 million.

Third, the assessment of economic value has, in many cases, been conducted at an extremely high level with the purpose of ranging orders of magnitude rather than stipulating value through a rigorous approach. As an example, the assessment of economic surplus derived from the Apple iPad (Milgrom et al 2011) considered that, in the absence of willingness-to-pay data, consumer surplus could be of the same magnitude of the product's producer surplus.[13]

The understandable limitations of extant research on the economic value of unlicensed spectrum raise the need to produce up-to-date evidence that brings additional support to the policy debate. This study commences with a summary of all economic benefits of unlicensed spectrum and formalizes the methodology for estimating total economic value. It then proceeds sequentially to assess the value of specific technologies that rely on unlicensed spectrum. For each technology, the economic value will be estimated by application or impact area. The last chapter dedicated to economic value estimation focuses on future uses of unlicensed spectrum. A final conclusion summarizes the evaluations of each technology, yielding a final value for specific metrics (economic value, GDP contribution, employment, consumer surplus). In this sense, the following study stands as a progression of analyses that were started by Thanki in 2009 and have gradually been extended and updated since.

[13] Milgrom et al. (2011) are cognizant of this limitation (calling it a "plausible first guess") and point out that assessing value in a rigorous fashion exceeds the purpose of their research.

II. ESTIMATING ECONOMIC BENEFITS OF UNLICENSED SPECTRUM

This chapter presents the approach utilized to estimate the economic value of unlicensed spectrum. We begin by presenting the intrinsic and derived sources of value of unlicensed spectrum, which serves as a backdrop for reviewing prior value estimation research. Based on this review, we present the approach to be followed in the study.

II.1. The intrinsic economic value of unlicensed spectrum

Unlicensed spectrum has fostered the establishment of standards that have enabled the development of numerous applications and devices (see table II-1):

Table II-1. Standards and enabled complementary technologies

Standards	Frequency bands	Geographic Range	Data rate	Devices and applications
Wi-Fi (802.11b, 802.11g)	• 2.4 GHz • 3.6 GHz • 5 GHz	• indoor: 38 meters • outdoor: 125 meters	• Up to 54 Mbps	• Computers • Printers • Mobile phones • Tablets
Bluetooth (802.15.1)	• 2.4 GHz	• Short range indoors	• 1-3 Mbps	• Phone headsets • PC networks • Barcode scanners • Credit card payment machines
ZigBee (802.15.4)	• 915 MHz	• 75 meters	• 250 Kbps	• Wireless light switches • Electrical meters with in-home-displays • Traffic management systems
WirelesHART (802.15.4)	• 2.4 GHz	• indoor: 60 -100 meters • outdoor: 250 meters	• 250 Kbps	• Equipment and process monitoring • Environmental monitoring, energy management • Asset management, predictive maintenance, advanced diagnostics
WirelessHD	• 60 GHz	• 30 feet	• 28 Gbps	• High Definition consumer electronic devices
WiGig (802.11ad)	• 60 GHz	• 5 -10 meters	• 6 Gbps	• Smartphones • Tablets • Docking stations • PCs & Peripherals • TV & Peripherals • Digital Cameras • Camcorders
RFID	• 50-500 KHz • 13.56 MHz • 0.9 to 2.5 GHz	• Up to 29 inches	• Read-only: 8.75 kbps • Active Read - Write: 3 kbps	• Asset tracking • Livestock tracking, credit card payments • Highway toll payments • Supply chain management

Source: Compiled by TAS

This section demonstrates how unlicensed spectrum should be considered a critical production factor to generate value across four dimensions:

- Complementing wireline and cellular technologies, thereby enhancing their effectiveness
- Developing alternative technologies, thus expanding consumer choice
- Supporting innovative business models
- Expanding access to communications services

II.1.1. The value of complementary technologies

A complementary technology is a resource that, due to its intrinsic strengths, compensates for the limitations of another. In the case of spectrum management, unlicensed frequency bands can enhance the effectiveness of devices that use licensed spectrum. For example, Wi-Fi base stations operating in unlicensed bands can enhance the value of cellular networks by allowing wireless devices to switch to hot-spots, thereby reducing the cost of broadband access and increasing the access speed rate. Consumers accessing the Internet within the reach of a Wi-Fi site can reduce their costs of access by turning off their wideband service. They can also gain additional access speed because the transfer rate of Wi-Fi sites is generally faster than that offered by cellular technology.

Wireless operators can also reduce their capital spending by complementing their cellular networks with carrier-grade Wi-Fi sites, which are considerably less expensive than cellular network equipment with similar capacity. In addition to reducing spending, wireless carriers can offer fast access service without a base station congestion challenge. Finally, cellular carriers derive benefits from avoiding CAPEX since a portion of traffic is off-loaded to residential Wi-Fi or business networks (Cooper, 2012).

As the list in table II-1 demonstrates, the list of devices and applications that complement and enhance the capability of fixed and wireless networks is fairly extensive. In most cases, fixed and wireless networks can deliver the value attached to specific applications only by coupling with the technology operating in unlicensed spectrum.

II.1.2. The value of alternative technologies

In addition to complementing cellular networks, unlicensed spectrum can provide the environment needed for operating technologies that are substitutes to licensed uses, thereby providing consumers with a larger set of choices. By limiting power and relying on spectrum with low propagation, unlicensed bands avoid interference, rendering the need for property rights irrelevant. In fact, some of the most important innovations in wireless communications are intimately linked to Wi-Fi for gaining access.

Several communications platforms exist that depend on the availability of broadband services. For example, on *Skype*, the recommended download/upload speed for a high quality video call is 500 kbps and 2 Mbps for a group video call. *Webex*, a similar service predominantly seen in the professional context, has a bandwidth requirement of 3 Mbps for high quality videos. While fixed broadband can support these services, in either mobile (on the go) or nomadic settings, *Skype* or *Webex* increasingly rely on Wi-Fi connectivity for access.

Similarly, *Viber,* a platform that supports free messaging and voice/video calling primarily on smartphones, but also on PCs and tablets, can only be supported by LTE networks or faster technologies. Below 4G, latency, cell tower saturation and handovers handling have negatively impacted customer experience. In addition, given the bandwidth use required to support the service (50 Mb for approximately 200 minutes), Wi-Fi appears to be the most common form of access. A similar concept could be applied to *What's App*, a common platform used primarily on Wi-Fi networks to substitute text messaging.

II.1.3. The value of innovative business models

By providing consumers with additional service choices, unlicensed spectrum also supports the development of innovative business models. The causality between unlicensed spectrum and innovation occurs at multiple levels. First, firms developing new applications in an unlicensed spectrum environment do not need approval from the operators of cellular networks. On the other hand, a firm that attempts to develop a product running on spectrum licensed to a set of exclusive holders faces a "coordination failure" barrier (Milgrom et al., 2011). Along those lines, if the product requires the acceptance and coordination of multiple license holders (say multiple cellular network operators), the innovator must negotiate with every one of them (unless it is willing to face the problem of restricting its market reach).

Second, even if the innovating firm restricts the number of cellular networks with which it negotiates, it still faces the complexities of reaching a financial agreement with the license holder. For example, despite its size and bargaining power, Apple spent a year and a half negotiating the initial marketing terms for the iPhone with AT&T[14].

Third, beyond the impact on time-to-market, small firms face an additional obstacle: spectrum exclusive license holders can impose a financial *hold-up* threat by raising the fraction of the potential revenues they would appropriate. This could reduce the incentive for small firms to launch new products.

The innovator greatly reduces all three of these obstacles when launching its product in an unlicensed spectrum environment. There is no need of prior agreement from license holders, no time-to market penalty, and no disincentives resulting from costly revenue splits. Finally, from a cost of entry standpoint, without licensing fees, required approvals, and the need for radio frequency engineering planning (Carpini, 2011), unlicensed spectrum results in extremely low set-up and deployment costs.

As a testament to the low innovation barriers in unlicensed spectrum environments, numerous applications launched in the past were developed leveraging unlicensed bands. These applications include wireless record players, transmission of radio signals over power lines, remote control operated devices, wireless microphones, garage door openers, telemetry systems, field disturbance sectors, auditory assistance devices, security alarms, and cordless phones. We

[14] Cohan, P. "Project Vogue: Inside Apple's iPhone deal with ATT", Forbes, 9/10/2013.

also count applications stores, and music streaming among the many innovative business models indirectly enabled by unlicensed spectrum[15].

While either fixed broadband or mobile broadband services can deliver these business models, technologies operating within unlicensed spectrum bands add additional convenience from the standpoint of nomadic mobility, speed of access, or affordability.

II.1.4. The value of expanding access to communications services

In addition to the applications discussed above, technologies operating in unlicensed spectrum can bridge the broadband coverage digital divide. According to a report from the NTIA and the FCC, in 2011 there were 26.2 million US citizens living within 9.2 million households (or 6.99%) unserved by fixed broadband services. As expected, the majority of these households were located in rural and isolated areas of the country. While the FCC report does not track broadband over cellular coverage, the National Broadband Map indicates that 3.2 million households (34% of the unserved number mentioned above) can only gain access to broadband services provided by the so-called Wireless Internet Service Providers (WISPs), which typically operate on unlicensed or lightly licensed spectrum in the 3.65 GHz band.

Further developments in the areas of spectrum sensing, dynamic spectrum access, and geolocation techniques (Stevenson et al., 2009) could improve the quality of wireless service based on unlicensed spectrum technologies. For example, as reported by Burger (2011), a new version of the Wi-Fi standard, 802.11af, sometimes called “Super Wi-Fi”, can substantially extend the geographic range of conventional 802.11 standard and provide cost-efficient access in rural settings.

II.2. The derived value of unlicensed spectrum

In addition to its intrinsic value, unlicensed spectrum generates “spill-over” value in other domains. In the first place, unlicensed spectrum has a direct positive impact on the value of licensed bands. For example, Milgrom et al. (2011) argue that a reduction in the supply of licensed spectrum caused by keeping or expanding the unlicensed bands can yield an increase in the price per MHz of licensed bands. Assuming that aggregate demand is relatively inelastic, scarcity could yield a price increase. In that sense, less available spectrum will not necessarily result in lower revenues for the government.

Beyond the unit value of MHz as a result of restricted supply, the reduction of licensed spectrum bands stimulates the development of technologies and services that complement such bands by enhancing the supply of capacity, thereby raising their intrinsic value per MHz. Most importantly, technologies operating in unlicensed bands have the ability to off-load data traffic from cellular networks, which allows service providers to maximize revenues while controlling capital expenditures. In addition, network off-loading also raises broadband’s consumer surplus. Effects such as higher download speeds increase consumer surplus (as indicated by research

[15] See also the recent launch of consumer wireless service providers running on unlicensed spectrum offering unlimited service at a fraction of the price charged by cellular carriers’ plans.

conducted among both consumers (Roston et al, 2010; Dutz et al, 2009) and enterprises (Grimes et al, 2009; Ospina, 2011).

Finally, by providing an environment for the development of alternative wireless communications platforms, unlicensed spectrum becomes a primary vehicle for increasing consumer choice of services.

II.3. A theoretical approach to measuring economic value of unlicensed spectrum

An attempt to measure rigorously the economic value of unlicensed spectrum requires the formalization of an approach that can integrate the various economic gains, be it consumer or producer benefits, as well as their net direct contributions to the GDP. The following section first reviews the approach used by prior research to estimate economic value. Based on the review of prior research, it outlines the framework that this study will follow.

II.3.1. Prior theoretical frameworks to measure economic value of unlicensed spectrum

In the first attempt to estimate economic value of unlicensed spectrum, Thanki (2009) selected applications and relied both on consumer and producer surplus (see table II-2).

Table II-2. Theoretical Underpinnings of Thanki (2009) Assessment of Annual Economic Value of Unlicensed Spectrum in the United States (in $ billions)

Example	Consumer Surplus	Producer Surplus
Residential Wi-Fi	$ 4.3 - $ 12.6	N.A.
Wi-Fi in hospitals	(*)	$ 9.6 - $ 16.1
RFID in retail clothing	$ 2.0 - $ 8.1 (**)	

(*) Mentioned in the study but not quantified
(**) Estimates cannot differentiate between pure efficiency gains (producer surplus) and benefits to consumers
Source: Thanki (2009)

In his study, Thanki (2009) also ascertains that if the effect of a technology "cannot be directly attributed to either consumer or producer surplus, (it) cannot be regarded as an economic gain."

The Milgrom et al. (2011) approach is also implicitly based on the concept of economic surplus. Beyond reiterating Thanki's 2009 estimates, their quantification of value derived from three applications is based on the assessment of consumer and producer surplus (see table II-3).

Table II-3. Theoretical Underpinnings of Milgrom et al (2011) Assessment of Annual Economic Value of Unlicensed Spectrum in the United States (in $ billions)

Example	Consumer Surplus	Producer Surplus
iPad	$ 7.5	$ 7.5
Wi-Fi Cellular off-loading	$ 25	N.A.
Speed effect (*)	$ 12	N.A.

(*) Alternative way of measuring off-loading consumer surplus
Source: Milgrom et al. (2011)

In his 2012 paper, Thanki again relies on the economic surplus framework, restating his residential Wi-Fi statement and adding an estimate of producer surplus for cellular off-loading: the cost saved by carriers by off-loading a portion of wireless data traffic to Wi-Fi hot-spots (see table II-4).

Table II-4. Theoretical Underpinnings of Thanki (2012) Assessment of Annual Economic Value of Unlicensed Spectrum in the United States (in $ billions)

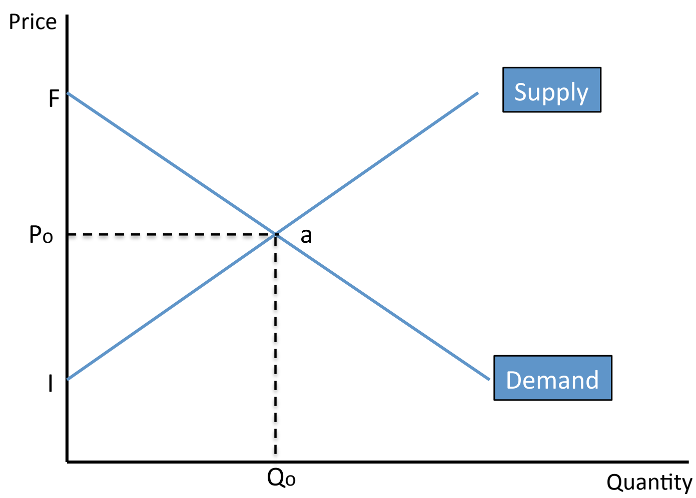
Example	Consumer Surplus	Producer Surplus
Residential Wi-Fi	$ 15.5	N.A.
Wi-Fi Cellular off-loading	N.A.	$ 8.5

Source: Thanki (2012)

Cooper (2012) also follows the same theoretical framework.

The methodology implicitly relied on in determining the economic impact of unlicensed spectrum in all four studies is based on the economic surplus approach (see figure II-1).

Figure II-1. Measurement of Economic Surplus



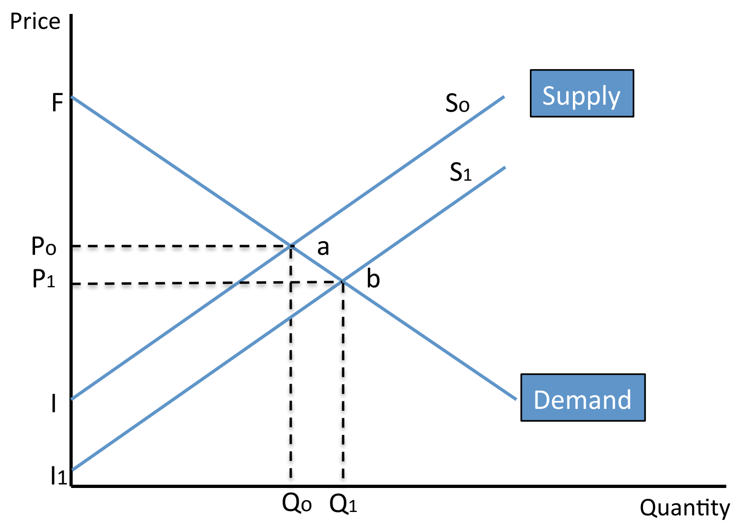
The concept of economic surplus is based on the difference between the value of units consumed and produced up to the equilibrium price and quantity, allowing for the estimation of consumer surplus (area of F, Po, a) and producer surplus (area of Po, I, a).[16] Consumer surplus measures the total amount consumers would be willing to pay to have the service compared to going without it altogether, while producer surplus measures the analogous quantity for producers that, in our context, is essentially the economic profit they earn from providing the service. The total surplus is contained in the area F, I, a.

[16] Following Alston (1990), we acknowledge that this approach ignores effects of changes in other product and factor markets; for example, unlicensed spectrum increases the economic value of technologies operating in licensed bands.

II.3.2. Our approach to measuring economic value of unlicensed spectrum:

Our approach to measuring economic value focuses first on the surplus generated after the adoption of the technologies operating in the unlicensed network bands.[17] The underlying assumption of this approach is that the unlicensed spectrum resource generates a shift both in the demand and supply curves resulting from changes in the production function of services as well as the corresponding willingness to pay. On the supply side, the approach measures changes in the value of inputs in the production of wireless communications. The most obvious example is whether Wi-Fi enabled by unlicensed spectrum represents a positive contribution to wireless carriers' CAPEX and OPEX insofar as they can control their spending while meeting demand for increased wireless traffic. From an economic theory standpoint, the wireless industry can then increase its output, yielding a marginal benefit exceeding the marginal cost. This results in a shift in the supply curve by a modification in the production costs (see figure II-2).

Figure II-2. Measurement of Economic Surplus Resulting From a Supply Shift

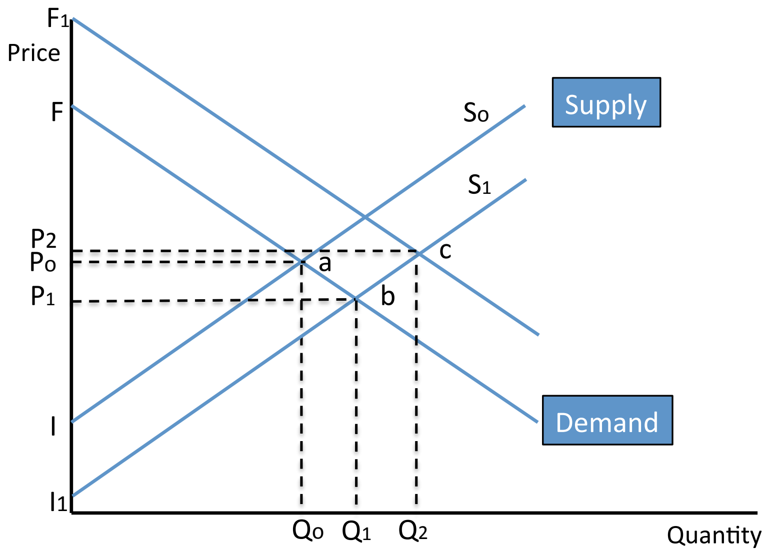


The development and adoption of technologies operating within unlicensed spectrum bands causes the shift in the supply curve, yielding a new equilibrium price and quantity. Under this condition, producer surplus is represented by the triangle F, b, P1, and consumer surplus by the area within P1, b, I1.

Additionally, since the demand curve is derived from the utility function, higher benefit to the consumer derived from the reliance on technologies enabled by unlicensed spectrum at a stable price will yield an increase in the willingness to pay, and consequently a shift in the demand curve (see figure II-3).

17 See a similar approach used by Mensah and Wohlgenant (2010) to estimate the economic surplus of adoption of soybean technology.

Figure II-3. Measurement of Economic Surplus Resulting From a Supply and Demand Shift



Under these conditions, total economic value is now represented by the area I1, c, F1, representing both changes in consumer and producer surplus.

To quantify incremental surplus derived from the adoption of technologies operating in the unlicensed spectrum bands, we itemize the number of technologies and applications intricately linked to this environment. However, we complement the concept of economic surplus with an assessment of the direct contribution of the technologies and applications to the nation's GDP.

