

Benefits of Competition in Mobile Broadband Services

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1. Executive Summary

The U.S. economy is as dependent on its networked Information and Communications Technology (ICT) as it is on its networks of roads, electricity, and water. Advanced telecommunications services—which increasingly include wireless services such as mobile broadband—are essential infrastructure for a 21st Century economy. Keeping pace with the growth in wireless demand is confronting policymakers and our wireless industry ecosystem with a mix of complex challenges and opportunities. The challenges include sustaining continued rapid investment and innovation to expand mobile broadband capacity and capabilities while managing scarce spectrum resources more efficiently. These goals must be accomplished in the face of an increasingly complex and dynamic global economy. Success will expand markets and contribute to keeping us on track to reposition our economy for economic growth in the future.

Our success will depend on preserving the benefits of facilities-based competition in the mobile broadband market. The economic viability of such competition is being challenged from a number of directions, including changing technology, market, and regulatory conditions. The purpose of this paper is to explain how mobile broadband competition contributes to value creation and to provide a lower-bound estimate of its sizable dollar impact.

Mobile competition promotes allocative, productive, and dynamic efficiency.² Consumers benefit from expanded choice, improved quality, and lower prices. Competition forces firms to adopt industry best practices in order to survive. That means adopting business process and technical innovations that lower costs. Competition also contributes to making the economy more robust in the face of uncertainty and exogenous shocks by ensuring that all of our mobile broadband eggs are not in a single basket. Finally, robust competition in mobile broadband reduces the need to resort to the significantly less attractive alternative of government regulation, enabling society to rely instead on market forces to ensure provisioning of essential telecommunications services. All of these salubrious effects have price effects, too: put simply, *efficient competition contributes to lower prices*.

Unfortunately, estimating the price effect of competition and its contribution to value is not straightforward. A number of different approaches might be attempted, each with different data requirements and underlying restrictive assumptions that may be subject to challenge. An alternative approach is to review past wireless telecommunications competition and the historical impact of that competition on pricing. If the competitive dynamic observed in the past is continued, it is reasonable to conclude that the pricing

effects observed during that time are indicative of pricing effects that might be expected in the future. Based on a historical review of the effects of competition in the U.S. wireless communications market, a conservative estimate is that prices would be at least ten percent (10%) higher were it not for facilities-based competition in the mobile broadband market.

The resulting contribution to consumer surplus of sustaining robust facilities-based competition in the U.S.'s mobile broadband market is adding significantly more than \$20 billion in total surplus each year, worth over \$200 billion in total. The magnitude of this lower-bound contribution should be kept in mind to focus our priorities in framing communications policies, including our design of the spectrum auctions. Indeed, whereas the auction proceeds are a one-time event, the benefits of competition accrue yearly and are significantly larger.

2. Mobile Broadband is Essential Infrastructure for a Smart Economy

We are in the midst of the third great wave in the evolution of our ICT infrastructure. During the last decades of the 20th century, the emergence of the Internet and personal computing brought the power of ICT to the mass market, but access was limited in terms of speed and coverage.³ At the same time, the expansion of cellular services enabled personalized and ubiquitous telephony for everyone. The current transition to mobile broadband has opened the door to always/everywhere available computing and data communications, greatly expanding the ways in which ICT capabilities may be embedded in our everyday social and economic lives.

This vision of an ICT-powered future may be articulated in multiple ways. It is sometimes referred to as the "Internet of Things" (IoT),⁴ as "Big Data",⁵ or as "Cloud Computing."⁶ Each refers to the post-PC world in which our distributed and networked ICT resources allow us to collect better information and automate decision-making to allow more dynamic optimization of all sorts of tasks. These range from smart HVAC for buildings to smart supply chains; from smart healthcare to smart power grids. A recent Cisco Systems, Inc. (Cisco) report identifies this as a \$19 trillion global opportunity;⁷ a McKinsey Global Institute study sees the potential for \$300 billion per year in savings in Healthcare alone;⁸ and Massachusetts Institute of Technology (MIT) economists have found enterprises that take advantage of the new IT capabilities perform significantly better.⁹

The shift anticipated by this vision is occurring across all sectors—from healthcare to education, from green energy to transportation infrastructure, and from commerce to government.¹⁰ Realizing this vision is a centerpiece of White House technology policy:

Ensuring America has 21st century digital infrastructure—such as high-speed broadband Internet access, fourth-generation (4G) wireless networks, new health care information technology and a modernized electrical grid—is critical to our long-term prosperity and competitiveness.¹¹

Wireless services, including mobile broadband, are critical for sustaining U.S. global competitiveness as we shift our economy toward "smart" (*i.e.*, information-technology augmented) production. To understand how important mobile broadband is to the U.S. economy, consider the following:

- Wireless broadband is expected to increase Gross Domestic Product (GDP) by 1.6% to 2.2%, or \$259 to \$355 billion in 2017;¹²
- The wireless broadband industry value chain, of which cellular is a key component, supported almost 4 million jobs, representing over 2.6% of total employment in the U.S. and accounting for \$146.2 billion of GDP in 2011, almost the same as oil and gas extraction and more than publishing, agriculture, or the motion picture industries.¹³
- Cellular service providers directly employed over 210,000 people and generated more than \$185 billion in revenues in 2012,¹⁴ and they have invested over \$300 billion (excluding auction revenues) since 2000.¹⁵

The economic benefits of the Internet of Things/Big Data/Cloud Computing future identified above depend on ensuring wireless access. In the last several years, significant progress has been made in expanding the reach and capabilities of mobile broadband services. Today, mobile subscription penetration exceeds 100%, as a growing share of subscribers using multiple devices—almost two-thirds of which are smartphones or tablets.¹⁶ As of October 2012, mobile broadband was available to 99.5 percent of the U.S. population.¹⁷

Better broadband services and user devices create demand for richer multimedia content and more interactive applications, driving a virtuous cycle of investment across the entire Internet and wireless value chain.¹⁸ As a consequence, mobile broadband traffic has been growing exponentially, and is expected to grow globally at a compound rate of 61% from 2013 through 2018.¹⁹ Keeping pace with this growth is critical if the U.S. is to sustain its position at the forefront of global competition. Ensuring a healthy wireless ecosystem is essential for that to occur.

The health of the wireless ecosystem faces challenges from several directions, including: (i) sustaining continued infrastructure investment to expand capacity and to upgrade to newer more efficient and capable 4G and beyond technologies in order to meet the exponential growth in wireless traffic; (ii) alleviating the scarcity of radio frequency spectrum, an essential input for all wireless services; and (iii) transitioning to a market-based ecosystem that can more efficiently manage this increasingly complex and dynamic industry. Robust competition in mobile broadband services will help address each of these challenges.

In recent years, the policy debate has increasingly focused on the need to expand commercial access to spectrum resources for mobile broadband.²⁰ Addressing this challenge is closely related to the other two challenges of spectrum scarcity and expanding the market-based mobile broadband ecosystem. For example, too little spectrum for wireless disrupts efficient infrastructure investment.²¹ Today, spectrum is

artificially scarce because of legacy regulation and updated policy that is insufficiently flexible and dynamic to ensure that spectrum is allocated to its most efficient uses over time.²² To address this last problem, the Federal Communications Commission (FCC) is engaged in a range of policy efforts to reform spectrum management to both expand commercial access to spectrum resources and to transition to a management regime that is more flexible, dynamic and responsive to market forces.²³ The proposed broadcast spectrum incentive auction planned for 600 MHz spectrum is a key example of this effort.

In the debates over how best to design this auction, attention has focused on ensuring that the auction generates significant revenue. At times, concern over auction revenue has suggested a perverse inversion of policy goals: the principal goal of communications policy and the spectrum auctions is to promote a healthy wireless sector, and that means promoting competition.²⁴ Promoting competition may or may not maximize auction revenues, but is more likely to maximize the total welfare benefits realized from use of our national spectrum resources.²⁵ Auction revenues are limited to the potential for the spectrum to generate producer surplus, whereas total surplus is the sum of consumer and producer surplus. Consumer surplus is typically estimated to be an order of magnitude larger than producer surplus.²⁶ Furthermore, while realizing significant proceeds from spectrum auctions is a key goal,²⁷ we should remember that competition is necessary for the auction to proceed.²⁸ Thus, the primary goal of auction design and communication policies should be to promote effective competition.²⁹

3. Benefits of Competition in Telecommunications Services

Competition delivers a number of important economic benefits. First, competition induces efficient behavior from firms and consumers and drives markets toward efficient outcomes. The process of market competition directs resources to their highest value uses for both production and consumption (allocative efficiency) and firms to operate at minimum cost (productive efficiency). Over time, the struggle for market share by firms and the quest by consumers to best satisfy their desires for quality at lower prices induces markets to remain efficient over time (dynamic efficiency). Firms are driven to innovate and invest in new technologies and expanded capacity to lower costs and better match their service offerings to consumer tastes and competitors' offers. A well-functioning competitive market ensures that the maximum amount of demand is satisfied at the lowest possible cost, or in effect, that prices are as low as is consistent with economic viability.³⁰

Because real markets are imperfect, this efficiency goal remains more an aspiration than a reality; however, economists are generally agreed that promoting market competition offers the best hope for realizing economic efficiency.

Most products and services are outputs of an industry value chain, consisting of multiple upstream and downstream firms that supply raw materials and intermediate goods used in the production of the final consumption goods and services. In telecommunications, this includes (among others) chipmakers, network and end-user equipment manufacturers, application software and content providers, value-added resellers, and the facilities-based

telecommunication network operators.³¹ Competition at each stage along the value chain contributes to ensuring the efficiency of the entire value chain, and a lack of competition at any stage, poses a risk to competition across the entire value chain.

3.1. The Importance of Facilities-Based Competition

The focus here is on facilities-based competition among mobile broadband providers. In the U.S., we have a combination of national network operators and smaller, regional facilities-based providers. Additionally, we have a large number of partial facilities-based or reseller providers who compete in retail broadband service markets, while relying on the facilities-based providers' wholesale provisioning of network services.

Thus far, the U.S. has benefited from this mix of facilities-based competition. Competition in mobile services has contributed to a history of continuously falling prices, improving service quality, and continuous innovation across the wireless value chain. For example, the average monthly bill for mobile services fell from \$63.53 (Dec94) to \$48.73 (Dec12), or 1.5% per year for the last two decades,³² while usage has soared. For example, in 1994, mobile services were limited to mobile telephony whereas today, mobile services include mobile telephony, text messaging, and a rich array of mobile data services. In 1994, average consumption was 119 minutes of mobile telephony per month whereas by 2011, average consumption included 615 minutes for telephony, 584 text messages, and 500 MB of mobile data services per month. The average price per mobile telephony minute fell from \$0.472 to \$0.047, or at a compound growth rate of -13% per year from 1994 to 2011.³³ Since 2005, the average price per text message fell from \$0.037 to \$0.011 by 2009 (an annual growth rate of -45%), while the average price for mobile data fell from about \$0.11 per MB in 2009 to \$0.03 per MB in 2011 (an annual growth rate of -48%).³⁴

At the same time, the quality of mobile services increased substantially as mobile service providers have upgraded their networks to successive generations of technology. The first generation (1G) of cellular systems was based on analog technology. The conversion to second generation (2G) all-digital systems began after 1995. These offered significant improvements in capacity and service quality, and also were more spectrally efficient. However, the 2G services were still basically voice-only.³⁵ Beginning in 2001, operators started to upgrade their networks to 3G technologies, although these services only began to be widely available after 2006 and usage did not take off until late 2007, following the successful introduction of the iPhone and subsequent Android smartphones.³⁶

We are currently in the midst of the switch to the latest (fourth) generation of mobile technology known as 4G LTE.³⁷ This latest innovation represents the true convergence of mobile telephone and Internet services, offering a unified platform for providing mobile services over an all-IP (Internet Protocol) network. The 4G LTE technologies provide a number of benefits, including greater flexibility in managing radio spectrum resources, promising higher speeds, better service quality, and greater spectral efficiency. Operators began the deployment of LTE in 2009 and the first national offering occurred in late 2010. It is expected that by the end of 2014, we will have four national LTE networks substantially built out with the new technology.³⁸

3.2. Sustaining the Virtuous Investment Cycle

There is a virtuous cycle of investment all along the value chain. New network capabilities, new devices, and new content and services stimulate demand growth. The demand growth stimulates additional investment in expanding capacity and enhancing network quality, and the cycle continues. Faster fixed and mobile broadband services were needed to handle the traffic-generating potential of more interactive and rich multimedia traffic from higher resolution displays and faster, more capable end-user devices (*e.g.*, PCs, smartphones, e-Readers, and tablets). With the growth in the addressable market of users and devices able to consume high-data-rate content (*e.g.*, higher resolution video) and interactive applications (*e.g.*, growing share of user-generated content), application developers, content providers, and providers of other complementary value-added services (from mobile commerce to wellness services, from mobile conferencing to streaming video) find it attractive and, with the right policies, feasible to upgrade the quality of their services and, in so doing, create further demand for expanding capacity and network functionality. Throughout all of this, consumers are becoming increasingly accustomed to and desirous of expanding their mobile usage.

In addition, upgrades by one carrier may induce other operators to either upgrade also or lower prices to keep their less capable services competitive. Innovation continuously raises the bar for consumer expectations, fueling demand for further investment.

3.3. Competition Drives Learning and Innovation and Enhances Reliability

The dynamics of market competition enable consumers to learn about and choose among an array of service offerings. Most of today's smartphone users started out as dial-up Internet users with telephony-only mobile phones. Yesterday's adolescent gamers are today's young professionals at the forefront of the Internet economy. Figuring out what mix of devices, network services, and product offerings will be successful in this rich market environment is difficult. It is only by allowing a marketplace that supports diverse competition at all levels that we can generate the market experimentation that leads to the "next big thing."

Today, some may question whether the Internet of Things/Big Data/Cloud Computing vision articulated earlier isn't over-hyped. Certainly, in the Internet economy, we have seen excess confidence dashed when it became clear that realizing the benefits of the Internet confronts significant challenges. For example, following the passage of the Telecommunications Act of 1996, we saw an explosion of investment by Competitive Local Exchange Carriers (CLECs) and by Web-based ventures seeking to capitalize on the promise of Business-to-Business (B2B) and Business-to-Consumer (B2C) market opportunities.³⁹ Unfortunately for many investors, the Dot.Com bust occurred in mid-2000 when it became clear to investors that there were significant challenges that needed to be overcome to realize the Internet economy's future promise.⁴⁰ Key elements of those challenges included the need for last-mile broadband access, the need to reform business processes to facilitate adoption of new Internet business models,⁴¹ and the rationalization of the regulatory framework.⁴² Although many of the Dot.com and CLEC ventures that failed were the result of the market's weeding out process of poorly run businesses, the

fundamental vision of Internet-enabled markets was sound. With the build out of broadband infrastructure, the further maturation of B2B and B2C processes and the organizational change needed by adopting enterprises to be effective, and with the recovery of the global economy, many of the promised Internet markets have developed, albeit later than originally hoped.⁴³ Moreover, even while a number of telecom and Internet companies were failing, telecommunications traffic continued to grow as businesses across the economy were driven inexorably to embrace the Internet and increased ICT use across their business operations.

Transitioning our economy to a "smart future" requires adjustments at every level, from the technologies used to support always on/everywhere available connectivity to the business processes that make use of those. There is not any perfect roadmap. Nor is there a single best solution that fits all market contexts and business situations. In this vibrant marketplace, the experimentation and reconfiguration of resources afforded by competitive markets is especially important. For example, the initial success of the iPhone was predicated on its ability to use WiFi, which some saw as a competitive threat to cellular mobile data services.⁴⁴ In actuality, however, WiFi helped encourage the ecosystem of wireless applications (*i.e.*, iPhone and Android app stores, handsets, multimedia content) that has helped fuel mass-market demand for mobile data services from both WiFi and cellularized carrier networks. More recently, the ability to use WiFi to off-load traffic from cellular networks has helped reduce the costs of meeting mobile broadband demand growth. Moreover, over time, both WiFi and cellular technologies have evolved to add functionality that previously had been better supported by the other. For example, the WiFi family of technologies under development by Project 802 of the IEEE have added support for real-time services (*e.g.*, voice telephony) and the coordinated management of multiple base stations (*e.g.*, to support wider-area coverage).⁴⁵ Analogously, cellular technologies such as 4G LTE have expanded the ability of cellular networks to better support asymmetric data traffic, and to co-exist in spectrum shared with other radio technologies.⁴⁶

This pattern of market competition and continuous innovation has proceeded at multiple layers across the value chain and is key to its healthy growth. At the level of mobile handsets, operating system ecosystems, cloud services, applications, and content, we see the potential for dynamic competition propelling innovation and investment to expand existing markets and develop new ones. All of this Internet-fueled activity, however, is ultimately dependent on last-mile mobile-access services, which in turn are dependent on access to scarce radio frequency spectrum, as key business inputs.

Finally, in addition to the experimentation and learning benefits of competition for mobile broadband demand and supply chains, there are also benefits in terms of reliability and robustness. Having multiple facilities-based networks provides a level of redundancy that can greatly enhance the overall reliability of the network economy. Having both fixed and mobile telephones, for example, means that consumers can still call emergency services if either the fixed or the mobile networks continue to operate. At longer time-scales, having diversity in business models and technology platforms affords

advantages in strategic robustness. In complex systems, having multiple choices (hardware/software, network paths, etc.) enhances resiliency and contribute to reliability.

3.4. Challenges to Sustainable Competition in Telecommunications

Sustaining significant facilities-based competition in the mobile broadband market may prove more difficult in the future. The increased difficulty is due, in part, to the increased need for spectrum resources and the growing capital intensity associated with meeting the performance requirements of ever-faster and more capable mobile broadband services.⁴⁷

Even putting aside considerations regarding spectrum scarcity, sustaining competition in telecommunications services, especially last-mile services such as fixed and mobile broadband access, poses significant economic challenges. Building and maintaining the networks requires large investments in capacity that is largely fixed, sunk, and/or shared, and subject to rapid economic depreciation because of the rapid pace of innovation in technology and markets. Investments are subject to significant technical, market, and regulatory uncertainty. Additionally, telecommunication networks benefit from positive demand-side network externalities that make the value of subscribing to a network increase with the size of the network. Taken together, these factors give rise to significant scale and scope economies and pose barriers to entry, limiting the number of facilities-based telecommunication networks that are economically viable.