By including the GDP contribution measurement, we follow Greenstein et al. (2010) and prior literature measuring the economic gains of new goods. On the one hand, we focus on consumer and producer surplus, but, on the other hand, we consider the new economic growth enabled by unlicensed spectrum. In measuring the GDP direct contribution, we strictly consider the revenues added "above and beyond" what would have occurred had the unassigned spectrum been licensed. Along those lines, if unit costs are available, we do not include them in the GDP contribution, but rather include them in a metric of producer surplus.

The assignment of each effect and underlying rationale is included in table II-5.

Table II-5. Approaches to Measuring Economic Value of Unlicensed Spectrum

	Economic Effect	Quantification	Rationale
Wi-Fi Cellular Off-Loading	Value of free Wi-Fi traffic offered in public sites	Consumer surplus	Price paid if traffic transported through the cellular network minus the price of paid Wi-Fi service equals the willingness to pay
	Total cost of ownership (cumulative CAPEX and OPEX) necessary to accommodate future capacity requirement with Wi-Fi complementing cellular networks	Producer surplus	Since mobile broadband prices do not decline when traffic is off-loaded to Wi-Fi, the gain triggered by cost reduction is producer surplus
	Contribution to GDP from the increase in average mobile speed resulting from Wi-Fi off-loading	GDP contribution	While speed increase could be considered consumer surplus, recent research asserts a spill-over in terms of economic efficiency
	Sum of revenues of service providers offering paid Wi-Fi access in public places	GDP contribution	These revenues would not exist without the availability of unlicensed spectrum
Residential Wi-Fi	Internet access for devices that lack a wired port (e.g. tablets, smartphones, game consoles)	Consumer surplus	Price to be paid if transported through the cellular network; this equals the willingness to pay
	Avoidance of investment in in-house wiring	Consumer surplus	Price to be paid for in-house wiring equals willingness to pay
Wireless Internet Service Providers	Aggregated revenues of 1,800 WISPs	GDP contribution	These revenues would not exist without the availability of unlicensed spectrum
Wi-Fi Only Tablets	Difference between retail price and manufacturing costs for a weighted average of tablet suppliers	Producer surplus	Availability of manufacturing and retail costs as well as sales volume
	Difference between willingness to pay for entry level tablet and prices of iPad and Android products	Consumer surplus	Availability of willingness to pay data, retail pricing, and sales volume
Wireless Personal Area Networks	Sum of revenues of Bluetooth-enabled products	GDP Contribution	These revenues would not exist without the availability of unlicensed spectrum
	Sum of revenues of other WPAN standards (ZigBee, WirelessHART)	GDP Contribution	
RFID	RFID value in Retailing	Consumer and producer surplus	Benefits to consumers and savings to producers resulting from RFID adoption
	RFID value in Health Care		

Source: TAS analysis

In the following chapters, we will proceed by estimating economic value according to the approaches described above.

III. THE VALUE OF Wi-Fi FOR CELLULAR OFF-LOADING

Wi-Fi is already transporting the majority of the mobile Internet traffic. Global analysts estimate that 40% of network off-loading occurs via public and private Wi-Fi facilities[18]. Cisco estimates that the global average for daily data consumption is four times higher over Wi-Fi than over cellular networks, averaging 55 MB and 13 MB per day, respectively.[19] As expected, the United States is well ahead of this trend. For example, based on a sample of 200,000 US users, Mobidia estimates that, as of January 2012, 88% of smartphone users were active Wi-Fi users, with a traffic off-loading factor of 63.4%.[20]

While the value of cellular off-loading is based on the congestion relief for licensed spectrum owners that comes from the additional spectrum (Bazelon, 2008), end users also see value in off-loading to private and public Wi-Fi since it allows them to gain access to the Internet without, in many instances, incurring transport costs (e.g. not paying the carrier). In addition, consumers can benefit from longer battery life[21] and faster access speeds (Cui et al, 2013).

Thus, as a complement to cellular networks, Wi-Fi reduces the cost of mobile broadband access, allows service providers to decrease the capital required to support exploding data traffic, and provides Internet access with generally faster access speeds than either 3G or even 4G. In addition, Wi-Fi allows for the provision of paid Internet access services (such as paid services at public sites such as airports).

To estimate the economic value of Wi-Fi for cellular off-loading, we will focus on four areas:

- Consumer surplus: the difference between the consumer's willingness to pay and the price paid for the service; along these lines, if a consumer accesses the Internet in a public hot-spot for free, surplus would equate to the monetary value he would pay to a cellular operator for gaining equal access; we do not include in this estimate the economic value associated with residential Wi-Fi (Thanki, 2009), which will be addressed in a subsequent section.
- Producer surplus: in light of the explosive growth in data traffic, wireless carriers operating in licensed bands deploy Wi-Fi facilities to reduce both capital and operating expenses while dealing with congestion challenges; since they monetize the Wi-Fi access they provide, surplus measures the difference in capital and operating expenses for the off-loaded traffic.
- Return to speed: since Wi-Fi accessibility allows, in general, faster access to the Internet than cellular networks do, higher speeds have a positive contribution on the economy in terms of increased efficiency and innovation.
- New business models: Wi-Fi allows for the entry of service providers of paid Internet access in public places (such as Boingo and iPass); they generate new revenues that would not exist if unlicensed spectrum bands were not available.

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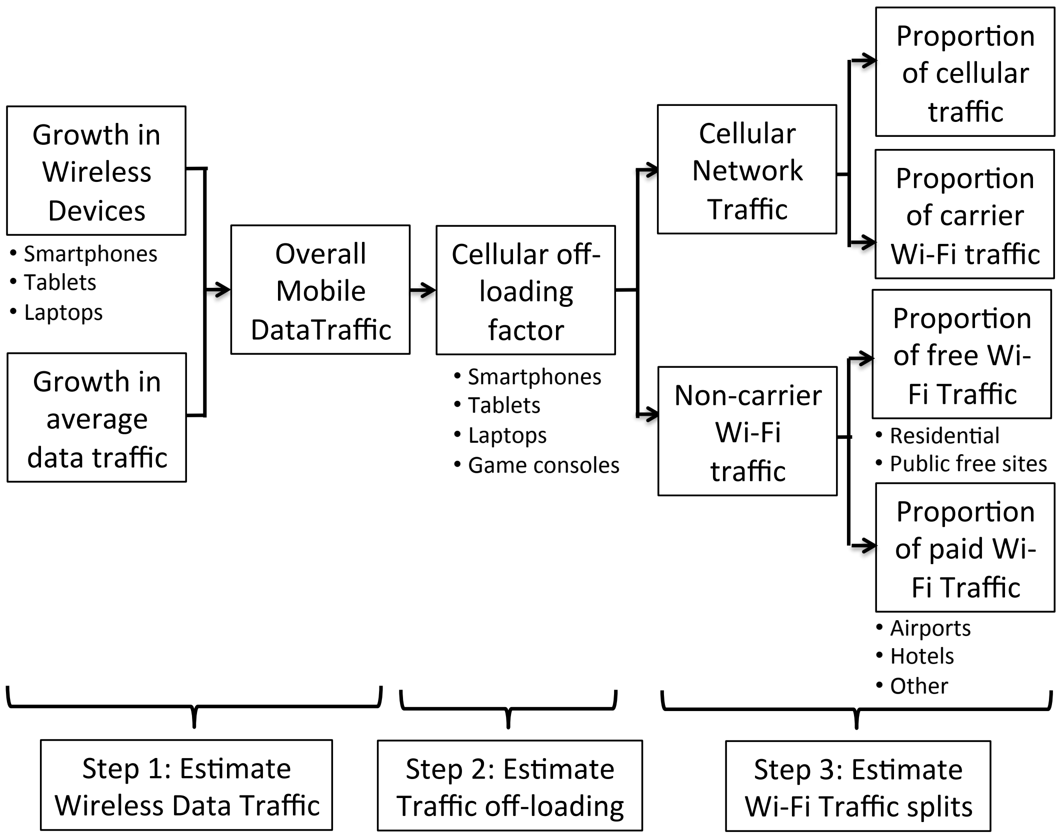
[18] Sources: Cisco (38.5%); Juniper Research (40%).
[19] Cisco (2013).
[20] Informa (2012). "Understanding today's smartphone user: demystifying data usage trends on cellular & Wi-Fi networks".
[21] Lee et al. (2010) estimated that Wi-Fi off-loading saves 55% of battery power.

Each of these four domains will be explored in turn. In order to quantify the economic value in each area, it is necessary to understand first how mobile data traffic flows between cellular and Wi-Fi networks in the United States. The estimation of cellular off-loading patterns required for quantifying its economic value proceeds along three steps (see figure III-1).

Figure III-1. Methodology for Estimating Off-Loading Traffic



We start by estimating current and future wireless data traffic. Estimates are calculated "bottom-up" from the installed base of devices and traffic by device. They are calibrated with existing measurements, such as Cisco's Visual Networking Index. After estimating wireless data traffic, we calculate the portion of traffic off-loaded to Wi-Fi sites. However, since off-loading patterns vary by device, off-loading traffic is calculated by type of terminal (tablet, laptop, smartphone) and then aggregated. Finally, since the economic value differs by the type of Wi-Fi site (for example, revenues from a paid site such as Boingo represent a direct contribution to GDP, while the benefit of accessing the Internet via a free public site has to be measured in terms of consumer surplus), we split Wi-Fi traffic across type of sites.

III.1. Estimating mobile data traffic:

Mobile data traffic in the United States has been growing at 59% per annum. Table III-1 presents historical data as measured by several analysts.

Table III-1. United States: Wireless Internet Traffic (2010-2013)
(in petabytes per month)

	2010	2011	2012	2013	CAGR
Cisco	81.92	122.88	204.80	327.68	59%
Strategy Analytics	257.5	451.3	744.0	1,165.9	65.4%
GSMA (*)	83.35	115.66	184.72	329.88	58%

(*) Calculated by TAS based on data from GSMA Intelligence
Source: Cisco; Compiled by TAS

The increased adoption of wireless data-enabled devices (smartphones, tablets, PCs) combined with an increase in usage has driven overall traffic growth. The installed base of smartphones reached 192.7 million in 2013, while this number amounted to 62 million for tablets. On the other hand, the number of laptops remains relatively stable at 241 million (2010-13 CAGR: 0.8%) due to tablet and, secondarily, smartphone substitution (see table III-2).

Table III-2. United States: Device Installed Base and Penetration (2009-2013)

		2010	2011	2012	2013	CAGR
Total Smartphones	Units (in millions)	112.89	139.34	172.00	192.75	19.5%
	Penetration (%)	36.00%	44.07%	53.96%	59.99%	18.6%
Tablets	Units (in millions)	26.41	35.01	46.41	61.53	32.6%
	Penetration (%)	8.42%	11.07%	14.56%	19.15%	31.5%
Laptops	Units (in millions)	235.18	237.16	239.08	240.99	0.8%
	Penetration (%)	75.00%	75.00%	75.00%	75.00%	0.0%
Devices per user		1.19	1.30	1.44	1.67	8.9%

Sources: Parks Associates; Cisco; Deloitte; TAS analysis

Beyond the laptop to tablet substitution, the installed base of smartphones has shifted to 4G (LTE) network standards that provide faster speed of access and, consequently, stimulate more intense data usage. Data also shows that as connected devices increasingly penetrate the subscriber base, the number of "devices per user" increases commensurately: from 1.19 in 2010 to 1.67 in 2013.[22]

Adding to the proliferation of devices, traffic per device has grown between 26.5% and 53.8% per annum driven by increased applications and content availability (see table III-3).

Table III-3. United States: Average Traffic Per Device (in Gigabytes per month)

	2010	2011	2012	2013	CAGR
Smartphones	0.28	0.40	0.56	0.80	41.6%
Portable Game Consoles	0.24	0.31	0.39	0.50	28.1%
Tablets	1.74	2.68	4.12	6.33	53.8%
Laptops	1.43	2.08	2.44	2.88	26.5%

Source: Cisco (2013)

[22] Credit Suisse (6 February 2011) estimates that the number of devices per unique user in the United States will climb from 1.2 in 2009 to 3.9 in 2015, as consumers add mobile broadband enabled laptops, tablets and connected devices to their device collections.

With the installed base and average data usage per device, total wireless Internet traffic in the United States can be calculated for the next five years. Our numbers estimate a total traffic of 1,238.4 million Gigabytes in 2013, reflecting a growth rate of 64.6% per annum. Projections regarding traffic growth from other sources vary, although they agree directionally (see table III-4).

Table III-4. United States: Mobile Internet Traffic (2013-2017)
(in million Gigabytes per month)

	2013	2014	2015	2016	2017	CAGR
This study	1,238.5	1,864.9	2,989.2	5,083.2	9,090.6	64.6%
Cisco (*)	737.3	1,353.2	2,514.6	4,728.3	8,990.6	86.9%
Ericsson (**)	1,238.5	1,857.7	2,786.5	4,179.8	6,269.7	50.0%

(*) Includes tablets; smartphones and also comprises feature phones.
(**) Ericsson estimates that mobile data traffic is expected to grow with a CAGR of around 50 percent (2012-2018). Using the estimated TAS baseline from 2013, the value for 2017 is calculated.
Source: compiled by TAS

This growth has and will continue to put pressure on the public networks of all service providers to accommodate the traffic without incurring congestion while generating acceptable levels of revenue. We will now estimate the portion of traffic that is off-loaded to Wi-Fi.

III.2. Estimating cellular network off-loading traffic

By relying on network off-loading statistics, the overall wireless data traffic numbers calculated above will now be divided between on- and off- cellular networks. Traffic statistics for network off-loading vary, although they all highlight the fact that Wi-Fi captures a majority of global network traffic (see table III-5).

Table III-5. Network Off-Loading Statistics

Country	Date	Type of Traffic	Wi-Fi Off-Loading Factor	Method of measurement	Author(s)
Korea	2/2010	iPhone users over 3G	65 %	Trace-driven simulation	Lee et al. (2010)
Canada, Germany, Japan, South Korea, UK and US	4/2013	Android LTE smartphones	73 %	Data collected by Mobidia My Data Manager installed in thousands of devices	Roberts (2013)
Japan	12/2012	Mobile data devices	43 %	KDDI traffic monitoring	KDDI as reported by GSMA
United States	1/2012	Smartphone app users	63.4%	Panel of 200,000 users	Mobidia
China	2012	Wireless data traffic	72 %	China Mobile traffic statistics	China Mobile as reported by GSMA
United States	2017	Mobile Data Traffic	66 %		Cisco VNI
World	2013	Mobile Data Traffic	38.5 %		Cisco VNI
World	2017	Mobile Data Traffic	46.1 %		Cisco VNI
World	2013	Mobile Data Traffic	40 %	Forecasting models	Juniper Research
World	2017	Mobile Data Traffic	60 %	Forecasting models	Juniper Research

Source: TAS compilation

Based on the premise that cellular off-loading varies by device, and assuming that off-loading will increase over time with the deployment of more Wi-Fi sites, this study looks at smartphones, tablets, and laptops to calculate the portion of overall mobile traffic transmitted through Wi-Fi (see table III-6).

Table III-6. United States: Wireless Device Off-Loading Factors (2012-2017)

	2012	2013	2014	2015	2016	2017
Smartphones	59 %	60 %	61 %	62 %	63 %	64 %
Tablets	77 %	77 %	77 %	78 %	78 %	78 %
Laptops	47 %	50 %	54 %	58 %	62 %	66 %

Source: Cisco; Mobidia; TAS analysis

By applying these off-loading factors to the total data traffic generated by each type of device, we project that total Wi-Fi traffic in the United States is currently 0.67 Exabytes and will reach 5.97 Exabytes by 2017, reflecting a 68.0% growth rate (see table III-7).

Table III-7. United States: Total Wi-Fi Traffic Per Device (2012-2017) (in Exabytes per month)

	2012	2013	2014	2015	2016	2017	CAGR
Smartphones	0.05	0.08	0.13	0.21	0.34	0.54	58.7%
Tablets	0.14	0.28	0.57	1.16	2.37	4.82	103.8%
Laptops	0.26	0.30	0.36	0.43	0.51	0.61	19.0%
Total	0.45	0.67	1.07	1.80	3.22	5.97	68.0%

Source: TAS analysis

Cellular traffic off-loading (or mobile off-loading) allows for the routing of traffic from mobile devices to Wi-Fi spots and the telecommunications network through fixed transmission. Per Cui et al., (2013), cellular network off-loading occurs at four network points: 1) private Wi-Fi (owned by users at home), 2) public paid Wi-Fi (hot-spots at airports, hotels, etc.), 3) public free Wi-Fi sites (coffee-shops, places of work and study), and 4) carrier-class Wi-Fi (network off-loading points owned by carriers, deployed to alleviate congestion and reduce network CAPEX). Based on this information, the following sections will calculate both consumer and producer surplus.

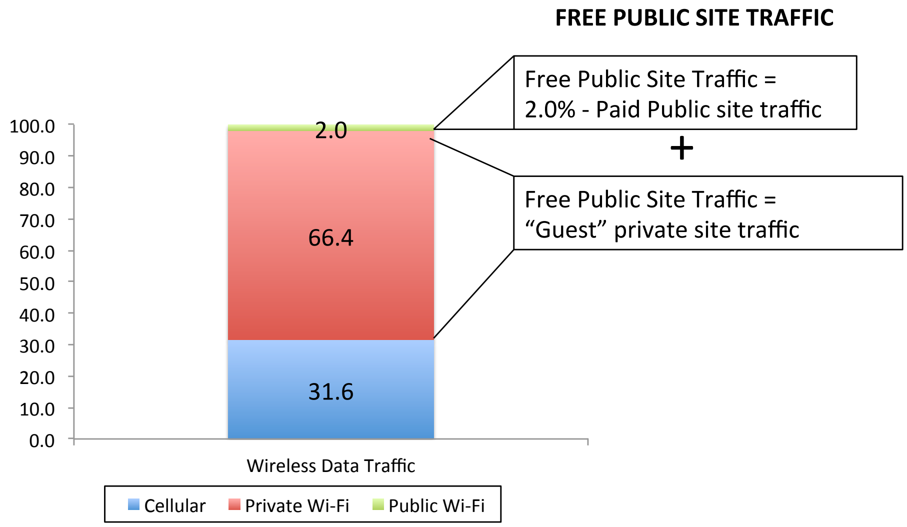
III.3. Estimating consumer surplus of free public access[23]

In the world's most advanced Wi-Fi markets, such as the US and UK, the vast majority of users today perceive data usage over Wi-Fi to be free. Reacting to consumer preference and perceptions, major retailers, such as Starbucks or McDonald's, have switched their entire hot-spot footprints to a free-to-end-user model.

As stated above, the consumer surplus of Wi-Fi comes from the utilization of free sites offered at airports, hotel lobbies (courtesy access), free extension of private sites (guest access points), and municipal facilities in public places.[24] The volume of Wi-Fi traffic transported through this type of facility is contingent upon free public hot-spot density. Based on the latest statistics generated by Mobidia's monitoring of 200,000 users in the United States, 2% of total US Android smartphone Wi-Fi traffic in January 2013 relied on "public managed networks." This category comprises all public venues, such as hotels, airports, franchised restaurants and coffee shops, and retail chains. However, a portion of this traffic is paid, and therefore excluded from this number. On the other hand, 66.4% of Wi-Fi traffic in the same category relies on self-provisioned/private Wi-Fi sites, which include private residences and enterprises. Likewise, a small portion of this traffic should be considered "public and free" insofar that it represents guest access to a private site (see figure III-2).

[23] The detailed model used for this estimation is included in appendix B.
[24] As noted before, residential Wi-Fi benefits are addressed in a separate section.

Figure III-2. United States: Android Smartphone Traffic Distribution



Source: Mobidia

Alternatively, self-reported data collected by Cisco indicates that 12% of the daily mobile device connect time occurs at retail locations (5%) and public places (7%) (Cisco IBSG, 2012). Assuming that self-reported data over-emphasizes free access, we estimate that all 2% of Public Wi-Fi is conducted in free sites, and only 1% is conducted in "guest" private sites. Along these lines, 3% of the total wireless traffic is "true no cost traffic."

The estimation of consumer surplus proceeds, then, by multiplying the total Wi-Fi traffic from table III-7 by 4.32%, representing the "true free traffic" conducted by public sites.

Table III-8. United States: Total Free Wi-Fi Traffic (2012-2017)

	2012	2013	2014	2015	2016	2017
Total Wi-Fi Traffic	0.45	0.67	1.07	1.80	3.22	0.45
Total Free Traffic (in Exabytes per month)	0.02	0.03	0.05	0.08	0.14	0.02
Total Free Traffic (in Exabytes per year)	0.23	0.35	0.55	0.94	1.67	0.23
Total Free Traffic (in million Gigabytes per year)	248.46	372.12	593.40	1,004.71	1,790.87	3,233.38

Source: TAS analysis

We calculated consumer surplus by multiplying the total free traffic by the difference between what the consumer would have to pay if s/he were to utilize a wireless carrier and the cost of offering free Wi-Fi (incurred by the retailer or public site). To do so, we needed an estimate of the average price per GB of wireless data transmitted by wideband networks, which we calculated by averaging the most economic "dollar per GB" plan of four major US wireless carriers (see table III-9).

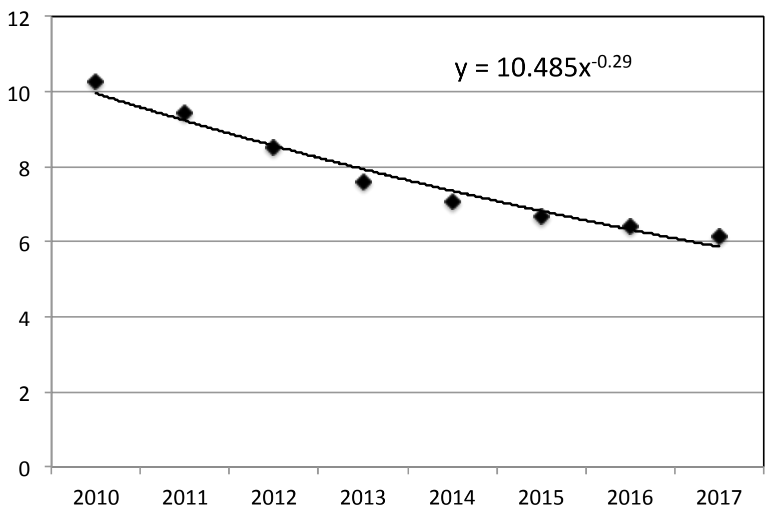
Table III-9. United States: Average Price Per Gigabyte (2013)

Carrier	Plan	Price per Gb
ATT	$50/5 Gigabytes cap	$ 10.00
Verizon	$355/50 Gigabytes cap	$ 7.10
Sprint	$79.99/12 Gigabytes cap	$ 6.67
T-Mobile	$70/10 Gigabytes cap	$ 6.67
Average		$ 7.61

Source: TAS analysis

Data for ATT and Verizon for 2010 and 2011 allowed for a projection of future prices per Gigabyte (see figure III-3).

Figure III-3. Estimate of Future Average Price Per Gigabyte (2010-2017)



Source: TAS analysis

According to these prices, while the average price per GB in 2013 is $ 7.61, by 2017, it will reach an estimated $6.15. As to the cost of offering the service, this would include an additional router and needed bandwidth. For estimation purposes, we assume those costs to be prorated at $2.50 per Gigabyte, which was what some Wi-Fi services in public sites charge per 2 hr. service (assuming this to be costs passed through to the customer). By relying on the total free Wi-Fi traffic shown in table III-8 and the average price per cellular Gigabyte minus the cost of provisioning Wi-Fi service, we calculated the consumer surplus of free Wi-Fi traffic (see table III-10).

Table III-10. United States: Consumer Surplus of Free Wi-Fi Traffic (2012-2017)

	2012	2013	2014	2015	2016	2017	Total
Total Free Traffic (in million Gigabytes per year)	248.46	372.12	593.40	1,004.71	1,790.87	3,323.38	
Price per cellular gigabyte ($)	8.52	7.61	7.05	6.68	6.39	6.15	
Cost per Wi-Fi provisioning ($)	2.50	2.50	2.50	2.50	2.50	2.50	
Consumer surplus per Gigabyte ($)	6.02	5.11	4.55	4.18	3.89	3.65	
Total Consumer surplus (in $ million)	1,496	1,902	2,700	4,200	6,966	12,130	29,394

Source: TAS analysis

As indicated in table III-10, consumer surplus of free Wi-Fi traffic in 2013 would reach an estimated $ 1.902 billion. It is important to mention that this estimate does not consider whether traffic would remain the same if the currently "free" traffic were to be charged. In other words, price elasticity could yield a scenario where traffic would diminish with a price increase. An analysis of consumer surplus would need to base its quantification on willingness to pay. However, data on Wi-Fi willingness to pay is not available.

III.4. Estimating producer surplus of carrier-grade Wi-Fi

Beyond consumer surplus, Wi-Fi also yields a benefit to the producers of wireless communications: the carriers. Carrier-class Wi-Fi allows the operator to leverage wideband access (for mobility) and Wi-Fi offloading through small cells (for network capacity).[25] By building hybrid networks, carriers preserve spectrum and reduce the CAPEX required to deploy additional base stations.[26] In addition, some service providers also claim they monetize their Wi-Fi offerings by directly charging customers[27]. Carriers also benefit from service differentiation and an improvement in the customer experience.[28]

To underscore the importance of deploying carrier-grade Wi-Fi, recent research conducted by Amdocs (2013) indicates that 89% of all service providers surveyed (including fixed, mobile, and cable) have either deployed - or plan to deploy or leverage - Wi-Fi networks complementing their cellular infrastructure.[29] In the United States, AT&T alone operates 32,000 hot-spots, while Softbank in Japan has deployed over 500,000 access points.[30]

The estimation of producer surplus is predicated on the assumption that in the absence of Wi-Fi, service providers would have to deploy cellular base stations to accommodate the growth in traffic. Thus, the calculation of producer surplus is based on the portion of capital investments (and potential incremental network operations and maintenance operating expenses) that service providers can avoid when they shift allocations from cellular network to carrier-grade Wi-Fi.

The analysis is then predicated on the following model (see figure III-4).

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[25] Carriers can also off-load traffic by deploying femtocells, which provide higher capacity. However, since these operate in licensed spectrum bands, they are not part of this analysis.

[26] Hybrid network architectures allow wireless operators to shift traffic away from the cellular network, where the capacity constraints are most acute, to cheaper shorter range small cells network, connected over a variety of backhaul connections (see Eslambolchi, 2012).

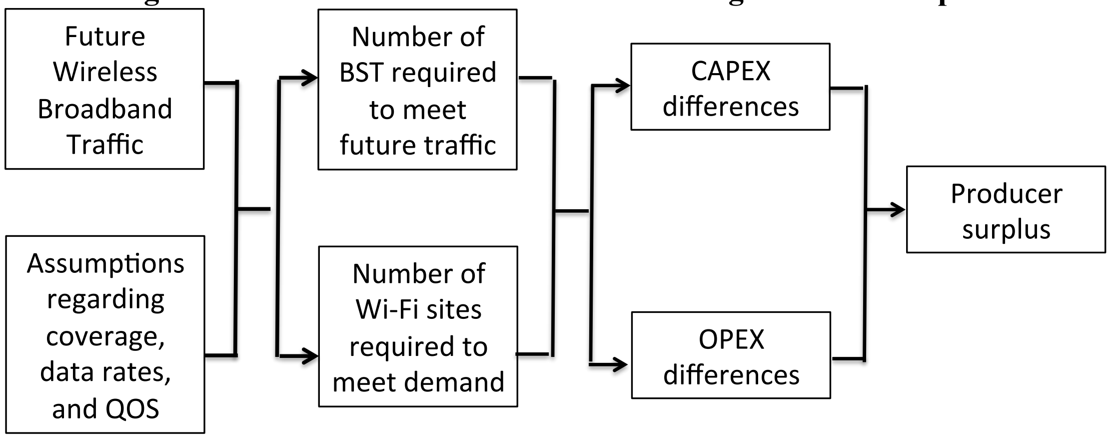
[27] See the example of ATT.

[28] See Amdocs (2013).

[29] On average, respondents ranked Wi-Fi's importance as 7+ out of 10, underscoring the strategic value of Wi-Fi for service provider growth.

[30] GSMA Intelligence (2013).

Figure III-4. Model Structure For Calculating Producer Surplus



The analysis starts with the predicted incremental wireless data traffic generated between 2013 and 2017. According to table III-7, future monthly traffic will amount to 5.97 Exabytes.

It is obvious that a cellular-only network could not economically handle all future traffic. While the economic advantage of Wi-Fi off-loading varies substantially by topography and size of the urban environment, carrier-grade Wi-Fi sites are considerably less expensive than cellular network equipment with similar capacity. For example, a cellular pico-cell (needed to offer access via conventional cellular service) costs between $7,500 and $15,000[31], while a carrier-grade Wi-Fi access point requires an investment of $2,500[32]. In addition, other capital and operating expense items show a clear advantage to Wi-Fi vis-à-vis an LTE macro cell (see table III-11).

Table III-11. Comparative Carrier Grade Wi-Fi and LTE Macro Cell CAPEX and OPEX

	Wi-Fi Site	LTE Macro Cell
New site acquisition	$ 600	$ 150,000
Collocation	-	$ 50,000
Backhaul	$ 300	$ 5,000
Monthly site rental	$ 20	$ 1,000
Site maintenance/month	$ 10	$ 200

Source: LCC Wireless (2012)

As it can be seen, Wi-Fi has significant economic advantages at the unit level. However, we must add a caveat here. Site density requirements for Wi-Fi are much higher than for cellular. For example, in a dense urban environment with high traffic, for each cellular site, 23 Wi-Fi hot-spots are required. The difference means that, from a Total Cost of Ownership (CAPEX and OPEX) standpoint, the driver that erodes some of the Wi-Fi economic advantage is OPEX, especially Wi-Fi site rental and backhaul costs. Along these lines, for the carrier-class Wi-Fi off-loading to materialize, site deployment needs to be managed on a case-by-case basis, by surgically placing sites primarily in high traffic areas.

[31] "When Femtocells become Picocells", the 3G4G Blog and Ubiquisys.
[32] Cisco Aironet 1552H Wireless Access Point.

In this context, a simulation was run to determine the economic advantage of relying on carrier-grade Wi-Fi sites to complement the deployment of LTE in the United States. According to Thanki (2012), achieving full LTE coverage in the United States relying on 2100 MHz to accommodate incremental wireless data traffic would require approximately 34,000 new base stations[33], representing a total capital investment of $ 8.5 billion. On two simulation cases of off-loading in New York and San Diego, LCC Wireless assumed a CAPEX benefit of Wi-Fi off-loading ranging between 22.3 % and 44.7 %. When averaging these two estimates, the CAPEX reduction would amount to $2.76 billion. Even under the OPEX considerations mentioned above, the Total Cost of Ownership remains lower under the Wi-Fi off-loading scenario (see table III-12).

Table III-12. Total Cost of Ownership of LTE Only Versus LTE+ Wi-Fi Off-Load

	LTE Only	LTE + Wi-Fi Off-Loading	Delta %/$
Total CAPEX	$ 8.5 billion	$ 5.7 billion	32.9 %/$ 2.8 billion
Total OPEX (*)	$ 48.7 billion	$ 40.8 billion	16.2 %/ $ 7.9 billion
TCO	$ 57.2 billion	$ 46.5 billion	18.71 %/$ 10.7 billion

(*) Opex to capex ratios assumed from LCC San Diego case
Source: LCC Wireless (2012); Thanki (2012); TAS analysis

In sum, the producer surplus of deploying carrier-grade Wi-Fi complementing the rollout of LTE to accommodate future traffic growth would amount to $ 10.7 billion. This amount does not include the CAPEX saved by traffic off-loading to residential and business Wi-Fi networks[34].

III.5. Estimating the economic return to speed of Wi-Fi Off-loading[35]

In addition to the sum of producer and consumer surplus generated by the aforementioned effects, wideband off-loading generates a "return to speed" economic value. As such, when a user accesses the Internet, the speed of access could be significantly higher via a Wi-Fi site than on either 3G or 4G LTE networks. While Milgrom et al. (2011) estimate the additional value of speed based on the research on consumer surplus of high-speed networks (Roston et al., 2010, and Dutz et al., 2009), more recent econometric research has been conducted aiming at measuring the impact on GDP of higher broadband speed (see Bohlin et al., 2013). At a higher level, the research concludes that in OECD countries a doubling of broadband speed is associated with per capita GDP growth of 0.3%. To measure the economic value of Wi-Fi speed, our analysis focuses on understanding how slow the network would become if it did not have the Wi-Fi technology as a complement. In this case, we consider the total traffic without differentiating between points of access (residences or public places). Our analysis begins by quantifying the speed differential between average cellular and Wi-Fi access. By factoring offloading effects in relation to cellular we can then understand speed increases and apply the Bohlin et al. (2013) model to estimate the impact on GDP.

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[33] This model was adapted by the author from Ofcom, the UK regulator, to assess the effect of differing traffic levels on cell site numbers in urban areas in its consultation "Application of spectrum liberalization and trading to the mobile sector" (Ofcom, 2009).
[34] See Cooper (2012).
[35] The detailed model used for estimating this effect is included in Appendix C.

We start with the quantification of speed differentials, which we calculate by subtracting the weighted average of Wi-Fi and cellular speeds (averaged according to traffic off-loading factors of table III-6) and calculating the speed decrease if cellular networks transported all Wi-Fi traffic (see table III-13).

Table III-13. Estimation of Speed Differential for Total US Traffic (in megabits per second)

	2012	2013	2014	2015	2016	2017
Average speed of cellular networks	2.41	3.43	4.88	6.94	9.87	14.05
Average Wi-Fi speed	11.50	13.32	15.43	17.88	20.72	24.00
Average speed of weighted average of cellular and Wi-Fi traffic	8.68	10.15	12.09	14.60	17.75	21.60
Speed decrease (average speed of cellular/average weighted average speed)	-72.21%	-66.21%	-59.65%	-52.45%	-44.36%	-34.96%

Source: Cisco; TAS analysis

It is worth noting that the speed differential of the hybrid cellular and Wi-Fi network diminishes over time because LTE is achieving a wider coverage. Nevertheless, the estimates confirm Morgan Stanley's statement that Wi-Fi is ten times faster than 3G, and that the 802.11n Wi-Fi standard is twice as fast as LTE (Morgan Stanley Research, 2009). Research cited by Benkler (2012) indicates that average 4G speed ranges between 3 and 14 Mbps, while 802.11c at 100 feet range is 208 Mbps.

Having calculated the speed decrease percentage, we then apply this percentage to the coefficient derived from the model developed by Bohlin et al. (2011 and 2013) to gauge the potential impact on GDP if cellular networks transported all traffic (see table III-14).

Table III-14. Econometric Model Measuring the Impact of Broadband Speed on GDP

Independent Variables	Coefficient
Average GDP growth (2008-2010)	0.577 *
Population density	-0.0441 *
Urban population	-0.0103 **
Labor force growth (%)	0.0492 *
Telecom revenue growth (%)	0.0492 *
Population growth (%)	-0.630 **
Average achieved downlink speed	-0.00214
Average achieved downlink speed squared	0.00142 *

*, ** significant at 1% and 5% critical value respectively
Source: Rohman and Bohlin (2011)

As table III-14 shows, by incorporating the elasticity of the coefficient of broadband speed and the square of the variable, the model assumes that the doubling of broadband speed causes a 0.3% increase in GDP growth. Our case shows the GDP impact on the **decrease** in speed. This is applied in turn to the GDP of the United States at current prices (see table III-15).

Table III-15. Broadband Speed Impact on GDP

	2012	2013	2014	2015	2016	2017
Speed decrease (%)	-72.21%	-66.21%	-59.65%	-52.45%	-44.36%	-34.96%
Model coefficient	0.30%	0.30%	0.30%	0.30%	0.30%	0.30%
Decrease in GDP per capita	-0.22%	-0.20%	-0.18%	-0.16%	-0.13%	-0.10%
GDP per capita (current prices)	49,922	51,248	53,328	55,837	58,436	61,134
Wi-Fi Traffic (% Total Traffic)	6.74%	8.79%	11.95%	16.63%	23.15%	31.37%
GDP Reduction (in $ millions) (current prices)	-2,284	-2,831	-3,634	-4,695	-5,831	-6,565

Source: Cisco; TAS analysis

Table III-15 indicates that if all cellular data traffic that is currently being off-loaded to Wi-Fi were to shift to cellular networks, the reduction in speed (in 2013 from an average 10.15 Mbps to 3.43) would have a $2.831 billion impact on GDP. This figure reflects the economic value of Wi-Fi in terms of increasing the speed of transporting wireless data.

III.6. Estimating new business revenues generated by Wi-Fi Off-loading

In addition to the value generated by the other effects, Wi-Fi off-loading can create new business opportunities for service providers offering Wi-Fi services in public places (airports, hotels) for a fee. In the last three years, operators in this space have deployed next-generation hot-spot technologies to replicate the ease of access and security provided by cellular networks. At the same time, to facilitate interoperability, they are signing up of roaming agreements. From a business model standpoint, innovation has allowed this sector to expand beyond the original pay-as-you-go access offer. In particular, it is worth mentioning retailer “push” marketing and promotions, neutral host provision to multiple cellular carriers, and bandwidth exchange for Wi-Fi capacity[36] (Maravedis-Rethink, 2013).

The most straightforward way of estimating the economic value of Wi-Fi in this domain is to add up the revenues of all firms operating in this space in the United States, excluding firms that offer services as a wholesaler (e.g. Trustive). Similarly, Wireless Internet Service Providers are addressed in chapter V.

Table III-16 presents a compilation of US Wi-Fi service providers, including some key financial metrics that allow for the estimation of their revenues.

[36] BandwidthX offers an open market exchange of capacity between public Wi-Fi operators and any partners in need of Wi-Fi capacity. The solution allows carriers to bid for and purchase Wi-Fi capacity dynamically from available WISPs, with pricing based on a range of network selection policies, including place, time of day, etc.

Table III-16. Compilation of Retail Wi-Fi Service Providers in the United States

Company	Business focus	Revenues (in $ millions)	Estimated portion of US revenues	US Revenues (in $ millions)
Boingo	Retail access; wholesale access (to ATT, Verizon); military bases; advertising	$ 105.98	7,000 sites in the US (out of 13,000) Per 10-K "revenue is predominantly generated in the US"	$ 105.98
iPass	Enterprise Wi-Fi services; wholesale access	$ 114.89	Per 10-K, 57% of revenues generated in the United States	$ 65.5
SONIFI (Lodgenet Interactive)	Hotels and Health care (cable and Wi-Fi)	$ 126.7	SONIFI's primary customer base is in the continental United States, however it also delivers services in Canada, Mexico and 15 other countries through relationships with local licensees.	$100
Total				271.5

Source: Company Annual reports and 10-K reports; TAS analysis

As table III-16 indicates, estimated total revenues generated by this sector in the United States have reached $ 271.5 million.

III.7. Conclusion

In summary, cellular traffic off-loading has multiple drivers of economic value. The analyses contained in this chapter enabled the calculation of annual economic value of Wi-Fi acting as a complement of wireless networks operating in licensed spectrum (see table III-17).