Indeed, for much of its history, the provisioning of telephone network services was viewed as a natural monopoly, and was regulated as such as a public utility that was owned by the government in many nations. However, beginning in the 1960s and accelerating thereafter, a growing number of governments recognized that expanding opportunities for competition and market liberalization offered a better path. The U.S. leadership in opening telecommunications markets to competition and the more extensive and earlier adoption of ICT enhancements by U.S. businesses contributed significantly to U.S. economic growth. For example, Jorgenson (2001) estimated that ICT added 1.18% to GDP growth and accounted for two-thirds of total factor productivity growth from 1995 through 2000, thereby helping to explain the resurgence in economic growth in the United States in the last half of the 1990s.⁴⁸ Jorgenson, Ho, and Stiroh (2007) estimated that ICT contributed 59% of the growth in labor productivity from 1995 through 2000 and 33% from 2000 to 2005.⁴⁹ Fuss and Waverman (2006) attributed 60% of the slower productivity growth experienced by Canada (relative to the US) in 2003 to Canada's less intensive use of ICT.⁵⁰

Over time, the growth in demand for telecommunication services and advances in technology made it feasible to introduce facilities-based competition in a growing range of telecommunication markets, from terminal equipment in the 1960s, to long distance services in the 1980s, to local last-mile services in the 1990s. Enabling this competition to emerge has required continuous change in regulatory policies and frameworks. Potentially the most significant of which was the divestiture of the Bell Telephone system in 1984 which created separate local and long distance telephone networks based on regulatory-defined geographic markets in an effort to enable competition to thrive in long distance, while continuing to protect the natural monopoly in last-mile services. As a

consequence of this, prices for long distance services fell substantially, dropping more than 85% from 1984 to 2006, after accounting for inflation.⁵¹

Of special importance for last-mile wired competition was the emergence of intermodal facilities-based competition between traditional telephone-based providers (AT&T and Verizon, the descendants of the Bell Telephone monopolies) and cable television providers. Indeed, the investments by cable providers to upgrade their networks to support interactive, two-way communications was motivated, in part, by the earlier efforts of the telephone providers to upgrade their networks to enable them to offer television services, thereby competing in the core market for cable television operators. Cable providers were justifiably alarmed that if the telephone companies were successful in meeting the capacity challenge of delivering high-data rate video programming downstream, the telephone companies' relative advantage in managing two-way traffic would provide them with a compelling competitive advantage in offering interactive and enhanced television services. As it turned out, telephone operators abandoned those earlier efforts, allowing cable operators a head start in the market for fixed broadband services that emerged as a consequence of the success of dial-up Internet access during the latter half of the 1990s.⁵² Since then, most U.S. markets have benefited from facilities-based broadband platform competition between wired telephone and cable television companies, although there is some concern that prospects for this competition as we move to ever higher data rate services are at risk.⁵³

In contrast to the more difficult history of wired last-mile competition, some degree of facilities-based competition between mobile telephony providers was guaranteed from the start. Two spectrum licenses for cellular services were granted in each local market beginning in the 1980s, and the potential for facilities-based competition was significantly expanded with the auctioning of PCS spectrum licenses in the mid-1990s. In the early days, national coverage had not yet been achieved, and operators were striving to assemble national networks. National coverage was accomplished through a mixture of industry consolidation and aggressive build out plans.

Increasingly, mobile and fixed network services are both competitors and complements.⁵⁴ In retail markets, mobile telephony is a significant competitor for fixed line telephony; however, the reverse is not true.⁵⁵ As a result, today a significant and growing number of households (38.2%) are now wireless-only telephone households.⁵⁶ At the same time, fixed network infrastructure is important for cellular services both to backhaul traffic from cellular base stations and because fixed broadband-connected WiFi networks allow the off-loading of significant cellular traffic, thereby reducing the costs of providing mobile broadband services. A recent estimate is that as much as 46% of mobile traffic will be off-loaded by 2017.⁵⁷

A review of the history of competition in telecommunication services and earlier economic analyses of the price effects demonstrates the important role that competition has played in keeping prices low, but does not provide strict guidance for determining the relationship between pricing and market structure, pricing and costs, or pricing and the intensity of competition (all of which are interrelated).⁵⁸ However, analysts almost

universally agree that there are significant competitive benefits in having more than two facilities-based competitors.⁵⁹

For example, were facilities competition to be reduced to the largest two providers—Verizon Wireless and AT&T—this consolidation would have adverse implications across the entire value chain. Verizon Wireless and AT&T are the two largest providers of fixed broadband services and also significant providers of backhaul services used by other facilities-based providers, including the only other two national cellular providers, Sprint and T-Mobile. In contrast to AT&T and Verizon, Sprint and T-Mobile do not have fixed broadband service businesses that they need worry about cannibalizing when they aggressively market their mobile broadband services.

The special risks associated with further consolidation of the largest two carriers attracted special attention during the review of the proposed merger of AT&T and T-Mobile in 2011. AT&T abandoned its plans in the face of significant opposition from policymakers, concerned that the merger posed an unacceptable risk to competition.⁶⁰ While advocating for the merger, AT&T argued that AT&T and T-Mobile would not invest as extensively in expanding their national networks unless they were permitted to realize the alleged scale/scope and complementary economies they argued the merger would offer. For example, AT&T claimed that without the merger, AT&T's LTE roll-out would only reach 80% of the U.S. population by 2018.⁶¹ In reality, AT&T deployed well in excess of its earlier claimed maximum without the acquisition of T-Mobile to confront the build out plans of competitors.⁶²

In addition to the threat to retail mobile service competition, the further consolidation of Verizon and AT&T would result in increased consolidation of potential markets for network equipment and handsets, spectrum resources, and application and content service delivery markets. Handsets have historically been tied to specific cellular networks, but advances in technology (*e.g.*, the convergence on LTE) and regulatory reforms (*e.g.*, local number portability and restrictions on phone locking) make it feasible to unbundle handsets and edge devices from particular radio networks. However, for such "mix-and-match" opportunities to expand customer choice, there need to be choices. Having only two facilities-based providers would pose a risk of monopsony power in upstream equipment, software, and application markets, which would, in turn, threaten the extent of competition and innovation in devices and other markets that are dependent on mobile broadband services.

Additionally, the further concentration of Verizon and AT&T's spectrum resources would be inconsistent with the direction of wireless evolution and the move toward more dynamic and flexible spectrum-management models. A significant threat to the wireless future is the continued and largely artificial scarcity of spectrum resources. This scarcity is artificial because it is principally due to a legacy spectrum management regime that has precluded the reallocation of spectrum resources to higher value uses as markets and technology evolve. Indeed, a principal goal of the 600 MHz incentive auctions is to effect the reallocation of spectrum resources from over-the-air television to use by mobile broadband services. To ensure that this process is not just a one-time correction, but part

of a move to a more flexible spectrum management regime into the future, we need to make sure we also develop more robust and dynamic secondary spectrum markets. Further concentration of Verizon and AT&T's spectrum resources would harm the competitiveness and liquidity of markets for the most important scarce resource for wireless services, namely, radio frequency spectrum rights.

The viability of reseller competition would also likely be threatened were we to have only two national facilities-based providers. The effectiveness of reseller competition is limited by the extent of underlying facilities-based competition. When wholesale network competition is effective, reseller competition can add importantly to expanding consumer choice, providing price discipline, and generally contributing to the vibrancy of market-based competition. In long distance telephone services, long distance reseller competition could be very effective because wholesale services were readily available from each of the three national facilities-based long distance providers (AT&T, MCI, and Sprint), even before the entry of the local telephone companies into long distance.

In mobile services, prepaid providers like MetroPCS (once the 5th largest carrier)⁶³ and Leap Wireless (once the 6th largest operator),⁶⁴ as well as mobile virtual network operators (MVNOs), such as TracFone, were important innovators in expanding the market for lower-priced pre-paid service models. Following their acquisitions, both MetroPCS and Cricket Wireless, the service brand for Leap, continue to be offered as prepaid subsidiary brands, similar to other MVNOs. The low-price competition offered by such brands puts downward pressure on the entire portfolio of mobile service offerings. However, the viability and effectiveness of reseller and subsidiary competition depends on the vigor of competition for the wholesale network services that resellers rely on. National resellers need access to the networks of national facilities-based providers and having more than two facilities-based providers is important for ensuring competitive wholesale markets.

Finally, in the absence of adequate facilities-based competition, the only likely recourse would be to reinstate more direct regulatory oversight of bottleneck facilities and some form of open access regulation.⁶⁵ While economists may disagree on the efficacy of open access regulation, they are generally agreed that direct regulation is, at best, a second-best choice compared to effective competition. Earlier efforts to impose such a framework on last-mile telephone incumbents under the Telecommunication Act of 1996 were unsuccessful. With respect to broadband services, it is possible to view the FCC's efforts to impose "network neutrality" regulation as an attempt to impose a form of open-access regulation on Internet access providers, but even the FCC recognized that imposing such rules on mobile providers posed additional difficulties. Furthermore, the FCC's authority to impose such rules was recently dealt a further blow by the decision of the Court of Appeals for the District of Columbia Circuit in January 2014.⁶⁶ How this regulatory quandary will be resolved is uncertain, but ensuring that there are more than two facilities-based competitors helps avoid the need to impose regulatory distortions.

In summary, the basic economics of competition and of mobile telecommunication services identify numerous important benefits from having facilities-based competition

among more than two national providers. Most of these benefits will ultimately be reflected in lower quality-adjusted prices. The price effect may be due to competition-induced, cost-reductions resulting from the diffusion of productivity enhancing innovations. Alternatively, cost reductions may result from the compression in margins that might otherwise occur if firms were able to exploit market power. Or, cost reductions may be observed in expanded value (quality) without an attendant price increase. This last manifestation of a cost reduction amounts to a decrease in appropriate quality-adjusted prices, but making such adjustments empirically is notoriously difficult. Observing these price effects directly is difficult in any case because it is necessary to control for quality improvements, product differentiation effects, and changes how products are sold (*e.g.*, whether bundled, subject to term contracts, or with special discounts). Additionally, the realization of the benefits of competition, whether due to enhanced innovation, elimination of excess profits, improvements in quality and consumer choice, or reliability are likely to occur over time and at different rates. The impact on observed consumer prices might be expected to vary asymmetrically across time and market segments. Taken together, these factors suggest that observed direct price effects of competition will likely significantly understate the benefits of competition.