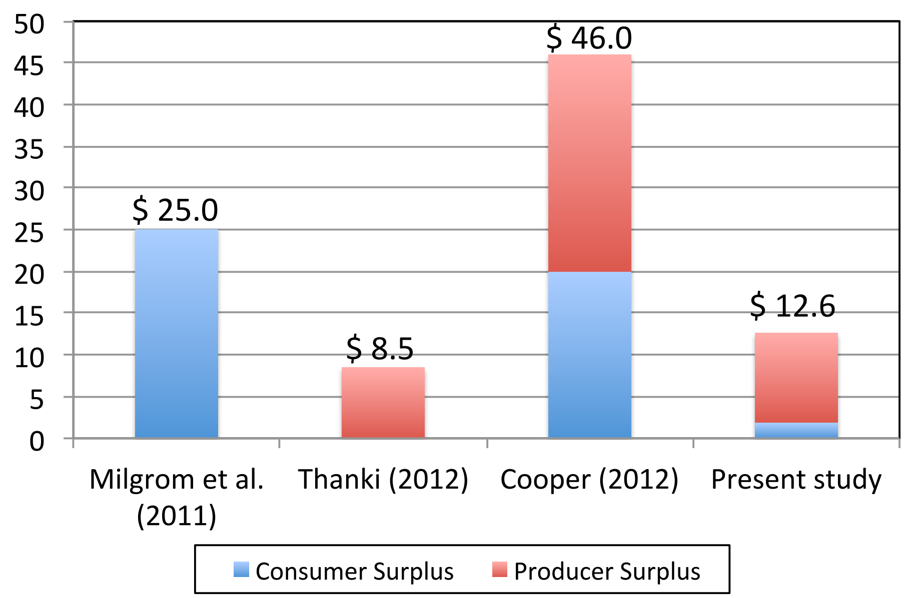
Table III-17. Summary of Economic Value of Wi-Fi Cellular Off-Loading (2013)

Effect	Underlying Premise	2013 Economic Value
Consumer Surplus	Value of Free Wi-Fi traffic offered in public sites	$ 1.902 billion
Producer Surplus	Total cost of Ownership (cumulative CAPEX and OPEX) required to accommodate future capacity requirement with Wi-Fi complementing cellular networks	$ 10.7 billion
Return to Speed	Contribution to GDP of increase of average mobile speed resulting from Wi-Fi off-loading	$ 2.831 billion
New Business Revenue	Sum of revenues of service providers offering paid Wi-Fi access in public places	$ 0.271 billion
Total		$ 15.704 billion

Source: TAS analysis

This value includes the producer surplus generated by the operators' deployment of carrier-grade Wi-Fi sites to respond to the growth in wireless data traffic ($ 10.7 billion). If we exclude the speed contribution to GDP and the new business revenue, economic surplus would amount to $ 12.602 billion. This figure is higher than Thanki's 2012 $ 8.5 billion estimate due to the increase in the volume of Wi-Fi sites since the author conducted his analysis. Wi-Fi off-loading's second value-creation effect comes from the consumer surplus derived from the utilization of free Wi-Fi sites deployed in public locations ($ 1.9 billion). This is calculated as the cost of the total wireless traffic transported in free Wi-Fi sites (3%) if the consumer would have to pay to a wireless carrier minus the cost to provide free Wi-Fi service. Our estimate is lower than Cooper's since we have a more conservative estimate of the annual benefit of off-loading for the carriers and because a portion of the consumer surplus assumed by Cooper (and Milgrom et al, 2011) has already been assigned to residential Wi-Fi (see figure III-5).

Figure III-5. Economic Value of Wi-Fi Off-Loading: Thanki (2012), Milgrom et al. (2012), Cooper (2012) Versus Present Study (in $ billions)



Source: TAS analysis

IV. THE VALUE OF RESIDENTIAL Wi-Fi

The economic value of cellular off-loading purposely excluded residential Wi-Fi insofar that this application does not represent a substitute to cellular transmission. Assessing the value of residential Wi-Fi is fairly complex because most service providers in the United States offer residential Wi-Fi connectivity as part of a bundled package with broadband access (see examples in table IV-1).

Table IV-1. Examples of Broadband Services

Operator	Offer	Wi-Fi as a component of bundle
AT & T (U-Verse) DSL	3 Mbps for US$ 29.95/month	Yes (*)
AT & T (U-Verse) DSL	6 Mbps for US$ 34.95/month	Yes (*)
Comcast CABLE	3 Mbps for US$ 19.99/month	Yes (At Home)
Comcast CABLE	105 Mbps for U$ 79.99/month	Yes (**)
Time Warner CABLE	3 Mbps for US$ 29.99/month	Yes (At Home)

(*) Wi-Fi at home and access to the entire AT&T national Wi-Fi network, at no extra charge
(**) Includes access to 500,000 Wi-Fi hot-spots at no extra cost
Source: Compiled by TAS

The approach taken by Thanki (2009) is based on the central assumption that, in the absence of residential Wi-Fi, customers' willingness to pay for broadband would be significantly lower. Based on the consumer surplus study by Orzag et al. (2009), which states that approximately 50% of users would be willing to pay $50 more for broadband, the author estimates a new demand curve for Wi-Fi only households[37]. With this new estimate, Thanki (2009) constructs three sensitivities in a scenario of no Wi-Fi: in other words, the author estimates the reduction of the imputed willingness to pay in the absence of Wi-Fi in the broadband offer. Based on this estimation, he finds that the economic value of residential Wi-Fi in the United States ranges between $4.3 billion (for a 10% of value attributed to Wi-Fi) and $12.6 billion (for 30% of value attributed to Wi-Fi). At the same time, Thanki (2009) noted that his estimates exclude the benefit derived from other uses, such as Internet for other home devices that cannot rely on a wired link (e.g. video game consoles, tablets). In a later work, Thanki (2012) updated his analysis while relying on the same approach, estimating the annual economic value of residential Wi-Fi in the United States to be $15.545 billion.

[37] The author extrapolates the UK Wi-Fi adoption (57% of households) to the US.

Rather than replicating Thanki's work, we consider it useful to restate the economic value of residential Wi-Fi using the technology, and then calibrating the results back to Thanki's estimates from 2012[38]. After all, the use of the technology determines the value and consumer surplus. The following list attempts to draw an exhaustive itemization of benefits of residential Wi-Fi:

- Provide internet access for devices that lack a wired port (e.g. tablets, smartphones, game consoles)
- Avoidance of investment in in-house wiring
- Easy networking between devices (printers, storage devices, computers)
- Sharing and streaming of media content (sound systems, home theaters, etc.)
- Hub of a network handling home automation
- Interface with the smart grid

We will quantify the value derived by each of these applications in turn.

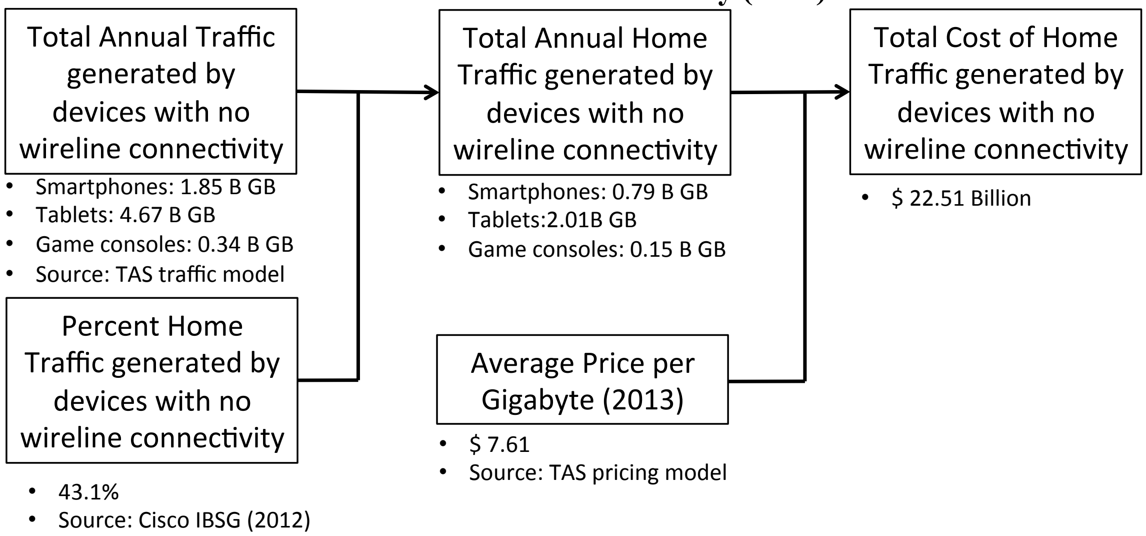
IV.1. Home Internet access for devices that lack a wired port

The underlying premise of this analysis is that in the absence of Wi-Fi, users would have to depend on the cellular network to gain Internet access. For this reason, estimating value would first measure the traffic generated by these devices at home and then would multiply it by the average price charged by cellular carriers.

Based on our traffic model, the total traffic generated by these types of devices in 2013 in the United States amounts to 6,862 million Gigabytes. According to Cisco IBSG (2012), 43% of use time of devices that lack a wired port occurs at home. Therefore, the portion of said traffic generated at home reached 2,959 million Gigabytes, which if it had to be transported by cellular networks resulting in costs of $22.51 billion in 2013 (see figure IV-1).

[38] The details of the estimates are presented in the model in Appendix D.

Figure IV-1. Annual Costs To Be Incurred by Home Traffic Generated by Devices With No Wireline Connectivity (2013)



Source: TAS analysis

IV.2. Avoidance in investment in in-house wiring

Residential Wi-Fi allows consumers to avoid paying for wiring to connect all home devices (printers, laptops, storage units, etc.). The average cost of deploying inside wiring in residence reaches approximately $190 per household[39]. Considering that 61% of US households currently have Wi-Fi[40], the avoidance cost of inside wiring for 70 million households, which in the absence of Wi-Fi yields a total cost of wiring of $13.567 billion.

IV.3. Other residential Wi-Fi applications

The economic value of other residential Wi-Fi applications mentioned in the introduction of this chapter, such as easy networking between devices, and the sharing and streaming of media content could be assimilated to the first two areas analyzed. In fact, these two areas could not exist without Wi-Fi enabling device connectivity. As a result, we consider that their value is already counted in sections 1 and 2.

In addition, the last two examples (hub of a network handling home automation, and interface with the smart grid) are more forward-looking and difficult to estimate in terms of their economic value.

IV.4. Conclusion

In sum, the analyses contained in this chapter enabled the estimation of economic value of residential Wi-Fi (see table IV-2).

[39] This is calculated based on a premise visit ($30), 3 hrs. of labor ($12/hr.), and number of rooms connected ($4.95 per room)
[40] Source: Watkins, David. *Broadband and Wi-Fi Households Global Forecast 2012*. Strategy Analytics

Table IV-2. Summary of Economic Value of Residential Wi-Fi

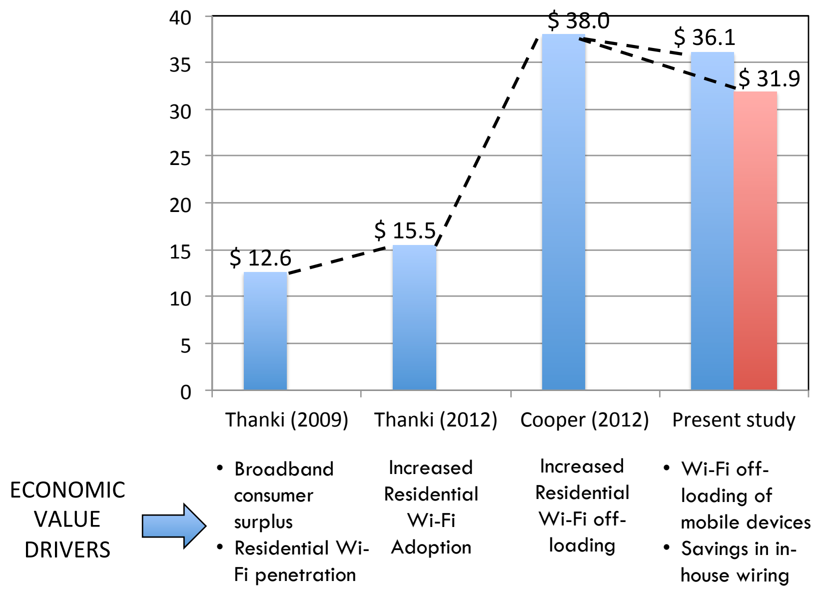
Effect	Underlying Premise	Amount
• Internet access for devices that lack a wired port (e.g. tablets, smartphones, game consoles)	• Cost required for those devices to access the Internet via cellular networks	$ 22.51 billion
• Avoidance of investment in in-house wiring	• Cost to wire the residence	$ 13.57 billion
• Easy networking between devices (printers, storage devices, computers) • Sharing and streaming of media content (sound systems, home theaters, etc.)	• Value captured in two prior effects	N.A.
• Hub of a network handling home automation • Interface with the smart grid	• Forward-looking applications and, therefore, difficult to quantify	N.A.
Total		$ 36.08 billion

Source: TAS analysis

In sum, the total annual economic value of residential Wi-Fi amounts to $36.08 billion, more than twice the value estimated by Thanki in 2012. Thanki's original estimate (2009), based on the extrapolation of consumer surplus (Dutz et al., 2009) and 57% Wi-Fi adoption across households, was ranged between $4.3 billion and $12.6 billion. In 2012, Thanki updated his analysis based on increased Wi-Fi households and estimated its economic value at $15.5 billion. In the same year, Cooper (2012) provided a higher estimate (which he considers to be conservative) of $38 billion. This last author factors in not only the increase in Wi-Fi penetration but also the growth in cellular off-loading. Our approach differs from Thanki's and Cooper's. Rather than extrapolating from fixed broadband consumer surplus research, we quantify savings incurred by consumers as a result of deploying Wi-Fi in their residences (all data, sources and calculations are included in chapter IV). As of 2013, 61% of US households are equipped with Wi-Fi, which has a net effect of providing free access for devices designed for wireless access (tablets, smartphones), generating annual transport savings of $22 billion. In addition, residential Wi-Fi services generate $13 billion in savings for households that do not require in-house wiring to interconnect PCs, printers, audio equipment, and the like. These estimates are two and a half times higher than Thanki's 2012 figures, and close to Cooper's (see figure IV-2). To calibrate our results, we replicated Thanki's estimates, multiplying the total number of Wi-Fi households (72,450,000) by an assumed willingness to pay of $36.8 per household per month[41]. This yields a total surplus of $31.9 billion (considered to be a low bound estimate).

[41] Thanki estimates the average monthly consumer surplus to be $27.6, which represents 30% of the home broadband value. He also states that there is additional value not captured in his analysis. (pp.35). Given the current Wi-Fi adoption and usage patterns, it is reasonable to assume that willingness to pay would amount to 40% of the value, which equals to $36.8 per month.

Figure C. Economic Value of Residential Wi-Fi: Thanki (2009, 2012), Cooper (2012) Versus Present Study (in $ billions)



Source: TAS analysis

V. WIRELESS INTERNET SERVICE PROVIDERS

Wireless Internet Service Providers (WISPs) rely primarily on unlicensed spectrum to offer broadband accessibility in rural areas of the United States. While some WISPs utilize licensed spectrum (Clear and Digital Bridge), the majority relies on UNII and ISM bands or lightly licensed spectrum in the 3.65 GHz band: 26mhz of unlicensed spectrum just above 900mhz, 50mhz in 2.4ghz and 100mhz in 5.8ghz (Larsen, 2011). According to Wireless mapping.com, the WISP Directory Database compiled by the WISP Association includes over 1,800 "documented and verified" WISPs. While WISPs initially utilized the 802.11b platform, they have mostly migrated to 802.11n, which allows them to deliver 10 Mbps service or higher to 200 customers from a single four sector base station (Larsen, 2011).

As demonstrated by the National Broadband Plan and the corresponding mapping effort, WISPs are critical in providing broadband service in rural areas. In 2008, the National Broadband Map determined that in 21 states with a large rural footprint, 4.93% of households were only served exclusively by a WISP (see Table V-1).

Table V-1. Occupied Households Passed by WISPs Only (2008)

State	Total Occupied Households	% of Households Passed by WISPs Only	Occupied Households Passed by WISPs Only
Michigan	4,009,186	4.34 %	173,834
Oregon	1,516,658	9.41 %	142,760
West Virginia	757,767	0.01 %	107
Texas	8,924,973	23.47 %	2,094,479
Massachusetts	2,615,877	0.10 %	2,489
Wyoming	215,923	4.87 %	10,517
Nebraska	730,577	10.66 %	77,845
Indiana	2,543,090	2.40 %	61,140
Ohio	11,870,733	1.28 %	151,893
Idaho	562,067	9.19 %	51,646
Illinois	4,851,822	2.83 %	137,330
Arkansas	2,942,753	2.36 %	69,319
Colorado	1,959,789	4.88 %	95,698
Arizona	2,336,959	4.21 %	98,382
California	12,764,753	1.40 %	178,743
Maryland	2,202,016	0.25 %	5,529
Montana	394,719	5.55 %	21,916
Nevada	994,992	7.34 %	73,000
Pennsylvania	5,062,337	0.47 %	23,957
South Carolina	1,825,000	0.84 %	15,393
Washington	2,581,680	1.95 %	50,225
Total	71,663,671	4.93 %	3,536,202

Sources: FCC

Wireless Mapping extended its analysis to the rest of the country and assessed coverage as of 2011. They concluded that WISP coverage grew .43 percentage points from 2008 to 2011 as shown in Table V-2.

Table V-2. United States: WISP Coverage (2011)

Total Households	Households With Access to a WISP	Households Where WISP Is Only Broadband Provider
131,704,731	60,147,903 (45.67 %)	3,226,087 (5.36 %)

Source: Wireless Mapping

To assess the economic value of the WISP industry we estimate total revenues for the sector. This approach first compiles the number of customers and then multiplies it by average revenue per customer.

Thanki (2012) estimates that the WISP customer base is approximately 3,000,000. This number is fairly close to the WISP-only served base shown in table V-2, although cable or telecommunications providers also serve some of the 3,000,000 customers belonging to the universe also served by cable or telecommunications carriers. Ubiquiti quotes 18 million subscribers but this number is based on equipment sales and includes machine-to-machine installations. Therefore, we opt to rely on Thanki's more conservative number.

We then multiply the number of subscribers by the lowest price of broadband service. We selected the most economic offer of a WISP´s supplier in Texas[42] (39.99 per month). Based on this metric, the estimated total annual revenues of the sector would be $1.439 billion. This number might be somewhat conservative because the customer base could be larger that 3,000,000 (although we do not have reliable statistics) and the average revenue per subscriber could be higher than the less expensive offer.

VI. THE VALUE OF Wi-Fi ONLY TABLETS

The only known assessment of the value of Wi-Fi only tablets conducted so far was done in a cursory fashion by Milgrom et al. (2011) in their estimation of the economic value of the iPad. The authors use the installed base of iPads as their starting point. Their assessment assumes that the sum of the producer surplus (equivalent to the production cost of $300) and the consumer surplus (inferred to be the difference between the retail price of $599 and the production cost) represent the economic value of a tablet with Wi-Fi only capability. This would approximate $15 billion.

It is important to mention that the consumer surplus calculated by Milgrom et al. (2011) is equated to price, which does not consider the fact that willingness to pay would exceed the price paid for the good. What, then, is the WTP for a tablet sold at $499? From a pricing strategy, most tablet vendors follow a versioning strategy (i.e. they sell a variety of products at different prices to different types of buyers), which pushes the consumer to self-select the product that takes the most of his consumer surplus. If successful, the willingness to pay for a Wi-Fi only tablet sold at $499 would not be as high as Milgrom et al. (2011) state. We will address this issue below.

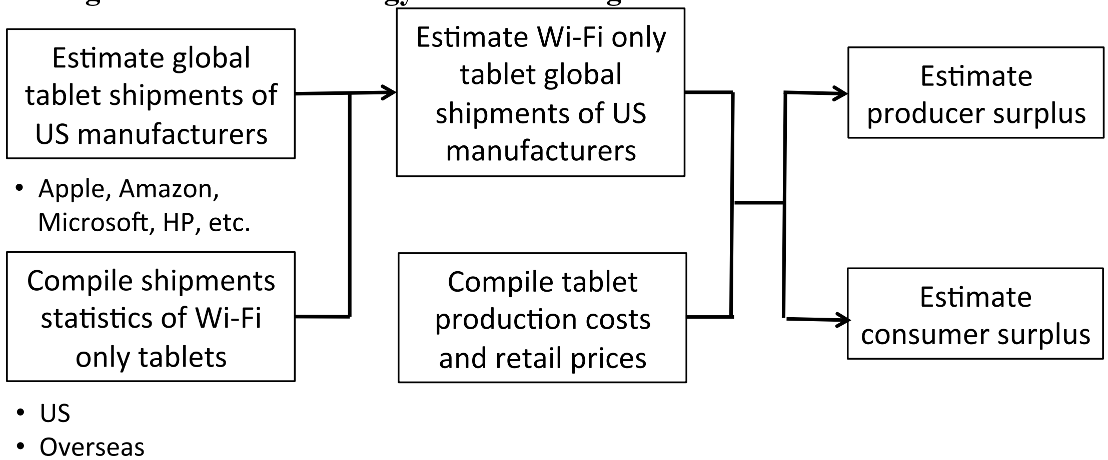
Further, considering the prior analysis to be conceptually correct, we will replicate it by updating the numbers along the following lines:

- Consider total shipments of Wi-Fi only tablets (while the iPad controls the largest share, we will include other alternatives as well)
- Contrary to limiting ourselves to the 32Gb Wi-Fi only models, we will include also devices with 16Gb and 64Gb
- Production costs and retail prices will be updated to reflect changes in economies of scale, and production learning curves

We will structure the approach to estimating the economic value of unlicensed spectrum in regard to tablets as follows:

[42] Internet America (http://www.internetamerica.com/) for a broadband connection.

Figure VI-1: Methodology for Estimating Wi-Fi Tablets Economic Value



We start by compiling statistics on worldwide shipments of tablets. Following Milgrom et al. (2011), we consider only those tablets manufactured by US companies (since we are estimating economic value for the United States). With these numbers, we estimate the portion of Wi-Fi only tablet shipments as opposed to tablets with both Wi-Fi and cellular connectivity. By calculating the total retail value and compiling statistics on gross margins, we calculate both consumer and producer surplus.

VI.1. Shipments of Wi-Fi only tablets

Based on different analyses, worldwide tablet shipments for 2013 ranged between 117 million and 145 million. The following table presents both the historical trends and a forecast summary of worldwide tablet shipments (see table VI-1).

Table VI-1. World-Wide Tablet Shipments (2010-2017) (in millions)

	2010	2011	2012	2013	2014	2015	2016	2017
IDC	17.9	70.9	117.1	221.3	270.5	332.4	359.4	386.3
Gartner	17.6	60.0	120.2	184,4	263.2	---	---	---
Juniper	---	55.2					253.0	---
HIS iSuppli	17.4	60.0	120.0	138.0	248.0	275.3	---	---
Statista	19.0	76.0	145.0	227.3	287.0	332.0	---	---

Source: Compiled by TAS

Considering the wide divergence in forecasts that reflect a rapidly growing market, we rely on the most recent study, produced by IDC; accordingly, 2013 shipments amount to 221.3 million, reaching 386.3 by 2017. Since the analysis aims to measure the economic value of unlicensed spectrum for the United States, we only use shipment statistics from US manufacturers. We apply shipment share statistics to the overall shipment numbers (see table VI-2).

Table VI-2. Tablet Shipment Market Share (2010-2017) (in percentage)

		3Q2011	2Q2012	2Q2013
US Manufacturers	Apple	59.7 %	60.3 %	32.4 %
	Others (1)	24.6 %	23.2 %	36.5 %
	Total	84.3 %	83.5 %	68.9%
Overseas Manufacturers	Samsung	6.5 %	7.6 %	17.9 %
	Asus	3.8 %	3.3 %	4.5 %
	Lenovo	1.1 %	1.3%	3.3 %
	Other (Acer, etc.)	4.0	4.3 %	5.4 %

(1) HP, Microsoft, Amazon, Dell, Google
Source: IDC; TAS estimates

Based on these numbers, we estimate that tablet shipments from US manufacturers (Apple, Amazon, HP, Microsoft) will reach 152 million by the end of 2013 (see table VI-3).

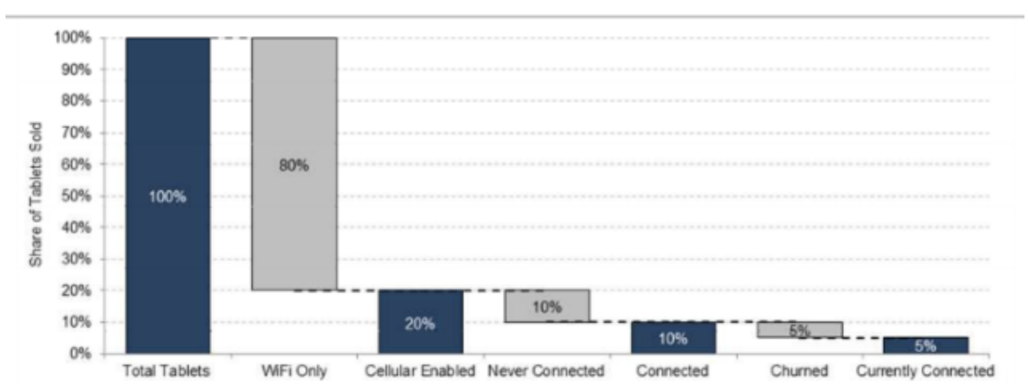
Table VI-3. US Manufacturers: Tablet Shipments (in millions)

	2010	2011	2012	2013
Total US	16.82	59.77	97.78	152.47

Source: TAS analysis

According to the latest selling figures, the value of tablets is intrinsically linked to Wi-Fi rather than cellular connectivity. Moffett (2013) estimates that only 20% of tablets are sold with wireless chipsets, and of this 20%, only half of these devices are connected to a wireless network. In other words, even amongst those users that purchase tablets with cellular connectivity capability, only 50% purchase a cellular contract. Furthermore, of those users that do purchase a contract, 50% end up churning out and disconnecting. The author therefore concludes that tablets are devices for nomadic connectivity in a stationary context, whereby Wi-Fi is the critical component of value (see figure VI-2)[43].

Figure VI-2. Tablets Purchased Versus Tablets Connected to Cellular Network

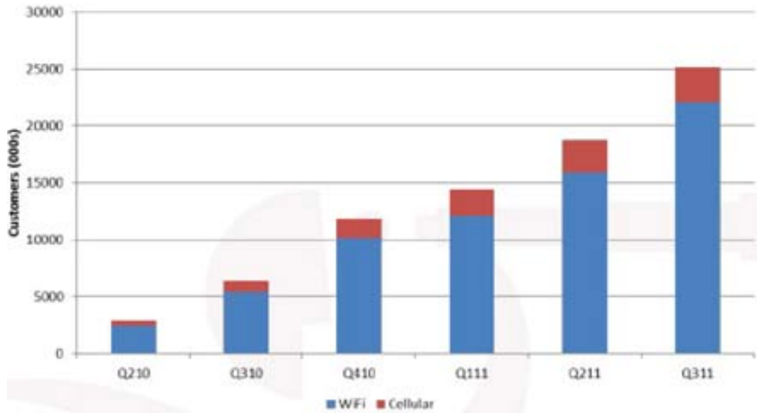


Source: Moffett Research (2013)

[43] This conclusion is consistent with time-of-day usage pattern, indicating that tablets are primarily devices used at home.

Research from the consulting firm Chetan Sharma confirms Moffett's (2013) estimates, determining that approximately 90% of tablets sold in the US were Wi-Fi only models (see figure VI-3).

Figure VI-3. US Tablet Shipments (2010-2011)



Source: Chetan Sharma (2011)

This finding is an important confirmation of the original assumption made by Milgrom et al. (2011):

> *"How much (of the iPad) value can we attribute to the presence of Wi-Fi? It seems hard to believe that a product for which 3G access is not standard but only an option, would have been nearly as successful or widespread, and perhaps it might not have succeeded at all, if users were forced to rely on a combination of cellular and wireline access to data and services" (p. 17)*

Wi-Fi only pricing versus the pricing of Wi-Fi and cellular devices helps in understanding the willingness to pay. An entry-level 16GB Wi-Fi only iPad costs $499, while a similar device with 4G connectivity costs $629. Including the fees associated with a data plan (e.g. ATT's less expensive 250 MB cap plan at $14.99 per month), it would add an additional $179 per year to the total cost of ownership without any impact on acquisition costs due to the lack of carrier subsidy. According to sales figures, most consumers are not willing to pay 60% more for cellular connectivity if the functionality of an essentially nomadic device can be met through Wi-Fi. More importantly, consumers are more likely to rely only on a tethered smartphone as Wi-Fi device, rather than needing two cellular devices.

Will this situation change in the future? Some analysts believe that Wi-Fi only tablets will decline 50% by 2016 (Juniper Research, 2013), although this trend doesn't seem likely given the current figures. Nevertheless, in trying to reverse this loss of value, cellular carriers could react by limiting two-year contract obligations (a big deterrent for a device with such a short replacement rate) and/or offering bundled data plans for tablets and smartphones. Furthermore, as seen in some emerging countries, the lack of broadband fixed access and Wi-Fi hot spots would render the purchase of a tablet with cellular connectivity a necessity. However, research conducted in India shows that only 23% of tablets shipped in 1Q2013 were cellular-enabled (CyberMedia Research, 2013).

Considering Moffett's more current US estimate, and extending this estimate to overseas shipments, we estimate Wi-Fi only shipments in (see table VI-4).

Table VI-4. US Manufacturers: Tablet shipments (in millions)

	2010	2011	2012	2013
Total Shipments	16.82	59.77	97.78	152.47
Percent Wi-Fi only	90%	90%	90%	90%
Wi-Fi only shipments	15.14	53.79	88.00	137.23

Source: TAS analysis

VI.2. Tablets retail pricing and production costs

As mentioned above, the assessment conducted by Milgrom et al. (2011) assumes that the economic value of a tablet with Wi-Fi only capability is represented by the sum of the producer surplus (equivalent to the production cost of $300) and the consumer surplus (inferred to be the difference between the retail price of $599 and the production cost). To determine the retail pricing and production costs of units sold, it is important to mention that many Android suppliers tend to offer only cellular connectivity products. For example, the Samsung Galaxy Note cannot be purchased without a data plan. In that sense, focusing solely on the economics of the iPad might not be that far off the mark (see table VI-5).

Table VI-5. iPad Air Economics

		Retail Price	Manufacturing Costs	Producer Surplus
Wi-Fi Only	16 GB	499	274	225
	32 GB	599	282.40	316.6
	64 GB	699	300 (E)	399 (E)
	128 GB	799	325 (E)	474 (E)
Wi-Fi + Cellular	16 GB	629	310	319
	32 GB	729	319 (E)	410 (E)
	64 GB	829	340 (E)	489 (E)
	128 GB	929	361	568

Source: IHS iSuppli; TAS analysis

Apple succeeded in reducing the manufacturing cost of the iPad while maintaining its retail price and leveraging production scale and experience curve. For example, the 16GB with Wi-Fi and cellular connectivity costs $310, 4.6% less expensive than the equivalent 3G iPad. Also, the margins increase with storage capacity because of scale in the core processor, which happens to be the same used core processor in the iPhone 5s.

To calculate consumer and producer surplus, we average economics for Wi-Fi and Wi-Fi and Cellular models (see table VI-6).

Table VI-6. Average iPad Air Economics

	Retail Price	Manufacturing Costs	Producer Surplus
Wi-Fi Only	649	295	354
Wi-Fi + Cellular	779	332	447

Source: TAS analysis

To calibrate iPad economics with other products, we compiled manufacturing costs for Apple's competitors (table VI-7).

TableVI-7. Other Tablet Economics

	Retail Price	Manufacturing Costs	Producer Surplus
Google Nexus 8 GB	199	181.75	17.25
Google Nexus 16 GB	249	199	50
Amazon Kindle Fire	199	201.70	-2.70
HP TouchPad 16 GB (Wi-Fi only)	279.99	306	-26
HP TouchPad 32 GB (Wi-Fi only)	370	328	42

Note: The negative surplus for Amazon and HP is not accurate insofar that both suppliers are cross-subsidizing the products with other revenue streams (e.g. for Amazon, e-book sales).
Source: HIS iSuppli

Considering the volumes of Wi-Fi only tablets, following Milgrom's assumption, total producer surplus in 2013 for Wi-Fi only Tablets amounts to $34.6 billion (see table VI-8).

Table VI-8. Producer Surplus of Wi-Fi Only Tablets (2013)

	Apple	Competitors	Total
Volume (in millions)	96.06	41.17	137.23
Average Producer Surplus	$ 354	$ 16	
Total Producer Surplus (in $ millions)	$ 34,196	$ 659	$ 34,855

Source: TAS analysis

Following Milgrom et al. (2011) in their assumption that consumer value is of the same magnitude as producer value, total economic value would amount to $ 69 billion. However, recent research on willingness to pay for tablets conducted by the Institute for Mobile Markets Research conducted in 2011 indicates that willingness to pay for a 16GB Wi-Fi only model ranges between $351and $524. Considering that the research was conducted in 2011 and the content value of tablets has greatly increased since then, we take the upper range. Considering that 60% of tablets sold are entry model (16GB Wi-Fi only), and keeping the 70%-30% split in favor of Apple, consumer surplus would equate to $ 7.987 billion.

In addition to the tablet estimates, one could add the somewhat less reliable producer surplus figures from devices such as the iTouch, an Apple product that connects exclusively through

Wi-Fi. Apple released US shipment numbers from 2007 of 46.5 million. Considering replacement and tablet substitution rates, the current installed base approximates 26 million. Retail price ranges between $ 229 and $399, with the mid-level model of $299. An estimate of manufacturing and parts cost (realized in 2007 and therefore not factoring in scale or experience effects) estimates a total of $155.04[44]. Considering a unit producer surplus of $144 would yield a total of $ 3.744 billion. Given the limited reliability of these figures, we decided to include them only as a reference.

VII. THE VALUE OF WIRELESS PERSONAL AREA NETWORKS

Wireless Personal Area Networks connect two or more devices within a very limited geographic area (sometimes within line of sight) by relying on unlicensed spectrum bands of 2.4 GHz and 915 MHz. While the most common standard is *Bluetooth*, two new standards (ZigBee and WirelessHART) now support specific application such as home automation and industrial device monitoring respectively. This chapter estimates the value added generated by these three standards.

VII.1. Bluetooth Applications

Mobile phone headsets, PC networking, PC peripherals, medical equipment, traffic control devices, barcode scanners, and credit card payment machines all rely on this technology. Quantification would rely on measuring the total US market for each Bluetooth-enabled technology. The following application sub-categories will be addressed in turn:

- Automotive
- Consumer Electronics
- Health & Wellness
- Mobile Telephony
- PC & Peripherals
- Sports & Fitness

VII.1.1 Automotive

The market for Bluetooth enabled devices, originally focused on hands-free voice calling, has grown to encompass a wide range of automotive applications. Safety concerns[45] and new hands-free driving laws originally spurred the deployment of hands-free calling systems. As of today, the majority of new cars and trucks[46] now include Bluetooth enabled hands-free voice calling systems as standard equipment. In addition, many consumers tend to add hands-free calling by

[44] iSuppli teardown reveals Apple's iPod touch is more than an iPhone without a phone, EMS Now, December 19, 2007.

[45] Eleven percent of drivers are talking on the phone while driving.
[46] All 12 of the world's major car manufacturers offer Bluetooth hands-free calling systems in their vehicles.

purchasing Bluetooth speakerphones that attach to their car's visor or rely on headsets. For example, according to NPD, the market for Bluetooth-equipped speakers represented $264 million in 2012[47].

Many different devices consumers use in the car offer hands-free calling ability - not just factory installed hands-free calling systems. For example, many car navigation systems now include Bluetooth hands-free calling. These devices include the small, affordable navigation devices that consumers can mount on the windshield if the car lacks an integrated navigation system. This added hands-free calling capability gives portable navigation devices benefits beyond just maps and navigation.

Beyond hands-free voice calling, Bluetooth now supports a whole range of automotive applications. Automakers and consumer electronic manufacturers have developed Bluetooth-enabled smartphone applications that run in the car.[48] The applications allow users to stream music over the Internet, listen to podcasts, get instructions from GPS systems, and receive information (traffic information, weather reports, destination information, cheapest gas station, etc.) on the flat-panel display in the car.

Finally, new phone applications that communicate wirelessly with a car to monitor and diagnose its mechanical and electrical systems have emerged. Adding wireless sensors to cars eliminates copper wires, thereby reducing vehicle weight, improving fuel economy, and lowering manufacturing costs[49].

Per the Consumer Electronics Association, the 2013 United States market for automotive consumer electronics is worth an estimated $ 9.2 billion[50]. However, only 35 percent of all devices are Bluetooth-enabled[51], which results in an approximate $3.22 billion total market for Bluetooth in-vehicle electronics.

VII.1.2. Consumer Electronics

Bluetooth technology can be found in many consumer electronics devices. The consumer electronics devices equipped with Bluetooth technology is segmented in two categories: at home and on the go applications (see table VII-1):

Table VII-1. Bluetooth Consumer Electronics Applications

Home	On the go
• TV sets • Remote controls • 3D glasses	• Headphones • Ear buds • Cameras

[47] http://allthingsd.com/20130703/bluetooth-speakers-popping-up-everywhere-heres-why/
[48] For example, Toyota and Hyundai offer new Bluetooth enabled systems for smartphone applications in the car, and Ford is aggressively pursuing the application market with its Bluetooth enabled Ford Sync system. Pioneer and Sony have developed the ability to connect smartphones to their latest car receivers.
[49] Carmakers are also testing other possible future uses. For example, Ford is exploring Bluetooth enabled systems that monitor a person's vital signs while driving.
[50] Source: Consumer Electronics Association. “The U.S. Consumer Electronic Sales and Forecasts”.
[51] Source: http://www.isuppli.com/Automotive-Infotainment-and- Telematics/Pages/Products.aspx.

• A/V receivers • Game consoles • Game controllers	• Speakers • Media players

The consumer electronics Bluetooth-enabled market comprises a primary area (Audio) and various applications (Ultra HD TV, Desktop 3D printers, video games).

Home audio unit shipments in the United States will increase by a projected 11%, reaching 11.4 million shipments by 2017. Soundbars and Bluetooth/Airplay-enabled speakers fuel this demand. Soundbar shipments could increase by 40% from 2012 to reach 2.8 million units, while portable connected speakers could generate $302 million in total revenue in 2013 – an increase of 35% year-over-year[52].

Television consumer equipment market analysts forecast Bluetooth-enabled device shipments - like TVs, set-top-boxes, remotes, and 3D glasses - to grow to almost 500 million units a year by 2018. The Bluetooth-enabled television market includes 3D television sets, TV remote controls, and Ultra HD. Annual shipments of Ultra HD in the United States are projected to reach 57,000 units, earning revenues of $314 million[53].

Another Bluetooth-enabled application, desktop 3D printers will reach unit sales in the United States of 41,000, with revenues of $52 million.

Finally, Bluetooth technology is already well established in the gaming industry because it is already built into every Nintendo Wii and Sony PlayStation. There's a large third-party market for Bluetooth enabled headsets, stereo headphones, remote controllers, and game controllers that work with these game consoles.

VII.1.3. Health & Wellness

Bluetooth-enabled health and wellness devices already on the market include wireless blood glucose monitors, heart rate monitors, weight scales, and stethoscopes. These devices collect vital health information from consumers with a wide variety of medical conditions – even allowing healthcare providers to monitor patients while at home or on the go.

The emergence of Bluetooth Smart devices with low energy technology allows manufacturers to design extremely small and longer-lasting wireless devices by shrinking battery size and requiring less power. Consumers can now wear tiny wireless sensors that operate for months or years with just a coin-cell battery. Bluetooth technology allows sensors to collect data securely and send it to enabled phones, tablets, and laptops. The sensor sends the health information to the computerized hub device, which stores and analyzes this information. Consumers can view their own health information or securely share their medical information with their healthcare provider. This ability to alert health care providers is critical. People can pair their phone with new types of Bluetooth wireless sensors to monitor everything from glucose and oxygen levels to heart rate and electrocardiograms.

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[52] Source The U.S. Consumer Electronic Sales and Forecasts.
[53] Source The U.S. Consumer Electronic Sales and Forecasts

Smart watches that monitor abnormal vital signs serve as another example of a Bluetooth-enabled health application. For example, a smart watch can help people with epilepsy by detecting abnormal movements in people prone to seizures and then sending alerts to their phones and their doctors.

By 2018, ABI Research expects more than 46 million Bluetooth enabled health and medical devices to ship per year. According to TechNavio, the global market for wireless patient-monitoring equipment should reach $9.3 billion by 2014. With the United States representing 26.7% of world GDP, this market amounts to $ 2.48 billion in 2014.