4. Competition Lowers Telecommunication Service Prices

The history of telecommunication services and the academic literature provide ample evidence of the direct impact of competition on lowering prices. However, much of the benefit of competition is associated with competition that impacts prices only indirectly. Before considering the empirical evidence of price effects, it is worth reviewing examples of non-price competition.

4.1. Service innovation and product differentiation

Relative to many other consumer products and services, it can be challenging for mobile service providers to differentiate their core services. Nevertheless, competition induces them to strive to differentiate their services in their relentless quest to attract and retain customers and adapt to changing market conditions. Once one provider identifies a service enhancement that is attractive to consumers, others are induced to copy or improve on those innovations. Price cuts are one obvious way to gain market share, but those are more easily imitated and often more costly in terms of the lost margins for inframarginal consumers. Non-price product differentiation helps soften price competition, and where feasible, is often preferred by firms.

Mobile operators have sought to differentiate their services by offering improved quality (*e.g.*, more expansive coverage, newer technology networks)⁶⁷ and expanded choice (*e.g.*, selection of handsets, retail points-of-sale). They have also differentiated their services with modified service plans and terms with special discounts, contract terms (including handset subsidies), and tiered usage bundles. The complex portfolios of service packages offered by mobile providers make it more difficult for consumers to directly compare prices. Additionally, mobile providers sought to enhance customer retention by locking customers into long-term contracts and offering them forward discounts (*e.g.*, friends-

and-family calling programs and roll-over minutes, the benefits of which are lost if a subscriber changes providers). A mix of carrot-and-stick strategies are employed by mobile operators to create or take advantage of customer switching costs in order to reduce churn. Nevertheless, customer churn is high in telecommunication services generally, and in mobile services, in particular. The FCC concluded that average customer churn has averaged 2 to 2.5% per month since 2005.⁶⁸ While product differentiation may bestow competitive advantage, the ease with which it may be imitated by other mobile service providers has meant that any such advantage may be short-lived.

For example, when the iPhone was released in June 2007, it was only available on AT&T's network. Relying on its own exclusive arrangements, Verizon turned to Research in Motion to create its own iPhone competitor, which yielded the 2008 Verizon-exclusive Blackberry Storm. Also soon after the release of the iPhone, in November 2007, Google, along with 34 partners, including competitive carriers such as T-Mobile and Sprint Nextel, announced the Open Handset Alliance. This alliance created the Android operating system that is widely used by smartphones and other devices that competitors could access to compete with AT&T's iPhones and Verizon's Blackberries.

Indeed, while AT&T led the industry in the case of the iPhone, competitive carriers are also especially likely to introduce innovative services and differentiated products. For example, MetroPCS launched the first LTE network in the U.S. in September of 2010⁶⁹ and released the first U.S. LTE smartphone a few months later.⁷⁰ About a year and a half after that, in August of 2012, MetroPCS unveiled the world's first commercially available voice over LTE (VoLTE) network and smartphone.⁷¹ Similarly, Cricket was the first carrier to offer the iPhone on a prepaid, off-contract basis, which it first offered in June of 2012.⁷² Sprint offered several of its own firsts, including the first US camera phone in 2002,⁷³ and the first 3G network, also in 2002. Likewise, T-Mobile was the first U.S. carrier to offer voice calling over WiFi (2007),⁷⁴ an Android handset (2008),⁷⁵ 3G (HSPA+) services (2009),⁷⁶ and unlimited nationwide 4G data (2012).⁷⁷ These and other examples illustrate the genius of competition—competitors across the spectrum are continuously seeking to find an advantage and that distributed experimentation helps accelerate the innovation cycle.

In addition to innovating and differentiating based on product features and capabilities, there is also a long history of innovations in pricing and service models. A review of some of this history is discussed further below.

4.2. Evidence from Cable Television Pricing Research

Cable television was originally provided as a monopoly franchise in most markets. Indeed, for a long time, the deployment of cable television systems was opposed by over-the-air broadcasters, with support from regulators, fearful that competition might damage consumers' access to television. Fortunately, this resistance was overcome and we now benefit from near ubiquitously available cable infrastructure as a wired broadband platform that offers a wired alternative to the telephone networks and enables us to contemplate the reallocation of broadcast television spectrum to higher value mobile broadband uses.⁷⁸

While the deployment of cable television systems offered compelling benefits, the fact that most markets were served by monopoly franchises denied consumers the benefits of competition. A number of researchers have looked at the price impact of facilities-based competition in the cable television market and have found significant price effects. The studies cover a wide range of data and methods, estimating price impacts of from 5% to over 20%.⁷⁹ For example, Kelly & Ying (2013) estimate that prices were 5.6 to 8.8% lower from 1993-2001 in cable markets with facilities-based competition.⁸⁰ Savage & Wirth (2005) estimated that competition was likely to lower prices by 14.2%.⁸¹ Beard & Ford (1999) estimated that prices would be 13-17% lower.⁸² Emmons and Prager (1997) found prices lower by 20.5% in 1983 and 20.1% in 1989.⁸³ Finally, the FCC reports that the price per channel of programming is 6.1% higher in communities without "effective competition" in 2012.⁸⁴

The above estimates likely understate the benefits of full facilities-based competition, which is the more relevant comparison with respect to evaluating the impact of national facilities-based competition in the mobile broadband market. For example, the FCC found that communities with over-builders had prices that were approximately 16-27% lower than those in non-competitive markets in 2004.⁸⁵ An analysis of California markets found prices in overbuilder markets were 22% lower than single-provider markets, while a study for overbuilder markets in Texas in 2005 found prices that were 30% lower for overbuilder markets than single-provider markets.⁸⁶ Related research has shown that increased competition from over-the-air channels increases the price reduction effect, but that additional channels beyond five do not add additional benefits.⁸⁷

4.3. Evidence on Wired Telephone Service Competition

Earlier, I noted the significant reductions in long distance prices with the increase in competition since the early 1980s. A further example of the impact of facilities-based competition in long distance services was provided by the entry of local telephone companies between 1999 and 2002.⁸⁸ Hausman et al. (2002) estimated that long distance telephone rates fell 9% in New York and 23% in Texas as a consequence of the additional facilities-based competition afforded by ILEC entry into those states.⁸⁹ These reductions are by no means insubstantial. After ILEC entry, it becomes more difficult to track the effect of facilities-based competition on wired telephone rates because most local services were provided at a flat monthly rate and separate billing for long distance disappeared as the regulatory distinction between long distance and local calling was erased.

Elsewhere researchers have looked at the impact of imposing local number portability (LNP) on mobile services, which allows customers to keep their mobile number when they move to another provider. Enabling LNP reduces customer switching costs and thereby increases the intensity of competition. Cho et al. (2013) examined the impact of LNP in Europe, where it was introduced in 2002, and concluded that it reduced prices by 7.9% on average.⁹⁰

4.4. Intermodal Competition between wired cable and telephone

Further evidence of the price effect benefits of competition is available from research analyzing the impact of increased broadband platform competition, most typically focusing on competition between cable and telephone providers offering "triple play" service bundles that include telephone, television, and data services.

A key motivation for service providers of switching to triple-play bundles was to reduce customer churn since bundled customers are less likely to switch service providers.⁹¹ The transition from per-service, per-use pricing to bundled pricing represented, in itself, a significant price reduction for many customers. Most consumers prefer the simplicity of purchasing services as a bundle, and there has been a trend across services to offer tiered service bundles, including unlimited usage bundles. With unlimited SMS, voice calling and/or mobile data usage, the marginal price to the consumer is zero.

Research also shows that wired platform competition benefits consumers. For example, Höffler (2007) showed that markets with cable modem and telephone DSL broadband competition achieved 2% higher penetration rates, allowing those countries to realize the economic benefits of broadband sooner.⁹² Pelcovits and Haar (2007) found that in markets where cable telephony competed with telephone company services that cable telephony prices were 23% less.

Finally, a GAO study of broadband platform competition (with bundled offerings that include television, telephone and Internet service) found that basic cable television rates ranged from 15-41% lower in broadband service provider markets.⁹³

4.5. Price competition in Mobile Services

The examples cited above provide empirical evidence of the long history of facilities-based competition's impact on pricing across a range of telecommunication service markets. Not surprisingly, similar effects are evident in the case of mobile telecommunication services. For example, the auctioning of PCS spectrum in 1995 enabled the entry of significant new facilities-based competition in markets across the United States which previously had been limited to two licensed providers. Crandall & Hausman (2000) found that cellular prices fell 3 to 4% per year from 1984-1995, but following entry of the PCS licensees, prices fell 17% per year, and the PCS providers offered prices that were "more than 50 percent lower than existing cellular rates."

Faulhaber et al. (2011) point to multiple indicia of wireless competition, including prices which fell faster than the Consumer Price Index (CPI).⁹⁴ Indeed, since 1997 the CPI for wireless telephone service has fallen 42%, while the CPI has risen 44%, representing an inflation-adjusted decline of 60%.⁹⁵

As noted earlier in the discussion of non-price competition and operator attempts to differentiate their services, there is also a significant history of price-related innovations, most commonly in the form of price reductions that competitors are induced to match to

remain competitive. For example, in 1998, AT&T lead the industry with its move to bundled offers with its "Digital One Rate Plan" offering a simplified single rate for national calls, disrupting what previously had been a mobile calling market with distance-sensitive calling rates.⁹⁶ The rest of the industry responded with competing offers in relatively short order. More recently, Verizon introduced unlimited plans in 2008 and then price cuts in 2009. Verizon's lead in upgrading its network gave it a relative advantage in competing for mobile data services at the time, but other carriers followed suit with their own price reductions that amounted up to 33% in some cases.⁹⁷

4.6. Summarizing the Price Effects

The evidence cited above spans decades of telecommunication experience and markets. Taken together, this provides strong evidence that competition contributes to lowering prices, allowing consumers to get more for less: more usage, better quality service, and paying less for individual and bundled components. There is a wide range of estimates across many markets, and so no obvious way to aggregate these into a reasonable single estimate of the price effect. In any case, any such attempt likely would require decomposing the effects of competition to its constituent parts (long/short term, cost/innovation related versus elimination of excess margins, *etc.*). The variability in evidence cited is due to differences in context as well as the motivation behind the empirical estimate. In the evidence cited, there are numerous examples and studies indicative of competition impacting prices by significantly more than 10% or even 20%.

Antitrust authorities, when examining market power often rely on a test of whether it is possible for a firm to sustain a "Small but Significant and Non-transitory Increase in Prices" (SSNIP) in the relevant market. This is commonly made operational by assuming a SSNIP of 5% for a year or more.⁹⁸

After due consideration of the qualitative and empirical evidence of competition's benefits cited above, it seems conservative to conclude that prices in the wireless broadband market would have been and will likely be in the future *at least 10% lower* if we are successful in promoting facilities-based competition.

Analytically, this approach to estimating the benefits of competition is a form of meta-analysis, akin to reduced-form econometric estimation. It obviates the need to make detailed and contentious assumptions about a wide range of issues. Those include assumptions about industry structure (how many facilities-based providers will the market sustain? How will the value-chain restructure itself?); the evolution of supply (technical innovation and investment) and demand (timing of Smart X market evolution); and regulatory policies. The approach adopted here seeks to incorporate such more detailed studies, aggregating their effects into a single effect ("10% lower prices") that can be easily grasped and estimated to provide a useful order-of-magnitude estimate of the value of mobile broadband competition.

5. Mobile Competition Generates Consumer Benefits of \$20B per year

Hicks (1940) first discussed the appropriate way to measure the surplus effects of a price decrease.⁹⁹ Hausman (1997, 1999) further developed these ideas for use in practical empirical estimation of the consumer surplus effects associated with the introduction of new goods and price drops.¹⁰⁰ Since Hausman originally applied these methods to first estimate the welfare benefits of cellular services, this approach has been used by economists in diverse contexts to estimate consumer welfare effects, including for Internet and mobile telecommunication services as in the cases of Brynjolfsson et al. (2003)¹⁰¹ and Grzybowski & Pereira (2008).¹⁰² Both of these make the common assumptions that demand may be approximated as log-linear and income effects may be disregarded to derive the following simple equation:

$$CS = p_0 q_0 \frac{1 - (1 + g)(1 + g\alpha)}{1 + \alpha}$$

where,

- CS is the change in consumer surplus expressed in dollars;
- p_0, q_0 are the original prices and quantities, so $p_0 q_0$ is industry revenue before the price change;
- g is the change in prices (which I will assume is -10%)
- α is the price elasticity of demand

To estimate this, only three values are required: (1) an estimate of industry revenues; (2) an estimate of the price change (which, based on a review of the relevant literature, I have conservatively assumed is -10%); and (3) the price-elasticity of demand.

The price elasticity of demand provides a measure of how sensitive demand is to prices.¹⁰³ We typically expect the elasticity of demand for goods that are necessities to be relatively unresponsive to prices and so to have lower demand elasticities. A number of studies of mobile service demand over the years have produced a wide range of estimates of demand elasticities. For example, Dewenter & Haucap (2007) estimated elasticities in the range -0.47 to -1.1;¹⁰⁴ Grzybowski & Pereira (2008) estimated -0.38;¹⁰⁵ Hausman (1997) estimated between -0.41 and -0.51;¹⁰⁶ and Parker and Röller (1997) estimated -2.5.¹⁰⁷

For the purposes of estimating the long-run benefits of mobile competition, it is reasonable to believe that demand will be more elastic than in the short-run, but as broadband services become more critical to end users, users will become less price sensitive overall. The more elastic demand, the greater the stimulus effect of lower prices and the greater the total value created by the market. From the earlier literature, it seems reasonable to conclude that a conservative estimate of the price elasticity of demand is -0.5.

With this assumption for the demand elasticity and $g = -10\%$, the CS equation reduces to 0.11 poq_0 .

At the end of 2012, CTIA's survey reported that there were 326 million mobile subscriptions, with an average revenue per unit (ARPU) of \$48.73. Historically, ARPUs evolve as the prices and mix of services consumed shift, but as noted earlier these have trended downwards since the 1980s but have been consistently above \$45 since 1993.¹⁰⁸

At the same time the number of subscriptions continues to grow. While the share of the population without any mobile device subscription has approached saturation, a rising share of users have multiple devices and are using mobile services in multiple ways. Estimating future subscription growth is uncertain, but has averaged between 3-4% in recent years. Two investment bank studies have estimated that the number of subscriptions by 3Q2013 were 331 million¹⁰⁹ and 341 million,¹¹⁰ respectively.

Given the above, it seems a conservative estimate for industry revenues is to assume an ARPU of \$45 and 340 million subscriptions as a reasonable lower bound average for the next decade. With this assumption, total industry revenues would be \$184 billion per year (only slightly less than what CTIA reported for the industry in 2012) and the consumer surplus associated with 10% lower prices would be approximately \$20 billion.¹¹¹ Assuming a 10% discount rate, that formula translates into a conservative estimate of the long-run benefit of facilities-based competition in the mobile broadband market of no less than \$200 billion.

6. Conclusions

Mobile broadband has the potential to unlock economic growth opportunities worth trillions of dollars as we transition to a (an ICT) "smart" economy. This potential expresses itself in the Internet of Things, Big Data, and Cloud Computing. It is what we need to do to realize the goals of the National Broadband plan and keep the U.S. economy on track for growth and leadership in the future.

Realizing the promise of this goal will necessitate overcoming many challenges both in the near and more distant future. Among those is the need to expand reform of national communication policies from universal service to spectrum management. The goal is to make regulations more responsive to and consistent with market-based competition. Indeed, the primary goal of communications policy is to promote competition as the best way to ensure a healthy industry ecosystem. In debates over the appropriate design of spectrum auctions and other communication policies, we have sometimes lost the forest for the trees, focusing on the ancillary goal of ensuring sufficient auction revenue, potentially at the expense of competition. Both goals are important, but promoting competition is and should remain the principal priority.

This paper conservatively estimates that the value of mobile competition to consumers is at least \$20 billion per year, or \$200 billion in present value terms. This is also the value

that may reasonably be expected to be lost if we fail to sustain an adequate level of facilities-based competition.

¹ The author has prepared this report in support of CCA and its members. All views expressed herein are the author's own.

² Allocative efficiency means that scarce resources (*e.g.*, spectrum) are directed to their highest value uses. Productive efficiency means that goods and services are produced at the lowest possible costs (*i.e.*, firms adopt industry best practices). Dynamic efficiency means that firms continue to be efficient over time, implying that investment is optimal and that innovation continues.

³ Most consumers accessed the Internet over (slow) dial-up (fixed line) telephone connections. Fixed broadband access services via DSL or cable did not become widely available until after 2000. *See, e.g.*, NATIONAL TELECOMMUNICATIONS & INFORMATION ADMINISTRATION (NTIA), HOW AND WHERE AMERICA GOES ONLINE, <http://1.usa.gov/Ms8H31> (last visited Feb. 25, 2014) (noting that, in August 2000, only five percent of the U.S. population had access to "something faster than a dial-up service in their homes"). The transition to broadband uncorked the last-mile bottleneck and greatly expanded the usability of the Internet and networked computing applications and content, providing a significant spur to the growth of the Internet. *See, e.g.*, INTERNATIONAL TELECOMMUNICATIONS UNION (ITU), IMPACT OF BROADBAND ON THE ECONOMY 1 (2012), *available at* <http://bit.ly/1dQdKX8> (explaining that broadband "is inextricably linked to the emergence of the Internet"); JOHN HARRIGAN & AARON SMITH, PEW RESEARCH, HOME BROADBAND ADOPTION 2007 9 (2007), *available at* <http://bit.ly/1hoz4Ct> (finding that those with broadband use the Internet more regularly and engage more frequently in a variety of online activities).

⁴ "The "Internet of Things" refers to a future of embedded sensors, in which everything from your toaster to your car is potentially connected to the Internet and able to take advantage of distributed computing and communications capabilities. Embedding computers/sensors in "things" will allow much greater scope for data collection and real-time automation to facilitate better decision-making. *See, e.g.*, INTERNET OF THINGS, <http://www.internet-of-things.eu/> (last visited Feb. 24, 2014); COMM'N OF EUR. CMTYS., INTERNET OF THINGS – AN ACTION PLAN FOR EUROPE (2009), *available at* <http://bit.ly/1dwo0PD>; ITU, THE INTERNET OF THINGS (2005), *available at* <http://bit.ly/1cNhua5>; JOSEPH BRADLEY ET AL., CISCO, INTERNET OF EVERYTHING (IOE) VALUE INDEX (2013), <http://bit.ly/N090Dc> (Cisco White Paper).

⁵ "Big Data" refers to the opportunity to take advantage of all of the real-time data that may be collected by today's networked ICT systems to make better business decisions. *See, e.g.*, Steve Lohr, *The Age of Big Data*, N.Y. TIMES (Feb. 11, 2012), *available at* <http://nyti.ms/1foD41k>; MICHAEL SCHROECK ET AL., IBM INST. BUS. VALUE, ANALYTICS: THE REAL-WORLD USE OF BIG DATA (Oct. 2012), *available at* <http://ibm.co/19fNVZL>; *see also* MIT, *Big Data Initiative at CSAIL*, <http://bigdata.csail.mit.edu/> (last visited Feb. 24, 2014) (providing an overview of MIT's activities in this area).