VII.1.4 Mobile Telephony

Most mobile phones and smartphones already include Bluetooth technology, allowing them to work with headsets, headphones, wireless speakers, hands-free calling systems in the car, and an array of other Bluetooth-enabled devices. This vast network of compatible products creates as many opportunities for companies making Bluetooth accessories as it does for companies manufacturing wireless phones.

According to market research firm ABI Research, nearly two billion smartphones will ship globally by 2018, almost triple the amount in 2011. Considering that the 2013 smartphone installed base in the United States is 192.75 million and that the cost of a Bluetooth chip required in each phone is worth $1, the total Bluetooth-related smartphone market amounts to $ 192.75 million[54].

VII.1.5 PC and Peripherals

The explosion in tablet sales and the continued growth in laptop sales is sparking demand for more Bluetooth enabled keyboards, speakers, stereo headphones, and other wireless computer accessories. They allow consumers to travel with their tablets and increase productivity by turning the tablet into a full-featured computer. In addition, since most laptops and tablets have weak speakers with poor sound, consumers shop for Bluetooth speakers or headphones to enhance their mobile computing experience. Laptop users also like to move around their home while continuing to listen to music without the hassle of speaker wires or headphone cords.

Tablet sales are expected to approach 250 million units by 2017 (virtually all with Bluetooth technology)[55]. Despite the skyrocketing tablet sales, the laptop market will also continue to grow. Research firm, ETForecasts, expects laptop sales to grow to 369 million in 2015. Most laptops come with integrated Bluetooth technology. Because laptops still outsell tablets by a wide margin, there are more laptops than tablets able to connect with Bluetooth accessories.

We used a similar approach to quantify the Bluetooth market in the PC, tablet, and peripheral sectors (see table VII-2).

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[54] Source: http://www.nickhunn.com/bluetooth-low-energy-aiming-for-the-trillions/
[55] Source: InStat

Table VII-2. United States: PC and Peripherals Bluetooth Market

Market	Value
PCs	$ 316.50
Tablets	$ 61.52
Printers	$ 7.00
Total	$ 385.02

Source: http://www.nickhunn.com/bluetooth-low-energy-aiming-for-the-trillions; TAS analysis

As indicated in table VII-2, the Bluetooth-enabled PC and peripheral market in the United States is worth $ 385.02 million.

VII.1.6 Sports & Fitness

As in the case of Health Care, Bluetooth technology has dramatically shrunk the size and power requirements of sensors able to measure pace, pulse, cadence, distance, and other workout information. Tiny sensors that operate for months with just a coin-cell battery have created a new wave of sports and fitness devices that help consumers track their workouts and athletic performance. Convenience also drives the popularity of fitness products, with Bluetooth technology allowing consumers to listen to music with wireless headphones while exercising. Some of the new wireless exercise devices made possible by Bluetooth technology include:

- Heart-rate monitors connected to a Bluetooth phone, which allows consumers to set the phone on a treadmill or other exercise machine, watch their pulse in real-time during workouts, and then analyze the information later
- Heart-rate monitors that automatically connect to a piece of exercise equipment at the gym and display users' heart rate on the machine while they work out
- Cycling computers that send speed, route, and other performance data wirelessly to a phone, where users can analyze it after a ride
- Bluetooth-enabled sports watches that connect wirelessly to a heart-rate strap, foot pod, or phone
- Wireless, water-resistant ear buds made to wear while working out

The many new wireless fitness devices enabled by Bluetooth increases demand for compatible applications that can analyze runs, bike rides, gym exercises, or other types of workouts. Bluetooth technology sends the workout data wirelessly to any Bluetooth ready device. From there, consumers process and analyze the information with the latest sports and fitness apps and securely share results online with personal trainers or friends. This workout data creates demand for new PC and phone applications to process and analyze a wealth of exercise information.

According to IMS Research, more than 60 million sports, fitness, and health monitoring devices with Bluetooth technology will ship between 2010 and 2015. Sport and Fitness unit shipments in the United States reached an estimated 10.2 million in 2013, with revenues of $854 million[56].

VII.2. Other WPAN standard applications

[56] Source: The U.S. Consumer Electronic Sales and Forecasts.

Beyond Bluetooth, ZigBee and WirelessHART also support Personal Area Networks. These products have a much lower proximity requirement than Bluetooth (up to 75 meters[57]), although the transfer data rate is lower (250 kbps).

VII.2.1 ZigBee

ZigBee supports secure communications at a low data transfer rate (maximum: 250 kbps) and an extended battery life, making Zigbee the standard of choice for home automation. ZigBee Home Automation offers a global standard for interoperable products enabling smart homes that can control appliances, lighting, environment, energy management, and security while offering the option to connect with other ZigBee networks. ZigBee technology will likely lead the smart home market.[58]

By the end of 2012, over 11 utilities installed more than 40 million ZigBee-enabled meters in the United States[59]. The world market for ZigBee-enabled energy management systems was worth $1 billion[60]. Assuming that the US represents 26.70% of the world economy, we estimate that the ZigBee US market conservatively amounts to $ 267 million.

VII.2.2 WirelessHART

Wireless HART is a technology operating in unlicensed spectrum bands primarily for industrial applications[61]. It provides connectivity in zones of difficult or costly wireline access. The technology can monitor pumps, cooling units, filters, engines, and valves otherwise difficult to access[62] at a very low cost. According to IDTech[63], the world market for WirelessHART in 2011 was $450 million. We estimate the US market for 2013 to be approximately $160 million.

VII.3. Conclusion

In order to estimate the total economic value of Wireless Personal Area Networks operating in unlicensed spectrum, we conservatively considered only those revenues to be generated by the applications that could not operate without the technology. We consider this estimate to be extremely conservative in the sense that, if the application is being operated via a competing alternative substitute technology, it was aggregated in a different category (see table VII-3).

Table VII-3. United States: Revenues Generated by Wireless Personal Area Networks Markets (in $ millions)

Standards	Applications	Application Could Not Be Operated Without Unlicensed Spectrum Standard	Unlicensed Spectrum Standard Supports Alternative Technology
Bluetooth	Automotive	$ 1,161.60	$ 2,058.40

[57] Data rate for WirelessHART outdoors reaches 250 meters.
[58] Source: http://www.fiercetelecom.com/press-releases/worldwide-smart-meter-revenue-surpass-us12-billion-2016-zigbee-early-techno
[59] http://www.onworld.com/smartenergyhomes/SmartHomeEnergyExecSum.pdf
[60] Source: ON World. *2016 Wireless/Wired Home Energy management Equipment*.
[61] Maley, R. (2013). *Building Secure Standards for the Smart Grid*. Presentation at the US-Mexico Smart Grid Conference.
[62] http://www.edcontrol.com/ins/novedades/nov_154_01_porquewirelesshart.htm
[63] IDTech. *Wireless Sensor networks 2011-2021*.

	Consumer Electronics		$ 668.00
	Health and Wellness		$ 2,483.10
	Mobile Telephony	$ 192.75	
	PC and Peripherals	$ 385.03	
	Sports and Fitness		$ 854.00
Zigbee		$ 267.00	
WirelessHART		$ 160.00	
Total		$ 2,166.38	$ 6,063.50

Source: TAS analysis

In summary, the revenue generated by Wireless Personal Area Network technologies operating in unlicensed spectrum in the United States in 2013 is $ 2.17 billion for applications that could not operate without technologies in those standards. If we add applications that can operate with unlicensed network technologies as a substitute to other alternatives (primarily wired connections), revenues would reach $ 8.23 billion.

Beyond the value generated by these applications, it is important to conclude that, since wireless personal area networks are purely private goods, generating minimal interference, there is no economic rationale to license the spectrum in which they operate.

VIII. THE VALUE OF RFID

When Thanki assessed the economic value of RFID (2009) dependent on unlicensed spectrum[64], he focused on a sector that had adopted the technology early (retailing) and one for which researchers had already developed studies on economic impact (Hardgrave et al., 2009). However, at the same time, he acknowledged that the usage of unlicensed spectrum in combination with RFID was “at its infancy.” For that purpose, while anchoring the benefits in the areas of retailer efficiency (fewer out-of-stock items) and increased sales, he had to range the impact scenarios depending on technology adoption in the sector. By running a net present value of economic returns across three scenarios, he concluded that RFID enabled by unlicensed spectrum in the retail sector supply chain could generate an annual value between $3.3 billion and $13.1 billion.

Since the time that Thanki produced his study, RFID has achieved a much wider adoption. In particular, the blending of general-purpose networks and RFID has yielded new applications such as powered, attachable tags that Wi-Fi APs can read. This led to its adoption in manufacturing plants, warehouses, logistics, hospitals, and other large facilities equipped with Wi-Fi networks and the need the track the movement of people or assets. The value of the US RFID market for 2013 is estimated at $7.88 billion, up from $6.51 billion in 2011, which includes tags, readers, software, labels, and other items. As expected, retail apparel is the largest pocket of demand, although benefits in the health care sector are also growing.

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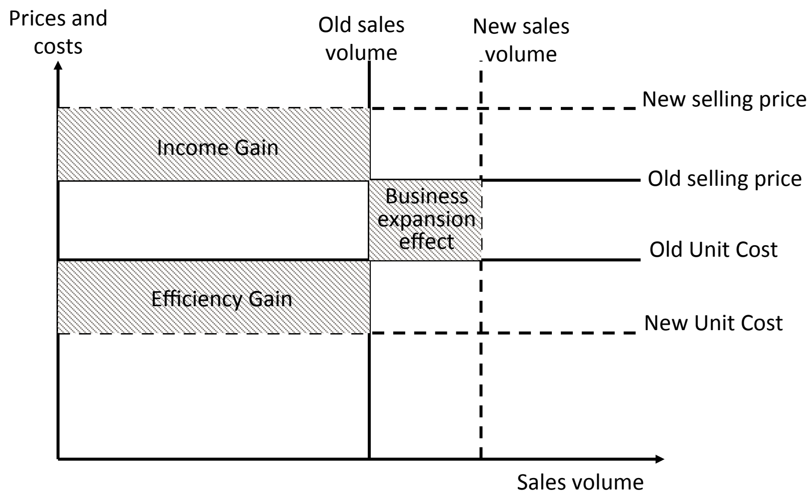
[64] RFID applications rely on the unregulated 120-150 kHz Low Frequency band, the 13.56 MHz high frequency ISM band, and the 902-928 MHz UHF band, among others.

The assessment of RFID benefits can be summarized in terms of both the operational efficiencies and revenue enhancing opportunities (see figure VIII-1).

Figure VIII-1. Economic Value of RFID



The efficiency gains include a reduction in labor costs, shrinkage losses, inventory write-offs, and non-working inventory. Income gains include increased product availability and faster time to market. Business expansion provides ubiquitous access to customers across multiple distribution channels. In addition, consumers benefit from some of the efficiency gains by way of lower prices. Furthermore, by allowing for less waiting time, an enhanced shopping experience, and improved customer care, RFID can increase consumer surplus. In the particular case of health care, consumer surplus results from improved compliance and fewer errors.

These benefits should be factored against the investment to understand the net present value of resulting cash flows. A study conducted at the University of Texas (Anitesh Barua, Deepa Mani & Andrew B. Whinston, 2006), from which the following analyses are compiled, follows this methodology.

VIII.1. RFID and retailing

The authors summarize the retailer and consumer benefits in the following areas (table VIII-1).

Table VIII-1. RFID Benefits in Retailing

Retailers	Consumers
• Reduction in Labor costs • Reduction in Shrinkage losses • Enhanced Inventory Turns • Reduction in Inventory Write-Offs • Reduced Stock-Outs and Improved Product Availability • Decrease in Lost Sales Due to Shipment Errors • Faster Time-to-Market for New Products • Ubiquitous Access Across Multiple Channels	• Customization of products and services • Enhanced shopping experience

Relying on case study data and results from other research, the authors develop an estimation of financial benefits for the sector, at both the 45% adoption, and the 100% RFID adoption level (table VIII-2).

Table VIII-2. Estimates of RFID Benefits in Retailing (in $ billions)

Benefit	Total Cost/losses	Cost Reduction at 45% Adoption	Cost Reduction at 100% Adoption
Reduction in labor costs	$ 260.63	$ 46. 33	$ 102.95
Reduction in shrinkage losses	$ 60.22	$ 11.67	$ 19.06
Enhanced inventory turns	$ 105.65	$ 7.35	$ 16.33
Reduction in inventory write-offs	$ 26.41	$ 2.11	$ 10.56
Reduced stock-outs	$ 51.00	$ 0.294 (*)	$ 0.652 (*)
Reduced shipment errors	$ 5,611.2	$ 0.089 (*)	$ 0.197 (*)
Faster time to market	$ 39.152	$ 0.63 (*)	$ 3.132 (*)
Ubiquitous access across multiple channels	$ 2,280.52	$ 0.112 (*)	$ 0.559 (*)
Customization		$ 20.45	$ 102.24
Enhanced experience	$ 29,054 (**)	$ 5.81	$ 29.05

(*) Quantified as EBITDA impact
(**) Measured as willingness-to-pay.
Source: Barua et al. (2006)

A survey conducted by Accenture found that more than 50% of US retailers had adopted RFID, meaning that the 45% adoption level offers a more realistic estimate of the current situation[65].

[65] The survey also states that based on reports of pilots projects in place, by 2017, take-up of RFID in retail will reach 100%.

According to the estimates for the 45% adoption scenario, the total economic value of RFID in the retailing sector in 2013 is $ 94.84 billion (see table VIII-3).

Table VIII-3. United States: RFID Economic Value in Retailing (2013) (in billions)

	Producer Surplus	**Consumer Surplus**
Reduction in labor costs	$ 46. 33	
Reduction in shrinkage losses	$ 11.67	
Enhanced inventory turns	$ 7.35	
Reduction in inventory write-offs	$ 2.11	
Reduced stock-outs	$ 0.29	
Reduced shipment errors	$ 0.09	
Faster time to market	$ 0.63	
Ubiquitous access across multiple channels	$ 0.11	
Customization		$ 20.45
Enhanced experience		$ 5.81
Total	$ 68.58	$ 26.26

Source: TAS analysis based on Barua et al. (2006)

Assuming a 30% adoption rate, Thanki (2009) estimated the total economic value in retail clothing stores alone to be $ 13.1 billion in 2019. As such, we find the estimate of a study pertaining to the total retail sector at 45% adoption to be fairly realistic.

VIII.2. RFID and health care

In the case of the health care sector, the authors of the University of Texas study differentiate the benefits across the constituencies of the value chain (table VIII-4).

Table VIII-4. RFID Benefits in Health Care

Product and Service Providers	Consumers
• Pharmaceutical manufacturers o Reduction in counterfeit, shrinkage and parallel trade o Efficient product recall o Efficient sample management o Enhanced inventory turns o Shorter clinical trials and faster time-to-market • Healthcare distributors o Enhanced inventory turns o Reduction in labor costs • Hospitals o Better equipment tracking and increased asset utilization o Enhanced inventory turns o Wider access to healthcare at reduced costs	• Faster access to better healthcare • Improved quality of patient care – fewer medical errors and improved compliance • Reduced mortality rates

In this case, the authors develop an estimation of financial benefits for the sector, both at 50% adoption and 100% adoption of RFID. However, in health care the adoption of RFID is relatively high for certain applications, in some cases stimulated by FDA mandates, and relatively low for others such as pallet-level tags (table VIII-5).

Table VIII-5. Estimates of RFID Benefits in Health Care (in $ billions)

Product and Service Providers	Benefit	Total Cost/losses	Cost Reduction at 50% Adoption	Cost Reduction at 100% Adoption
Pharmaceutical manufacturers	Reduction in counterfeit, shrinkage and parallel trade	$ 4.307	$ 1.000	$ 1.852
	Efficient sample management		$ 6.500	$ 12.73
	Enhanced inventory turns		$ 4.505 (**)	$ 15.54
	Shorter clinical trials and faster time-to-market		$ 0.100	$ 0.159 (*)
Healthcare distributors	Enhanced inventory turns	$ 5.984	$ 0.410 (***)	$ 1.784
	Reduction in labor costs	$ 1.878	$ 0.130 (***)	$ 0.563
Hospitals	Better equipment tracking	$ 7.253	$ 1.451 (****)	$ 3.627
	Enhanced inventory turns	$ 544.02	$ 17.952 (****)	$ 44.881
	Wider access to healthcare at reduced costs			$ 2.503
Consumers	Faster access to better healthcare		$ 1.500	$ 3.417
	Improved quality of patient care – fewer medical errors and improved compliance	$ 148.30	(*****)	(*****)

(*) Quantified as EBITDA impact
(**) At 29% adoption levels
(***) At 23% adoption levels
(****) At 40% adoption levels
(*****) Excluded because difficult to replicate calculations
Source: Barua et al. (2006)

Based on the more conservative adoption estimates of the study, the total economic value of RFID in the health care sector in 2013 is $ 36.07 billion (see table VIII-6)

Table VIII-6. United States: RFID Economic Value in Health Care (2013) (in $ billions)

Product and Service Providers	Benefit	Producer Surplus	Consumer Surplus
Pharmaceutical manufacturers	Reduction in counterfeit, shrinkage and parallel trade	$ 0.925	
	Efficient sample management	$ 6.50	
	Enhanced inventory turns	$ 4.50	
	Shorter clinical trials and faster time-to-market	$ 0.10	
Healthcare distributors	Enhanced inventory turns	$ 0.41	
	Reduction in labor costs	$ 0.13	
Hospitals	Better equipment tracking	$ 1.45	
	Enhanced inventory turns	$ 17.95	
	Wider access to healthcare at reduced costs		$ 2.53
Consumers	Faster access to better healthcare		$ 1.50
	Improved quality of patient care – fewer medical errors and improved compliance		---
Total		$ 31.96	$ 4.03

Source: TAS analysis based on Barua et al. (2006)

VIII.3. Conclusion

The implementation of RFID in the Retail and Health Care industries generates a total economic value of $130.3 billion (see table VIII-7).

Table VIII-7 United States: RFID Economic Value in Retail and Health Care (in $ billions)

Sector	Producer Surplus	Consumer Surplus	Total
Retailing	$ 68.58	$ 26.26	$ 94.84
Health Care	$ 31.9	$ 4.03	$ 35.99
Total	$ 100.54	$ 30.29	$ 130.83

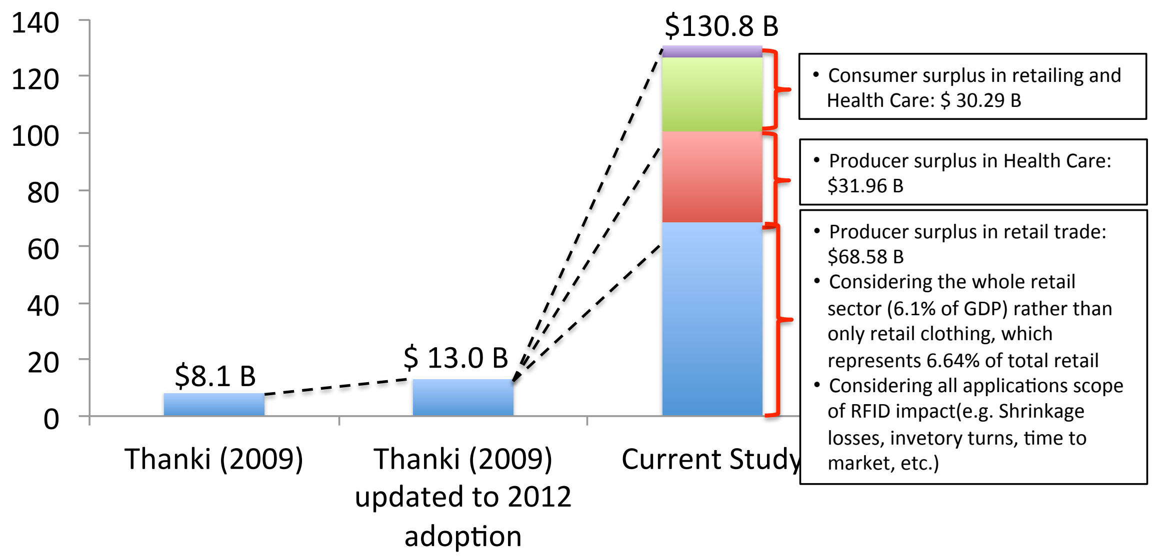
Source: TAS analysis

This number is considerably higher than Thanki's estimate in his 2009 paper. Thanki conducted the only prior estimate of RFID impact in 2009, focusing only on retail clothing (understandably so, since retail clothing was an adoption leader of RFID and there was already research on economic impact available at the time). The economic value estimated by Thanki in 2009 ranged between $2.1 and $8.1 billion. However, he recognized that the usage of RFID was "at its infancy". In fact, his model assumed that RFID in retail clothing would reach 60% (high take up scenario) only in 2019.

Several things have happened since 2009. First, adoption of RFID in retail clothing has exceeded Thanki's high uptake scenario (reaching 52% in 2012). If we were to consider only Thanki's original industry (retail clothing), and the acceleration of RFID take-up, the economic value of this technology would increase approximately to $13 billion. Second, the blending of general-purpose networks and RFID has yielded new applications, which has led to their adoption in manufacturing plants, warehouses, and logistics chains. As a result, penetration has increased well beyond retail clothing, reaching the whole retail trade sector. According to a survey by Accenture, more than 50% of US retailers have already adopted RFID. Third, research on the economic value of RFID has greatly expanded since 2009 (Gorshe et al, 2012; Waller et al, 2011). For example, Thanki recognizes that his analysis does not consider the value that might be generated in preventing shrinkage, reducing inventory holdings, and using data for marketing purposes. In conclusion, three trends are at work that greatly enhance RFID economic value beyond the original estimate: more penetration in retail clothing, enhanced adoption in the retail sector as a whole, and more applications.

In addition, beyond retail trade, RFID adoption has expanded in the health care industries, a sector that was not originally considered by Thanki. The impact of all these changes is presented in figure VIII-2.

Figure VIII-2. Economic Value of RFID: Thanki (2009) Versus Present Study (in $ billions)



To sum up, implementing Radio Frequency Identification in two of the largest sectors of the US economy (retailing (6.1% of GDP) and health care (7.4% of GDP)) results in efficiencies that generate the largest portion of economic surplus ($ 130.83 billion). This estimate does not include all other areas impacted by RFID, such as manufacturing supply chain (Sarac et al., 2009) and livestock tracking.

IX. THE VALUE OF FUTURE APPLICATIONS

The study of applications that have reached wide adoption and impact indicates the economic value already created by unlicensed spectrum bands. However, as noted by several academics, the innovation incentives generated by this environment allow us to predict the future impact of still embryonic technologies. This chapter reviews some of those applications, but does not estimate their potential economic value given their limited adoption at present.

IX.1. WirelessHD

These two technologies rely on the 60 MHz unlicensed spectrum band to deliver a data transfer rate between 6 Gbps and 28 Gbps over a range between 5 and 30 meters. WirelessHD is primarily used for high definition consumer electronic devices, while WiGig supports smartphones, PCs, tablets, and related peripherals[66].

At 28 Gbps of data transfer rate, WirelessHD surpasses HDMI, which is the most utilized HD connectivity (10 Gbps). Companies such as LG, Matsushita, NEC, Samsung, SiBEAM, Sony, and Toshiba have jointly sponsored this technology. WirelessHD is not yet widely adopted although it will likely replace HDMI in future connectivity of high definition devices. It works with a wide range of devices including laptops, tablets, televisions, Blu-ray players, DVRs, camcorders, gaming consoles, adapter products.

IX.2. Super Wi-Fi and rural wireless coverage

Super Wi-Fi operates in the frequency bands between 54 MHz and 698 MHz to deliver broadband up to 10 miles with high penetration at 20 Mbps download and 6Mbps upload speeds. As discussed in Chapter II, it can extend the range of Wi-Fi and provide broadband in rural areas. Super Wi-Fi relies on empty channels of spectrum (known as white spaces) and uses Dynamic Spectrum Access that optimizes access to available unused bands. Users will predominantly use Super Wi-Fi networks to access smart, radio-enabled devices that report their location to an Internet database. The database will dictate the TV white spaces channels and appropriate power level based on in its current location. The database has a list of all protected TV stations and frequencies across the country, so the devices can avoid interference with TV broadcasts and wireless signals. This technology is truly dynamic – as different TV channels become available, Super Wi-Fi devices can opportunistically switch from one group of channels to another.

IX.3. Advanced Meter Infrastructure

Advanced Meter Infrastructure systems provide detailed, time-based information regarding the utilization of electric, gas and water meters. The meters have the ability to transmit the collected data through a variety of communications technologies, ranging from Broadband over Power

[66] Source: http://www.wirelesshd.org/about/specification-summary/.

Line, Fixed Radio Frequency and public networks (landline or cellular)(Adke et al., 2011). If relying on unlicensed spectrum, AMI transmits 1-8 kbps per channel over 0.25 miles[67].

IX. 4. Energy demand side management

Smart Home power meters, which utilize Bluetooth-enabled hub devices, can reduce energy costs, helping homeowners to save money and use less energy. As intelligent energy delivery technology advances, two-way communications will allow smart meters to send real-time energy consumption information directly to homeowners, empowering them to conserve energy and save on their utility bills. For example, homeowners will be able to use their Bluetooth-enabled smart phone, tablet or PC to monitor and adjust their heat and air conditioning, even when they're not home. The displays and applications on today's phones and other hub computing devices can allow users to control all the appliances and systems throughout a smart home with ease.

Smart homes will also make it easier for people to make sure all their windows and doors are locked. Cars have had wireless remotes for years, allowing drivers to lock and secure them with the touch of a button. Homeowners, however, must walk around and visually check every door and window in their homes. Companies that solve these challenges will tap into a huge market of homeowners eager to take advantage of technologies they already have in their cars or offices.

IX.5. Machine to machine communications

Beyond the technologies mentioned above, unlicensed spectrum bands would be critical to the communication of devices equipped with microcontrollers in order to deliver applications in areas as diverse as environmental management (pollution / air quality monitors, weather stations, water level monitors), urban landscape (street lighting control systems, parking meters), health care (dialysis machines, defibrillators, ventilators, pacemakers). Enhanced connectivity of devices via unlicensed spectrum could increase their ability to process information and interact with other terminals.

As of 2012, the number of interconnected devices had reached 4 billion, including all handheld mobile terminals at a pairwise interconnected rate of $8 * 10^{18}$ (Thanki, 2012). While forecasts vary greatly, they all concur in an explosive growth in the number of devices and the increase in pairwise interconnections. Complementing cellular networks, Wi-Fi, Bluetooth Low Energy, and ZigBee would be highly suited standards to support a large portion of machine-to-machine interconnection. In fact, most home security systems which monitor whether or not windows and doors are open already rely on Wi-Fi technology.

[67] Electric Power Research Institute (2007). *Advanced Metering Infrastructure.* Palo Alto, California: EPRI.

X. CONCLUSIONS

The sum of effects outlined above indicate that the technologies operating in unlicensed spectrum bands in the United States generated a total annual economic value of $222 billion in 2013, and contributed $ 6.7 billion to the nation's GDP (see table X-1).

Table X-1. United States: Summary of Economic Value of Unlicensed Spectrum (2013)

	Effect	Economic Value			GDP
		Consumer Surplus	Producer Surplus	Total Surplus	
Wi-Fi Cellular Off-Loading	Value of free Wi-Fi traffic offered in public sites	$ 1.902	N.A.	$ 1.902	N.A.
	Benefit of total cost of ownership required to support future capacity requirement with Wi-Fi complementing cellular networks	N.A.	$ 10.700	$ 10.700	N.A.
	Contribution to GDP of increase of average mobile speed resulting from Wi-Fi off-loading	N.A.	N.A.	N.A.	$ 2.831
	Sum of revenues of service providers offering paid Wi-Fi access in public places	N.A.	N.A.	N.A.	$ 0.271
	Subtotal	$ 1.902	$ 10.700	$ 12.602	$ 3.102
Residential Wi-Fi	Internet access for devices that lack a wired port	$ 22.510	N.A.	$ 22.510	N.A.
	Avoidance of investment in in-house wiring	$ 13.570	N.A.	$ 13.570	N.A.
	Subtotal (*)	$ 36.080	N.A.	$ 36.080	N.A.
Wireless Internet Service Providers	Aggregated revenues of 1,800 WISPs	N.A.	N.A.	N.A.	$ 1.439
Wi-Fi Only Tablets	Difference between retail price and manufacturing costs for a weighted average of tablet suppliers	N.A.	$ 34.885	$ 34.885	N.A.
	Difference between willingness to pay for entry level tablet and prices of iPad and Android products	$ 7.987	N.A.	$ 7.987	N.A.
	Subtotal	$ 7.987	$ 34.885	$ 42.872	N.A.
Wireless Personal Area Networks	Sum of revenues of Bluetooth-enabled products	N.A.	N.A.	N.A.	$ 1.739
	Sum of revenues of ZigBee-enabled products	N.A.	N.A.	N.A.	$ 0.267
	Sum of revenues of WirelessHART-enabled products	N.A.	N.A.	N.A.	$ 0.160
	Subtotal	N.A.	N.A.	N.A.	$ 2.166
RFID	RFID Value in Retailing	$ 26.26	$ 68.58	$ 94.84	N.A.
	RFID Value in Health Care	$ 4.03	$ 31.96	$ 35.99	N.A.
	Subtotal	$ 30.29	$ 100.54	$ 130.83	N.A.
TOTAL		$ 76.26	$ 146.13	$ 222.38	$ 6.707

(*) A lower range in Residential Wi-Fi consumer surplus would amount to $ 31.9 billion
Source: TAS analysis

The efficiencies derived from implementing Radio Frequency Identification in two of the largest sectors of the US economy (retailing (12% of GDP) and health care (18% of GDP)) generate the largest portion of economic surplus ($130.83 billion). This estimate does not include all other areas impacted by RFID, such as the manufacturing supply chain and livestock tracking.

The next surplus effect in importance is generated by residential Wi-Fi. As of 2013, 63% of US households are equipped with Wi-Fi, which has a net effect of providing free access for devices that are designed for wireless access (tablets, smartphones), thereby generating annual savings of $22.5 billion. In addition, residential Wi-Fi services generate $13.6 billion in savings for households that do not have to deploy in-house wiring to interconnect PCs, printers, audio equipment, and the like. These estimates are three times higher than Thanki's 2009 figures, which are partly explained by the increase in residential Wi-Fi adoption, as well as the enhanced value derived from the technology[68]. To calibrate our results, we replicated Thanki's estimates, multiplying the total number of Wi-Fi households (72,450,000) by an assumed willingness to pay of $36.8 per household per month[69]. This yields a total surplus of $31.9 billion (considered to be a low bound estimate).

The producer surplus resulting from the adoption of tablets ($ 34.9 billion) is almost as high as residential Wi-Fi, and was five times the surplus estimated by Milgrom et al. (2011) for the iPad. While 2013 sales of tablets increased from 17.9 million in 2010 to approximately 220 million in 2013[70], average producer surplus per unit dropped because Apple's competitors tablet margins are substantially lower than the iPad.

The next category in economic value creation is that related to Wi-Fi cellular off-loading. This comprises first the producer surplus generated by operators' deployment of carrier-grade Wi-Fi sites to respond to the growth in wireless data traffic ($ 10.7 billion). The difference with Thanki's 2012 estimate of $ 8.5 billion is due to the increase in the volume of Wi-Fi sites required since the author conducted his analysis. The second value-creation effect derived from Wi-Fi off-loading comprises the consumer surplus derived from the utilization of free Wi-Fi sites deployed in public locations ($ 1.9 billion).

Finally, unlicensed spectrum provides an environment for the development of new businesses generating revenues who should be considered as direct contribution to the GDP ($3.87 billion): paid Wi-Fi access in public places (e.g. Boingo), Wireless Internet Service Providers (WISPs), Bluetooth-enabled products (e.g. chipsets to enable hands-free wireless calling), ZigBee-enabled products (e.g. home automation), and WirelessHART (e.g. industrial monitoring systems). An additional contribution to the GDP is the spillover impact of faster-than-cellular broadband wireless connections ($ 2.8 billion).

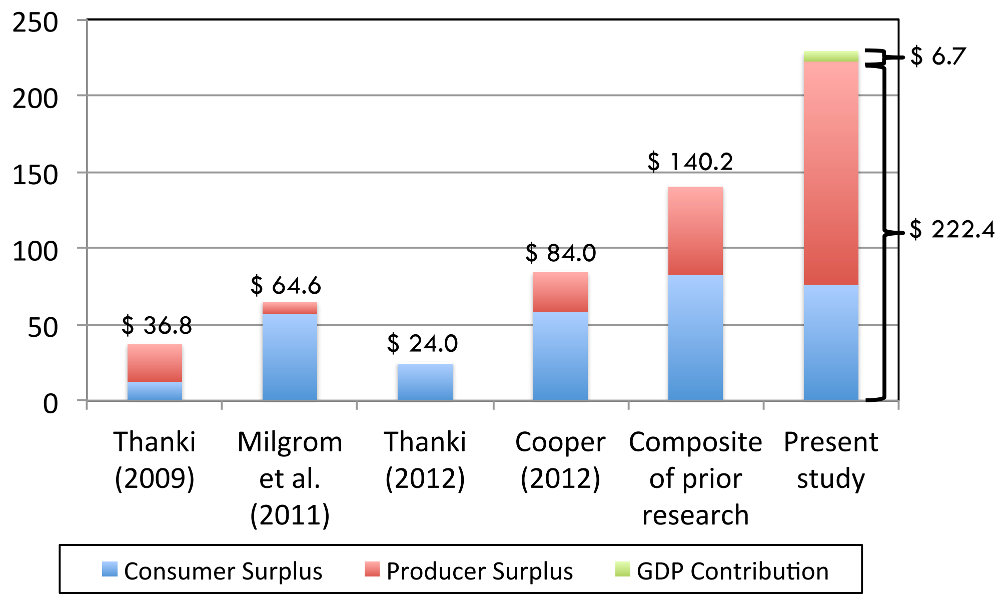
[68] It should be noted that our approach for measuring consumer surplus differs from Thanki's.

[69] Thanki estimates the average monthly consumer surplus to be $27.6, which represents 30% of the home broadband value. He also states that there is additional value not captured in his analysis. (pp.35). Given the current Wi-Fi adoption and usage patterns, it is reasonable to assume that willingness to pay would amount to 40% of the value, which equals to $36.8 per month.

[70] This number was reduced to subtract shipments from manufacturers based overseas, and tablets with cellular connectivity, yielding a total of 137 million units for 2013.

To summarize, we believe that the aggregate economic surplus estimate of $222 billion and $6.7 billion in direct GDP contribution succeeds in capturing the whole range of applications, as well as addressing the increase in value per technology operating in unlicensed spectrum bands (figure X-1)

Figure X-1. Unlicensed Spectrum Economic Value in the United States: Comparison with Prior Studies (in $ billions)



Source: TAS analysis

This number is well above that one estimated by recent studies because it reflects a more detailed analysis of the multiple relatively heterogeneous applications and technologies that rely on unlicensed spectrum. Following the analysis of numerous authors (Milgrom et al, 2011; Carter, 2003; Cooper, 2011; Bayrak, 2008; Marcus et al, 2013; Benkler, 2012) we conclude that any policies focused on this portion of the spectrum must help to preserve the value generated so far as well while encouraging the generation of future economic surplus.

A final comment related to these estimates has to do whether the current assignment of unlicensed spectrum bands risks, in light of the explosive growth in usage, in becoming a bottleneck of future value creation. Indeed, our estimate of Internet traffic trends indicates that total Wi-Fi traffic in the United States is currently 0.67 Exabytes per month and will reach 5.97 Exabytes by 2017, reflecting a 68.0% growth rate. Wi-Fi households in the US, currently at 61%, are forecast to reach 86% by 2017[71]. According to IDC, tablet worldwide shipments, currently at 221 million, are estimated to reach 386 million by 2017. According to Gorsh et al, while 52% of retailers surveyed had already implemented or piloted RFID within their organization, 23 % are considering launching pilots in the near future[72]. All in all, there are

[71] Gillott, I. (2012). U.S. Home Broadband and Wi-Fi Usage Forecast 2012-2017. Austin, TX: iGR.
[72] Gorsh, M, Rollman, M, and Beverly, R. (2012) Item-level RFID: a competitive differentiator. Chicago, Illinois: Accenture.

currently 20,339 different unlicensed devices certified for use in the 2.4 GHz band alone, approximately three times the amount in any licensed band[73].

In the context of accelerating adoption of applications operating in unlicensed spectrum, it would be relevant to ask the question whether there is enough spectrum space to accommodate the expected growth. As pointed by Indepen, Aegis and Ovuum (2006), congestion could result either from the density of devices used for a given application or when one set of devices of a given application interferes with a set of devices running another application. Until 2008, roughly 955 MHz were allocated to unlicensed uses below 6 GHz (Hazlett et al., 2010). In 2010, the FCC allocated additional unused spectrum between broadcast TV channels. That said, the most used bands remain in the 900 MHz, 2.4 MHz, 5.2/5.3/5.8 GHz, 24 GHz, and above 60 GHz (Milgrom et al., 2011). In fact, the 2.4 GHz and 5GHz bands have become increasingly congested due to the intense Wi-Fi usage.

If future assignment of unlicensed spectrum is not fulfilled, it is plausible to consider that economic value creation would be at risk. This case is similar to the transition from 3G to 4G and the allocation of additional licensed spectrum for mobile broadband. Where do we see the effects that would be most at risk? Our quantification of the risk of not assigning additional unlicensed spectrum assumes that, beyond a certain point of network congestion, application or technology demand stops growing.

In the first place, let us address the so-called return to speed. At the current rate of traffic off-loading, the average speed of mobile traffic in the United States in 2013 was 10 Mbps[74]. Our analysis showed that if all the off-loaded traffic were to be conveyed through cellular networks, the speed would decline to 3.43 Mbps, with the consequent negative impact of $2.8 billion in GDP (see section III.3 for detailed calculations). Over five years, the impact would amount to $ 23.56 billion. The benefit derived from the additional speed resulting from off-loading is what we call the Wi-Fi return to speed. However, if we assume that, due to congestion, the average Wi-Fi speed does not increase to 17 Mbps, as Cisco projects, but stays at current levels (13.32 Mbps), the average speed of all mobile traffic would not change significantly from today, which means that $ 10.6 billion of the Wi-Fi speed return over the next five years would disappear.

Obviously, average speed could decline even further beyond the current level, with the consequent increase in value erosion. According to a study by Williamson et al. (2013), this scenario is highly likely. Once an 80-100 Mbps fiber link is deployed to a customer premise, the last mile is not the bottleneck any more, and the residential Wi-Fi becomes the congestion point. This is because there is a difference between the speed advertised speed in a typical Wi-Fi router (150 Mbps) and the delivered speed, which is below 70 Mbps[75]. Given that Wi-Fi shares available capacity across devices, if a typical Wi-Fi household is running multiple devices, the service will degrade and be substantially less than what could be handled by a fiber link.

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[73] Wireless Innovation Alliance. Background on Unlicensed Spectrum.
[74] This is calculated by prorating total mobile traffic by Wi-Fi and cellular speeds according to off-loading factors (see appendix C).
[75] The difference is due in part to the need to assign part of the capacity to the data overheads. In addition, advertised speeds are based on tests that relying on large packets, while the average packet size is much smaller. Finally, range and attenuation are factors to be considered in the reduction of speed. Williamson et al. (2013) estimate that delivered speed is approximately 50% of the advertised.

A second area of negative impact under a scenario of limited unlicensed spectrum assignment is service degradation in public places (airports, convention halls, etc.). Research by Wagstaff (2009) and Van Bloem et al. (2011) indicates that in dense device environments, data overheads that are generated to keep the connection running consume between 80% and 90% of capacity. In the context of increasing traffic volumes, Wi-Fi is becoming the contention point in public access networks. Some of this pressure could be alleviated by the upcoming Wi-Fi standard 802.11ac. While it is difficult to quantify the negative impact of this degradation, a large portion has been considered above in the reduction of the so-called Wi-Fi speed return. In addition, no additional assignment of unlicensed spectrum could result in the disappearance of the Wi-Fi service provider industry since, with lower service quality level, these operators could not compete with cellular service provider: an erosion of $271 million direct contribution to the GDP.