⁶ "Cloud Computing" refers to the vision of evolving the Internet from a data communications platform to a general computing utility, providing on-demand access to computing, storage, and telecommunications resources. The rise of the Internet of Things and Big Data will require us to improve the capabilities to store, manage, and access more ICT resources in the network. *See, e.g.*, ORACLE, ACHIEVING THE CLOUD COMPUTING VISION (2010), *available at* <http://bit.ly/1kckezn>; ITU, DISTRIBUTED COMPUTING: UTILITIES, GRIDS, AND CLOUDS (2009), *available at* <http://bit.ly/1mxCcha>; *see also* MIT, *MIT News—Cloud computing*, <http://bit.ly/1fRTuAd> (last visited Feb. 24, 2014) (providing an overview of MIT's activities in this area).

⁷ Cisco estimates that there are \$14 trillion in private sector and \$4.6 trillion in public sector worth of opportunities to be realized associated with transitioning to the IoT vision. See JOSEPH BRADLEY ET AL., CISCO, EMBRACING THE INTERNET OF EVERYTHING TO CAPTURE YOUR SHARE OF \$14.4 TRILLION (2013), <http://bit.ly/19VH4F1>; JOSEPH BRADLEY ET AL., CISCO, INTERNET OF EVERYTHING: A \$4.6 TRILLION PUBLIC-SECTOR OPPORTUNITY (2013), <http://bit.ly/1euphGi>. Cisco also estimates that the IoT contributed \$613 billion in global corporate profits in 2013. See Cisco White Paper at 1. Analysts' opinions vary widely as to the magnitude of potential benefits and when they will be realized. For example, the Gartner Group sees \$1.9 trillion in global economic value-add by 2020, while the International Data Corporation (IDC) expects IoT technology and services to generate global revenues of \$8.9 trillion by 2020. See Press Release, Gartner Group, Gartner says the Internet of Things Installed Base will Grow to 26 billion units by 2020 (Dec. 12, 2013), available at <http://gtnr.it/1h780GZ>; Press Release, IDC, The Internet of Things is Poised to Change Everything, Says IDC (Oct. 3, 2013), available at <http://bit.ly/1dSdjf6>. Although many of these estimates may be overly optimistic, the economic potential is huge.

⁸ See JAMES MANYIKA ET AL., MCKINSEY GLOBAL INST., BIG DATA: THE NEXT FRONTIER FOR INNOVATION, COMPETITION, AND PRODUCTIVITY (2011), available at <http://bit.ly/1gYqIAC>.

⁹ For instance, one study finds that firms that take advantage of "Big Data"-powered data and business analytics have 5-6% higher productivity. See ERIK BRYNJOLFSSON ET AL., STRENGTH IN NUMBERS: HOW DOES DATA-DRIVEN DECISIONMAKING AFFECT FIRM PERFORMANCE? (2011), available at <http://bit.ly/1kcppPV>.

¹⁰ This vision is articulated in the National Broadband Plan. See FEDERAL COMMUNICATIONS COMMISSION, CONNECTING AMERICA: THE NATIONAL BROADBAND PLAN (2010) (National Broadband Plan), available at <http://www.broadband.gov>.

¹¹ The White House, *Technology*, <http://1.usa.gov/1mxH6L3> (last visited Feb. 25, 2014).

¹² See ALAN J. PEARCE ET AL., PCIA—THE WIRELESS INFRASTRUCTURE ASSOCIATION, WIRELESS BROADBAND INFRASTRUCTURE: A CATALYST FOR GDP AND JOB GROWTH 2013-2017 (2013), available at <http://bit.ly/1gAzkfC>.

¹³ ROGER ENTNER, RECON ANALYTICS, THE WIRELESS INDUSTRY: THE ESSENTIAL ENGINE OF US ECONOMIC GROWTH (2012), available at <http://bit.ly/Msb2Le>.

¹⁴ See CTIA—THE WIRELESS ASSOCIATION (CTIA), BACKGROUND ON CTIA'S SEMI-ANNUAL WIRELESS INDUSTRY SURVEY (2013) (CTIA Survey), available at <http://bit.ly/1fV3qc8>.

¹⁵ See Andrew Berg, *U.S. Operators Drop \$30.1B in CapEx in 2012*, WIRELESS WEEK (May 3, 2013), available at <http://bit.ly/1hAsOX5>.

¹⁶ As of December 2012, there were 326 million mobile subscriptions in the U.S.—more than the county's population, as many subscribers have multiple devices. See CTIA, *Wireless Quick Facts*, <http://www.ctia.org/your-wireless-life/how-wireless-works/wireless-quick-facts> (last visited Feb. 25, 2014). Forecasters expect smartphone and tablet penetration to reach 80% and 64% in 2014, respectively. See, e.g., eMarketer, *Smartphone, Tablet Uptake Still Climbing in the US* (Oct. 14, 2014), <http://bit.ly/11k9Nx2>.

¹⁷ See *Implementation of Section 6002(b) of the Omnibus Budget Reconciliation Act of 1993 and Annual Report and Analysis of Competitive Market Conditions With Respect to Commercial Mobile Services*, Sixteenth Report, 28 FCC Rcd 3700, 3749 ¶ 48 (2013) (*Sixteenth Mobile Competition Report*).

¹⁸ The growth in devices and shift toward higher-capacity devices is fueling exponential growth in mobile broadband traffic. A single smartphone can generate as much traffic as 49 non-smartphones, and a tablet as much as 127 non-smartphones. CISCO, VISUAL NETWORKING INDEX: GLOBAL MOBILE DATA TRAFFIC FORECAST UPDATE, 2013-2018 15 (2014), *available at* <http://bit.ly/1b13ryX>. The monthly traffic per smartphone is expected to increase from 529MB/month to 2,672MB/month from 2013 to 2018. *See id.*

¹⁹ *Id.*

²⁰ *See* National Broadband Plan at 75-79 ; PRESIDENT'S COUNCIL OF ADVISORS ON SCIENCE AND TECHNOLOGY (PCAST), REPORT TO THE PRESIDENT: REALIZING THE FULL POTENTIAL OF GOVERNMENT-HELD SPECTRUM TO SPUR ECONOMIC GROWTH (2012) (PCAST Report), *available at* <http://1.usa.gov/1eqkp6T>; ITU, ESTIMATED SPECTRUM BANDWIDTH REQUIREMENTS FOR THE FUTURE DEVELOPMENT OF IMT-2000 AND IMT-ADVANCED (2006), *available at* <http://bit.ly/1mGaS3V>; 4G AMERICAS, SUSTAINING THE MOBILE MIRACLE: A 4G AMERICAS BLUEPRINT FOR SECURING MOBILE BROADBAND SPECTRUM IN THIS DECADE (2011) *available at* <http://bit.ly/1c64NcD>.

²¹ While the move toward smaller cells is not motivated solely by the need to reuse scarce spectrum, investment costs are increased by excessive spectrum scarcity. *See* JOHN CHAPIN AND WILLIAM LEHR, MIT, MOBILE BROADBAND GROWTH, SPECTRUM SCARCITY, AND SUSTAINABLE COMPETITION (2011), *available at* <http://bit.ly/1hcW1ZO>.

²² In economic terms, regulatory barriers distort the opportunity costs of using spectrum resources efficiently. For example, incumbent users of TV broadcast and government spectrum are confronted with too low an opportunity cost, whereas mobile broadband providers and new entrants confront an opportunity cost for incremental spectrum that is artificially elevated.

²³ The PCAST report summarizes these efforts, including expanding options for shared spectrum, secondary spectrum trading, and reallocating spectrum for flexible, exclusive use licenses such as anticipated by the broadcast spectrum incentive auction. *See* PCAST Report.

²⁴ According to the FCC:

Promoting competition is a fundamental goal of the Commission's policymaking. Competition has played and must continue to play an essential role in the mobile wireless industry – leading to lower prices and higher quality for American consumers, and producing innovation and investment in wireless networks, devices, and services.

Sixteenth Mobile Competition Report, 28 FCC Rcd at 3958 ¶ 410.

²⁵ Economic theory is ambiguous on how best to maximize auction proceeds. For example, an auction that included monopoly rents might maximize producer willingness-to-pay for spectrum rights, but ensuring a competitive auction may better ensure that the auction captures the producer surplus. For further discussion, see Lehr, William and Musey, J. Armand, "Right-Sizing Spectrum Auction Licenses: The Case for Smaller Geographic License Areas in the TV Broadcast Incentive Auction," November 20, 2013, *available at* SSRN: <http://ssrn.com/abstract=2357792> or <http://dx.doi.org/10.2139/ssrn.2357792>.

²⁶ *See* Thomas W. Hazlett & Roberto E. Muñoz, *A Welfare Analysis of Spectrum Allocation Policies*, 40 RAND J. ECON. 424 (2009); Jerry A. Hausman, *Valuing the Effect of Regulation on New Services in Telecommunications*, 28 Brookings Papers on Econ. Activity 1 (1997); Gregory L. Rosston, *The Long and Winding Road: The FCC Paves the Path with Good Intentions*, 27 TELECOMM. POL'Y 501 (2003).

²⁷ Congress provided the FCC with the authority to undertake the Broadcast Incentive Auction through the Spectrum Act. *See* Middle Class Tax Relief and Job Creation Act of 2012, Pub. L. No. 112-96, §§ 6402-03, 125 Stat. 156 (2012).

²⁸ An auction with a single buyer would serve no purpose.

²⁹ A recent paper by Mayo and Sappington (2014) also focuses on competition concerns and auction design, but with a very different goal in mind from the purpose of this paper. *See* John Mayo & David Sappington, *Employing Auctions to Allocate Scarce Inputs*, Working Paper, Georgetown Center for Bus. & Public Pol. (Feb. 2014), <http://tinyurl.com/lotvn7l>. Mayo and Sappington present an abstract model of duopoly competition that extends the economics literature on vertical foreclosure to the question of auction design. Their principal result suggests that an auction design that does not seek to limit increased spectrum acquisition by the largest competitors (*i.e.*, an "unfettered auction") may offer the best way to maximize total (consumer) welfare. The authors do not offer empirical estimates, nor do they attempt to map their results to current industry conditions, an effort that would require significant additional effort. Moreover, their model does not directly address the viability of competition. That is, the model assumes that Cournot competition will continue but with potentially slightly different market shares depending on how the auction is designed. Nevertheless, by highlighting the complex series of assumptions that are necessary to yield a tractable theoretical result, their paper provides an indirect endorsement of the methods employed in this study.

³⁰ Economic viability makes it necessary for efficient firms (*i.e.*, cost-minimizing firms) to have a reasonable expectation that they will recover their costs, which includes covering their operating costs and earning a fair risk-adjusted return on their invested capital. This equates with an economic profit of zero, but with a reasonable level of net income as an accountant would report it.

³¹ For analysts' views on the mobile broadband or Internet value chain, *see, e.g.*, ATKEARNEY, INTERNET VALUE CHAIN ECONOMICS (2010), <http://bit.ly/N128p3>; OPEN INTERNET ADVISORY COMMITTEE, OPENNESS IN THE MOBILE BROADBAND ECOSYSTEM (2013), *available at* <http://bit.ly/1mHfrea>; Chetan Sharma, *Mobile Operator's Dilemma (and Opportunity): The Fourth Curve*, GIGAOM (Jul. 17, 2012, 12:27 PM), <http://bit.ly/1kgayUD>.

³² The average monthly bill fell faster in real terms, as the overall Consumer Price Index (CPI) increased over the same time period. *Compare* News Release, Bureau of Labor Statistics (BLS), CPI—Dec. 1994, *available at* <http://1.usa.gov/1hwhI5m>, *with* News Release, BLS, CPI—Dec. 2012, *available at* <http://1.usa.gov/1mxWFTb>.

³³ *See Sixteenth Mobile Competition Report*, 28 FCC Rcd at 3877, Tbl. 38.

³⁴ *See id.* at 3832, 3879-80, Tbls. 30, 40. Obtaining reliable estimates of market pricing for mobile services is complicated because many services are sold in bundles and the average price per unit needs to be imputed on the basis of aggregate revenue data.

³⁵ Text messaging and other limited data services were possible with 2G systems, but the usability and hence usage of data services was quite limited—although industry participants and analysts understood that data traffic would account for the majority of traffic in the future. *See, e.g.*, *The Shape of Phones to Come*, ECONOMIST, May 22, 2001, *available at* <http://econ.st/1ewbcbw> (describing voice's displacement by data).

³⁶ The first Apple iPhone was introduced in June 2007 with AT&T and was not even a 3G phone. *See* CrunchBase, *iPhone*, <http://bit.ly/Kk58uA> (last visited Feb. 25, 2014). However, Apple's iconic design and the inclusion of WiFi helped ignite rapid growth in mass market consumer use

of mobile data services, including Internet access. Apple followed its initial success with its first 3G handset the following summer. *See id.* The first 3G Android handsets (based on the OS developed by Google) became available in October 2008, and were first offered by T-Mobile. *See* Charlie Sorrel, *Official: First Android Phone to Debut on September 23*, WIRED (Sept. 17, 2008), available at <http://wrd.cm/1fq4xWk>. Prior to the release of the iPhone and the mass transition to smartphone devices it inspired, the majority of cellular mobile data service traffic was due to dongle-connected PCs and smartphones like BlackBerry, Treos, and others used by "road warrior" business professionals. *See, e.g.*, Walter S. Mossberg & Katherine Moehret, *Testing Out the iPhone*, WALL. ST. J., June 27, 2007, available at <http://on.wsj.com/OCMjGb> (comparing the newly release iPhone to then-popular Blackberry and Treo models).

³⁷ LTE stands for Long Term Evolution and is under development by the international standardization effort, 3GPP. *See* 3GPP, <http://www.3gpp.org/> (last visited Feb. 25, 2014). 3GPP has been engaged in standardization efforts for mobile cellular networks since 1999 when it was working on 3G standards. *See* 3GPP, *Cover Story*, <http://bit.ly/1bKDd48> (last visited Feb. 25, 2014). The first true LTE standard issued by 3GPP was Release 10 (2010), but operators sometimes branded interim versions like Release 9 (2009) as 4G LTE. *See, e.g.*, ERIK DAHLMAN ET AL., 4G: LTE/LTE-ADVANCED FOR MOBILE BROADBAND 1 (1st ed. 2011). 3GPP is currently finalizing LTE Release 12, with work on future generations proceeding concurrently. *See* Dino Flore, *3Gpp RAN: Rel-12 and beyond* (Feb. 2014), available at <http://bit.ly/1hnof3A>.

³⁸ Operators have been converting to LTE on a market-by-market basis, rolling out services once the necessary infrastructure upgrades are completed. *See, e.g.*, Kevin Fitchard, *AT&T Passes the 500-Market Milestone in its LTE Rollout*, GIGAOM (Jan. 6, 2014, 5:08 PM), <http://bit.ly/MvGmce>. Morgan Stanley forecasts that, by the end of 2014, Verizon and AT&T will each have LTE networks covering 300 million POPS (94% of the U.S. population), with Sprint covering 275 million POPS (86%) and T-Mobile covering 225 million POPS (70%). *See* MORGAN STANLEY EQUITY RESEARCH, *TELECOM SERVICES: 2014 OUTLOOK* (2013), available at <http://bit.ly/1k84KQ3>.

³⁹ *See, e.g.*, Elise A. Couper et al, *Boom and Bust in Telecommunications*, 89 FED. RES. RICHMOND ECON. Q. 1, 14-17 (2003), available at <http://bit.ly/1mI4fOy>.

⁴⁰ *See, e.g.*, HASUNG HWANG & CONCETTA STEWART, *LESSONS FROM DOT-COM BOOM AND BUST* (2006), available at <http://bit.ly/1mDwKu>.

⁴¹ For example, the viability of B2C depended on first developing the capabilities of B2B, which were themselves a natural extension of earlier enterprise business process automation efforts.

⁴² Much of the CLEC investment was premised on a regulatory model that required incumbent local telephone companies to unbundle their networks. *See* Couper et al, *supra* n. 3939 at 13.

⁴³ It is worth remembering that high-flying companies like Netflix (streaming video), Facebook (social networking), and Amazon (mCommerce and cloud computing) were hardly the first or only businesses seeking to address markets that have resulted in their subsequent success (and the failure of earlier or less well-executed businesses).

⁴⁴ For an early discussion of why 3G and WiFi were more likely to evolve as complements, *see* William Lehr & Lee McKnight, *Wireless Internet Access: 3G vs. Wifi?*, TELECOMM. POL'Y 27, 351-70 (2003), available at <http://bit.ly/1hnpGii>.

⁴⁵ *See* IEEE 802, <http://www.ieee802.org/>. The IEEE working group principally responsible for "WiFi" WLAN standards is P802.11. *Id.* The original WiFi standards were 802.11a (operating at 2.4GHz) and 802.11b (operating at 5GHz). *See* Cisco, *802.11 Security Summary*,

<http://bit.ly/1dz1Snw> (last visited Feb. 26, 2014). Subsequent enhancements have added significant functionality for extending WiFi into a much wider range of usage environments. For pointers to on-going work, *see* <http://www.ieee802.org/11/PARs/index.html>.

⁴⁶ For example, the industry is in the early stages of considering how LTE might operate in unlicensed spectrum, which is where WiFi technologies currently operate. *See, e.g.*, Qualcomm, *LTE Advanced in unlicensed spectrum*, <http://bit.ly/1eugLHv> (last visited Feb. 26, 2014).

⁴⁷ *See* JOHN CHAPIN & WILLIAM LEHR, *MOBILE BROADBAND GROWTH, SPECTRUM SCARCITY, AND SUSTAINABLE COMPETITION* (2011), *available at* <http://bit.ly/1cmGr97>.

⁴⁸ *See* Dale Jorgenson, *Information Technology and the U.S. Economy*, 91 AM. ECON. REV. 1 (2001).

⁴⁹ *See* Dale Jorgenson et al., *A Retrospective Look at the U.S. Productivity Growth Resurgence*, 22 J. ECON. PERSPECTIVES 3 (2008), *available at* <http://bit.ly/1ew4B0A>.

⁵⁰ *See* MELVYN FUSS AND LEONARD WAVERMAN, *BELL CANADA, CANADA'S PRODUCTIVITY DILEMMA: THE ROLE OF COMPUTERS AND TELECOM* (2006), *available at* <http://bit.ly/1poZEzN>.

⁵¹ From 1984 to 2006, the average revenue per minute for long distance (a blend of domestic and international) fell from \$0.32 to \$0.07 per minute. *See* FCC, *Trends in Telephone Service* 13-1 (2008), *available at* <http://fcc.us/1foXBJ3>. A significant share of this reduction has been attributed to rate rebalancing, with a shift from wage-based access charges to fixed subscriber line charges for recovering the non-traffic sensitive costs of local access.