A third area of negative impact if additional unlicensed spectrum is not assigned could be an erosion of the benefit to carriers generated by cellular traffic off-loading. With high-density device environments being so prone to contention, if Wi-Fi does not benefit from additional spectrum, cellular carriers would experience service degradation when users roam into Wi-Fi. In other words, Wi-Fi's value of complementarity would be greatly diminished, reducing the $10.7 billion estimated producer surplus.

Following the evidence generated in this study, we conclude that any policies focused on this portion of the spectrum must preserve the value generated so far as well as the capacity to generate economic surplus in the future. Given the emerging body of evidence of congestion within the unlicensed spectrum bands and their estimated economic value, it would highly beneficial to pursue additional research linking up the study of congestion scenarios, the advantage of additional allocation and the risks of not proceeding along this path.

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APPENDICES

A. United States: Mobile Internet Traffic Forecast (2012-2017)

Variable	2010	2011	2012	2013	2014	2015	2016	2017	SOURCE
Population	313,579,434	316,208,509	318,777,991	321,316,861	323,855,320	326,408,880	328,976,336	331,551,643	GSMA
Number of Internet Users	232,048,781	238,467,001	245,000,000	253,577,938	262,456,206	271,645,320	281,156,163	291,000,000	CISCO
Users of Internet (%)	74.00%	75.41%	76.86%	78.92%	81.04%	83.22%	85.46%	87.77%	CISCO
Total Devices	N/A	1,391,317,440	1,608,000,000	1,782,955,851	1,976,947,492	2,192,046,080	2,430,548,125	2,695,000,000	CISCO
Device (by inhabitant)	N/A	4.40	5.04	5.55	6.10	6.72	7.39	8.13	CISCO
IP Traffic (Exabytes per month)	7.04	9.60	13.10	16.13	19.87	24.46	30.13	37.10	CISCO
Internet Traffic (Exabytes per month)	4.00	5.44	7.40	9.35	11.81	14.92	18.84	23.8	CISCO
Internet Traffic (Share)	56.87%	56.68%	56.49%	57.94%	59.44%	60.97%	62.54%	64.15%	CISCO
Mobile Traffic (Exabytes per month)	0.08	0.12	0.20	0.32	0.49	0.77	1.21	1.90	CISCO
Mobile Traffic (Share)	1.09%	1.29%	1.54%	1.95%	2.49%	3.16%	4.02%	5.12%	CISCO
Other Traffic (Exabytes per month)	2.96	4.03	5.50	6.47	7.56	8.77	10.07	11.40	CISCO
Other Traffic (Share)	42.04%	42.03%	41.98%	40.10%	38.08%	35.87%	33.44%	30.73%	CISCO
Non-PC Device Traffic (Exabytes per month)	3.57	4.74	6.29	8.35	11.09	14.73	19.56	25.97	CISCO
Traffic From non-PC Device (Share)	41.28%	44.51%	48.00%	51.76%	55.82%	60.19%	64.91%	70.00%	CISCO
Smartphone and Tablets Traffic (Exabytes per month)	0.11	0.21	0.39	0.75	1.41	2.68	5.09	9.65	CISCO
Smartphone and Tablets Traffic (Share)	1.26%	1.95%	3.00%	4.62%	7.12%	10.96%	16.88%	26.00%	CISCO
PC Traffic (Exabytes per month)	N/A	N/A	6.14	6.80	7.53	8.34	9.24	10.23	CISCO
PC Traffic (Share of Internet Traffic)	N/A	N/A	83.00%	72.77%	63.80%	55.94%	49.04%	43.00%	CISCO
Fixed/Wi-Fi (Exabytes per month)	N/A	N/A	3.67	4.88	6.48	8.61	11.44	15.21	CISCO
Fixed/Wi-Fi (Share)	N/A	N/A	28.00%	30.22%	32.61%	35.20%	37.99%	41.00%	CISCO
Fixed/Wired (Exabytes per month)	N/A	N/A	9.17	10.72	12.54	14.66	17.14	20.03	CISCO
Fixed/Wired (Share)	N/A	N/A	70.00%	66.46%	63.10%	59.91%	56.88%	54.00%	CISCO
Average broadband Speed (Mbps)	8.22	10.30	12.90	16.01	19.87	24.67	30.62	38.00	CISCO
Average Mobile Connection Speed (Mbps)	0.48	1.08	2.41	3.43	4.88	6.94	9.87	14.05	CISCO
Average Smartphone Connection Speed (Mbps)	0.73	1.46	2.94	4.04	5.56	7.65	10.53	14.48	CISCO
Wi-Fi Speeds from Mobile Device (Mbps)	6.89	8.90	11.50	13.32	15.43	17.88	20.72	24.00	CISCO
Average traffic mobile connection (Gb per month)	0.23	0.37	0.60	0.89	1.33	1.97	2.93	4.36	CISCO
Average traffic by smartphone (Gb per month)	0.06	0.11	0.20	0.37	0.68	1.27	2.37	4.42	CISCO
Average Tablet connection Speed (Mbps)	0.99	1.92	3.70	4.87	6.42	8.46	11.15	14.70	CISCO
Average traffic mobile connected laptop (Gb per month)	1.60	1.98	2.45	3.03	3.75	4.65	5.76	7.13	CISCO
Average traffic mobile connected tablet (GB per month)	0.17	0.25	0.37	0.55	0.81	1.19	1.75	2.58	CISCO

Note: 2013-2016 are TAS interpolated calculations
Source: VNI Forecast Highlights (CISCO),
http://www.cisco.com/web/solutions/sp/vni/vni_forecast_highlights/index.html.

B. United States: Free Wi-Fi Traffic (2010-2017)

1. Devices	2010	2011	2012	2013	2014	2015	2016	2017	SOURCE	CAGR 2010-2013
Smartphones	112,888,596	139,344,317	172,000,000	192,751,370	216,006,342	242,066,967	271,271,742	304,000,000	CISCO	19.52%
Smartphone (Penetration)	36.00%	44.07%	53.96%	59.99%	66.70%	74.16%	82.46%	91.69%	CISCO	18.56%
Tablets	26,407,591	35,008,499	46,410,709	61,526,599	81,565,710	108,131,526	143,349,784	190,038,569	CISCO (Mail)	32.57%
Tablets (Penetration)	8.42%	11.07%	14.56%	19.15%	25.19%	33.13%	43.57%	57.32%	TAS	31.50%
Laptops	235,184,576	237,156,382	239,083,493	240,987,646	242,891,490	244,806,660	246,732,252	248,663,732	DELOITTE	0.82%
Laptops (Penetration)	75.00%	75.00%	75.00%	75.00%	75.00%	75.00%	75.00%	75.00%	DELOITTE	0.00%
Total Devices (Smartphones+Tablets+Laptops)	374,480,763	411,509,198	457,494,202	495,265,616	540,463,542	595,005,153	661,353,778	742,702,301	TAS	9.77%
Total Devices Per Capita	1.19	1.30	1.44	1.54	1.67	1.82	2.01	2.24	TAS	8.88%
Portable Gaming Console	42,615,887	46,954,004	51,733,724	57,000,000	62,802,360	69,195,376	76,239,173	84,000,000	PARK ASSOCIATES	10.18%
Portable Gaming Console (Penetration)	13.59%	14.85%	16.23%	17.74%	19.39%	21.20%	23.17%	25.34%	PARK ASSOCIATES	9.29%
PC	329,082,731	329,082,731	329,082,731	316,501,079	304,400,454	292,762,467	281,569,428	270,804,328	CISCO (Mail)	N/A
PC (Penetration)	105%	104%	103%	99%	94%	90%	86%	82%	TAS	N/A
Phone	289,085,114	292,640,736	296,240,090	299,883,715	303,572,155	307,305,961	311,085,691	314,911,910	CISCO (Mail)	1.23%
Phone (Penetration)	92.19%	92.55%	92.93%	93.33%	93.74%	94.15%	94.56%	94.98%	TAS	0.41%
M2M Connections	31,111,111	46,666,667	70,000,000	95,042,737	129,044,599	175,210,742	237,892,980	323,000,000	CISCO	45.10%
M2M Connections (Penetration)	9.92%	14.76%	21.96%	29.58%	39.85%	53.68%	72.31%	97.42%	TAS	43.93%
2. Average Traffic per Device (Gb per month)										
Smartphones	0.28	0.40	0.56	0.80	1.13	1.60	2.27	3.21	CISCO	41.60%
Tablet	1.74	2.68	4.12	6.33	9.73	14.97	23.01	35.38	CISCO (Mail)	53.76%
Laptop	1.43	2.08	2.44	2.88	3.40	4.02	4.74	5.60	CISCO	26.48%
Portable Gaming Console	0.24	0.31	0.39	0.50	0.64	0.81	1.03	1.31	CISCO	28.11%
PC	15.40	17.68	20.31	23.33	26.80	30.78	35.35	40.60	CISCO (Mail)	14.86%
Phone	0.31	0.49	0.79	1.28	2.06	3.31	5.33	8.59	CISCO (Mail)	60.95%
M2M	0.04	0.05	0.07	0.10	0.14	0.20	0.28	0.39	CISCO	39.05%
3. Total Traffic per device (Gb per month)										
Smartphones	31,723,574	55,448,934	96,917,969	153,796,072	244,054,142	387,281,830	614,565,337	975,234,375		69.25%
Tablets	45,985,183	93,735,136	191,067,541	389,467,671	793,881,922	1,618,230,608	3,298,563,967	6,723,716,751		103.84%
Laptop	335,321,758	493,535,400	584,400,375	695,199,712	826,953,359	983,661,915	1,170,044,724	1,391,691,259		27.51%
Portable Gaming Console	10,154,567	14,535,566	20,372,953	28,554,596	40,021,933	56,094,477	78,621,647	110,195,581		41.15%
PC	5,066,567,473	5,819,415,328	6,684,129,826	7,383,809,800	8,156,730,733	9,010,559,324	9,953,764,811	10,995,702,968		13.38%
Phone	88,706,552	144,528,663	235,479,049	383,663,567	625,099,064	1,018,467,409	1,659,378,367	2,703,607,931		62.93%
M2M	1,194,306	2,490,943	5,195,313	9,808,199	18,516,840	34,957,830	65,996,676	124,594,727		101.76%
Total Traffic (Gb per Month) (Smartphones+Tablets+Laptops)	413,030,514	642,719,470	872,385,884	1,238,463,455	1,864,889,422	2,989,174,353	5,083,174,029	9,090,642,385		44.20%
Total Traffic (Gb per Month)	5,579,653,413	6,623,689,970	7,817,563,024	9,044,299,618	10,705,257,992	13,109,253,394	16,840,935,530	23,024,743,592		17.47%
3.1 Total Traffic per device (Exabytes per month)										
Smartphones	0.03	0.05	0.09	0.14	0.23	0.36	0.57	0.91		69.25%
Tablets (Model)	0.04	0.09	0.18	0.36	0.74	1.51	3.07	6.26		103.84%
Laptop (Model)	0.31	0.46	0.54	0.65	0.77	0.92	1.09	1.30		27.51%
Portable Gaming Console (Model)	0.01	0.01	0.02	0.03	0.04	0.05	0.07	0.10		41.15%
PC	4.72	5.42	6.23	6.88	7.60	8.39	9.27	10.24		13.38%
Phone	0.08	0.13	0.22	0.36	0.58	0.95	1.55	2.52		62.93%
M2M (Model)	0.00	0.00	0.00	0.01	0.02	0.03	0.06	0.12		101.76%
Total Traffic (Exabytes per Month) (Smartphones+Tablets)	0.07	0.14	0.27	0.51	0.97	1.87	3.64	7.17		91.21%
Total Traffic (Exabytes per Month) (Smartphones+Tablets+Laptops)	0.38	0.60	0.81	1.15	1.74	2.78	4.73	8.47		44.20%
Total Traffic (Exabytes per Month)	5.20	6.17	7.28	8.42	9.97	12.21	15.68	21.44		17.47%
Total Trafifc (CISCO)	4.84	5.64	6.62	7.60	8.92	10.85	13.89	19.02		16.18%
Mobile devices like smartphones or tablets (CISCO)	0.11	0.21	0.39	0.75	1.41	2.68	5.09	9.65	CISCO	89.67%
4. Percent Wi-Fi Offloading										
Smartphones	57.11%	58.05%	59.00%	59.97%	60.95%	61.95%	62.97%	64.00%	CISCO	1.64%
Tablets	76.60%	76.80%	77%	77%	77%	78%	78%	78%	CISCO	0.26%
Laptop	41.03%	43.91%	47.00%	50.30%	53.84%	57.62%	61.67%	66.00%	TAS	7.03%
Average	41.03%	43.91%	47%	50%	54%	58%	62%	66%	CISCO	7.03%
5. Total Wi-Fi Traffic per device (Exabytes per month)										
Smartphones	0.02	0.03	0.05	0.08	0.13	0.21	0.34	0.54		69.25%
Tablets	0.03	0.07	0.14	0.28	0.57	1.16	2.37	4.82		103.84%
Laptop	0.15	0.22	0.26	0.30	0.36	0.43	0.51	0.61		27.51%
Total Wi-Fi (Exabytes per month)	0.20	0.31	0.45	0.67	1.07	1.80	3.22	5.97		50.20%
No cost Wi FI (%)	4.32%	4.32%	4.32%	4.32%	4.32%	4.32%	4.32%	4.32%		
No cost Wi Fi (Exabytes per month)	0.01	0.01	0.02	0.03	0.05	0.08	0.14	0.26		50.20%
No cost WI Fi (Exabytes per Year)	0.10	0.16	0.23	0.35	0.55	0.94	1.67	3.10		50.20%
No cost Wi Fi (Million Gb Per year)	109.83	174.74	248.46	372.12	593.40	1004.71	1790.87	3323.38		50.20%
6. Pricing per Gb										
ATT	$ 10.00	$ 10.00	$ 10.00	$ 10.00						
Verizon	$ 10.81	$ 9.62	$ 8.37	$ 7.10	$ 6.57	$ 6.24	$ 5.96	$ 5.74		
Sprint	$ 10.15	$ 9.03	$ 7.86	$ 6.67						
t-Mobile	$ 10.15	$ 9.03	$ 7.86	$ 6.67						
Verizon (Price Evolution)	12.36%	14.89%	17.95%							
Average price per Gb	$ 10.28	$ 9.42	$ 8.52	$ 7.61	$ 7.05	$ 6.68	$ 6.39	$ 6.15		
Average cost of Wi-Fi provision	$ 2.50	$ 2.50	$ 2.50	$ 2.50	$ 2.50	$ 2.50	$ 2.50	$ 2.50		
7. Economic Impact of Free Wi Fi										
Economic impact (Million USD per year)	854.19	1,209.51	1,496.87	1,900.86	2,697.07	4,201.96	6,966.73	12,121.72		30.56%

C. Return to Speed

1. Mobile/Wi-Fi Traffic	2012	2013	2014	2015	2016	2017	SOURCE
Average Mobile Connection Speed (Mbps)	2.41	3.43	4.88	6.94	9.87	14.05	CISCO
Wi-Fi Speeds from Mobile Device (Mbps)	11.50	13.32	15.43	17.88	20.72	24.00	CISCO
Speed Gap Wi -Fi vs Mobile (Mbps)	9.09	9.89	10.56	10.94	10.84	9.95	TAS
Average Speed (Mbps)	8.68	10.15	12.09	14.60	17.75	21.60	TAS
Mobile Traffic (Exabytes per month)	0.20	0.32	0.49	0.77	1.21	1.90	#REF!
Total Wi-Fi (Exabytes per month)	0.45	0.67	1.07	1.80	3.22	5.97	TAS
Total Traffic (Exabytes per month)	0.65	0.98	1.56	2.58	4.43	7.87	TAS
Mobile Traffic (Exabytes per year)	2.41	3.78	5.93	9.29	14.55	22.80	TAS
Total Wi-Fi (Exabytes per year)	5.35	8.02	12.78	21.65	38.58	71.60	TAS
Total Traffic (Exabytes per month)	7.77	11.80	18.71	30.93	53.13	94.40	TAS
2. Economic Impact of Wi-Fi Speed							
Speed Wi-Fi over Mobile Speed (Mbps)	9.09	9.89	10.56	10.94	10.84	9.95	TAS
Speed decrease (%)	-72.21%	-66.21%	-59.65%	-52.45%	-44.36%	-34.96%	TAS
Wi-Fi Traffic (% Total Traffic)	6.74%	8.79%	11.95%	16.63%	23.15%	31.37%	TAS
Coefficient of Bohlin	0.30%	Growth in GDP per capita					
Decrease in GDP Per Capita	-0.22%	-0.20%	-0.18%	-0.16%	-0.13%	-0.10%	TAS
GDP Per Capita (Current Prices)	49,922.11	51,248.21	53,327.98	55,837.31	58,436.31	61,133.84	USA BUREAU
Population	313,579,434	316,208,509	318,777,991	321,316,861	323,855,320	326,408,880	USA BUREAU
GDP Reduction (Current Prices)	-2,284,207,081	-2,830,964,976	-3,634,031,416	-4,694,544,449	-5,831,419,302	-6,565,326,374	TAS

D. Residential Wi-Fi

Total Traffic per Month	2010	2011	2012	2013	2014	2015	2016	2017
Smartphones	31,723,574	55,448,934	96,917,969	153,796,072	244,054,142	387,281,830	614,565,337	975,234,375
Portable Gaming Console	10,154,567	14,535,566	20,372,953	28,554,596	40,021,933	56,094,477	78,621,647	110,195,581
Tablets	45,985,183	93,735,136	191,067,541	389,467,671	793,881,922	1,618,230,608	3,298,563,967	6,723,716,751
Total	87,863,323	163,719,636	308,358,462	571,818,339	1,077,957,997	2,061,606,915	3,991,750,952	7,809,146,706

Total Annual traffic	2010	2011	2012	2013	2014	2015	2016	2017
Smartphones	380,682,884	665,387,212	1,163,015,625	1,845,552,861	2,928,649,702	4,647,381,961	7,374,784,045	11,702,812,500
Gamning Conbsoles	121,854,802	174,426,788	244,475,433	342,655,155	480,263,198	673,133,721	943,459,770	1,322,346,971
Tablets	551,822,192	1,124,821,635	2,292,810,490	4,673,612,048	9,526,583,060	19,418,767,297	39,582,767,607	80,684,601,007
Total	1,054,359,878	1,964,635,635	3,700,301,548	6,861,820,064	12,935,495,960	24,739,282,979	47,901,011,421	93,709,760,478

Split per location		
Location	Hours	
Home	2.6	43.1%
Friend's home	0.35	5.8%
At work	0.8	13.3%
At work remote location	0.4	6.6%
Retail location (stores, restaurants)	0.38	6.3%
Public location (parks, schools)	0.45	7.5%
Travel locations	0.45	7.5%
On The Go	0.6	10.0%
	6.03	

Total Annual Trafffic at Home	2010	2011	2012	2013	2014	2015	2016	2017
Smartphones	164,141,874	286,899,959	501,466,107	795,760,769	1,262,767,699	2,003,846,285	3,179,840,550	5,045,988,806
Gamning Conbsoles	52,541,042	75,208,897	105,412,293	147,745,175	207,078,659	290,240,079	406,798,574	570,166,190
Tablets	237,933,283	484,997,720	988,608,172	2,015,156,107	4,107,647,754	8,372,934,490	17,067,196,646	34,789,380,202
Total	454,616,199	847,106,576	1,595,486,571	2,958,662,051	5,577,494,112	10,667,020,853	20,653,835,770	40,405,535,198

Average Price per Gb	$10.28	$9.42	$8.52	$7.61	$7.05	$6.68	$6.39	$6.15
Price per home traffic	$ 4,672,296,843	$ 7,981,379,757	$ 13,600,954,551	$ 22,509,870,715	$ 39,293,937,014	$ 71,279,887,723	$ 131,980,574,122	$ 248,389,076,544