⁵² Cable modem-based broadband services established an early lead over telephone-based DSL broadband services after 1996. *See* SHARON GILLETT AND WILLIAM LEHR, *AVAILABILITY OF BROADBAND INTERNET ACCESS: EMPIRICAL EVIDENCE* (1999), *available at* <http://bit.ly/MYEEkz>.

⁵³ The FCC's National Broadband Plan notes the potential for only limited facilities-based competition for high-speed broadband services as cable upgrades to DOCSIS 3.0, while telephone providers limit their expansion of FTTx services. National Broadband Plan at 42.

⁵⁴ For a discussion of the implications of mobile competition for broadband competition, *see* WILLIAM LEHR, *MOBILE BROADBAND AND IMPLICATIONS FOR BROADBAND COMPETITION AND ADOPTION* (2010), *available at* <http://bit.ly/1fCiyyN> (prepared on behalf of Broadband for America).

⁵⁵ Historically, fixed line telephony offered higher call quality relative to mobile telephony from locations with fixed telephone lines. However, mobile telephony allows calls to be made from any location, and over time with improvements in the quality of mobile telephony, the quality advantages of fixed line telephone calls has disappeared.

⁵⁶ As of December 2012, 38.2% of U.S. households only had cellular telephone service, up from less than 10% as recently as June 2006. *See* STEPHEN J. BLUMBERG AND JULIAN V. LUKE, *CENTER FOR DISEASE CONTROL (CDC), WIRELESS SUBSTITUTION: EARLY RELEASE OF ESTIMATES FROM THE NATIONAL HEALTH INTERVIEW SURVEY, JULY-DECEMBER 2012* (2013), *available at* <http://1.usa.gov/1huqwZu>.

⁵⁷ *See* J. SCOTT MARCUS AND JOHN BURNS, *EUR. COMM'N, STUDY ON IMPACT OF TRAFFIC OFF-LOADING AND RELATED TECHNOLOGICAL TRENDS ON THE DEMAND FOR WIRELESS BROADBAND SPECTRUM* (2013), *available at* <http://bit.ly/1mp3VnR>.

⁵⁸ Economic theory supports the proposition that additional competition will result in lower prices, but is ambiguous as to the contribution of additional competitors. For example, in the classic model of Bertrand (price) competition, the competitive outcome is achieved with just two firms; while in Cournot (quantity) competition, the competitive outcome is only reached as the number of firms becomes infinite. Most real-world markets are somewhere in between, with firms seeking to differentiate their products and thereby attenuate the extent of price competition. See Avner Shaked and John Sutton, *Relaxing Price Competition through Product Differentiation*, 49 REV. ECON. STUD. 1, 3-13 (1982); Maarten Janssen and Eric Rasmusen, *Bertrand Competition Under Uncertainty*, 50 J. INDUS. ECON. 1, 11-21 (2002). Product differentiation occurs even in markets such as telecommunication services where the services might be perceived as relatively homogeneous. See Shane Greenstein and Michael Mazzeo, *The Role of Differentiation Strategy in Local Telecommunication Entry and Market Evolution: 1999-2002*, 54 J. INDUS. ECON. 293, 323-50 (2006).

⁵⁹ Parker and Röller found evidence of cellular prices significantly exceeding competitive levels and even what would be predicted in a competitive duopoly model in the U.S. during the period from 1984-1988 when regulations restricted competition to two firms. See Philip Parker and Lars-Hendrik Röller, *Collusive Conduct in Duopolies: Multimarket Contact and Cross-Ownership in the Mobile Telephone Industry*, 28 RAND J. ECON. 207, 304-22 (1997).

⁶⁰ There was a large docket of comments. See, e.g., *Applications of AT&T Inc. and Deutsche Telekom AG for Consent to Assign or Transfer Control of Licenses and Authorizations*, FCC Staff Analysis and Findings and Order, 26 FCC Rcd 16184 (2011). Additional comments and documents can be found through the FCC's electronic comment filing system by searching Docket No. 11-65. See FCC, *Electronic Comment Filing System* (last accessed Feb. 25, 2014), available at <http://bit.ly/1huHAP3>.

⁶¹ See Free Press, Reply to Opposition, WT Docket No. 11-65 (June 20, 2011).

⁶² By the end of 2014, all four of the national mobile operators are expected to have their LTE networks substantially built: Verizon and AT&T's covering 300 million POPS, or 94% of the population; Sprint covering 200 million POPS (67% as of end of 2013) and T-Mobile covering 230 million pops (72% by end of 2014). See Eric Zeman, *Sprint LTE Network Slowly expands*, INFORMATIONWEEK (Sept. 16, 2013), available at: <http://ubm.io/1hbIeCS>; Chris Neiger, *Sneak Peak at T-Mobile in 2014*, THE MOTLEY FOOL (Dec. 18, 2013), available at <http://bit.ly/NvhZMv>.

⁶³ See, e.g., *Applications of Deutsche Telekom AG, T-Mobile USA, Inc. and MetroPCS Communications, Inc. for Consent to Transfer of Control of Licenses and Authorizations*, Memorandum Opinion and Order and Declaratory Ruling, 28 FCC Rcd 2322, 2324 ¶ 5 (2013).

⁶⁴ See, e.g., *AT&T Inc., Leap Wireless International, Inc., Cricket License Company, LLC and Leap Licenseco, Inc. Seek Consent to the Transfer of Control of AWS-1 Licenses, and International 214 Authorizations, and the Assignment of One 700 MHz License*, Pleading Cycle Established, 28 FCC Rcd 12776 (WTB 2013).

⁶⁵ As noted earlier, broadband (including mobile broadband) is essential infrastructure which means it is a necessary input for significant segments of our economy. See Section 2, *supra*. To protect competition in downstream sectors, regulators will need to ensure adequate access to the bottleneck facilities. This may require direct or indirect regulation – for example, a credible threat of regulation may be sufficient.

⁶⁶ See *Verizon v. FCC*, United States Court of Appeals for District of Columbia Circuit, No. 11-1355 (Jan. 14, 2014), available at <http://1.usa.gov/1eBNagO>.

⁶⁷ See Tommaso M. Valletti, *A model of competition in mobile communications*, 11 INFO. ECON. & POL. 1, 61-72 (1999), available at <http://bit.ly/1hcozTi>.

⁶⁸ See *Sixteenth Mobile Competition Report*, 28 FCC Rcd at 3864 ¶ 257.

⁶⁹ See Sascha Segan, *MetroPCS Launches First LTE Network in U.S.*, PC Magazine (Sept. 21, 2010), <http://bit.ly/OIeAdP>.

⁷⁰ See Brad Reed, *MetroPCS Snags First LTE Android Phone*, NetworkWorld (Feb. 9, 2011), <http://bit.ly/1ji2cLq>.

⁷¹ See Droid Life, *MetroPCS Launches World's First VoLTE Network and Smartphone* (Aug. 7, 2012), <http://bit.ly/1imCvtJ>.

⁷² See Alex Heath, *Cricket Brings Prepaid iPhone to the US*, Cult of Mac (May 31, 2012), <http://bit.ly/1mlg38r>.

⁷³ PhoneArena, *Sprint, Sanyo Offer First US Camera Phone* (Nov. 4, 2002), <http://bit.ly/1hPliYf>.

⁷⁴ News Release, T-Mobile, *T-Mobile Celebrates 10 Years of Innovation with Launch of Unlimited Nationwide 4G Data Plans* (Sept. 5, 2012) (T-Mobile News Release), available at <http://t-mo.co/1jMqle6>.

⁷⁵ *Id.*

⁷⁶ *Id.*

⁷⁷ *Id.*

⁷⁸ See, e.g., FCC, *Evolution of Cable Television*, <http://fcc.us/1puLKvK> (providing a history of cable television regulation).

⁷⁹ In addition to the studies cited separately in the discussion below, the following empirical research notes the price lowering effect of competition on cable television rates: Thomas W. Hazlett, *Competition vs. Franchise Monopoly in Cable Television*, 4 CONTEMP. ECON POL'Y 2, 80 (1986); S. Levin & J. Meisel, *Cable Television and Competition: Theory, Evidence, and Policy*, 15 TELECOMM. POL'Y 519 (1991); Robert Rubinovitz, *Market Power and Price Increases for Basic Cable Service Since Deregulation*, 24 RAND J. ECON. 1 (1993); Richard O. Beil et al., *Competition and the Price of Municipal Cable Television Services: An Empirical Study*, 5 J. REG. ECON. 401 (1993); Austan Goolsbee & Amil Petrin *The Consumer Gains from Direct Broadcast Satellites and the Competition with Cable TV*, 72 ECONOMETRICA 351 (2004).

⁸⁰ See Mary T. Kelly & John S. Ying, *Testing the Effectiveness of Regulation and Competition on Cable Television Rates*, E. ECON. J. (2013), available at <http://bit.ly/1cNoHXV>.

⁸¹ See Scott J. Savage & Michael Wirth, *Price, Programming and Potential Competition in US Cable Television Markets*, 27 J. REG. ECON. 25 (2005).

⁸² See T. BEARD & G. FORD, PHOENIX CTR. FOR ADVANCED LEGAL & ECON. PUB. POL'Y STUD, *COMPETITION BETWEEN WIRELINE NETWORKS AS FRAGMENTED DUOPOLY WITH AN EMPIRICAL APPLICATION TO THE CABLE TELEVISION INDUSTRY* (1999).

⁸³ See William M. Emmons & Robin A. Prager, *The Effects of Market Structure and Ownership on Prices and Service Offerings in the U. S. Cable Television Industry*, 28 RAND J. ECON. 732 (1997). Indeed, they conclude that "it seems reasonable to infer that approximately 20% of the price of basic service provided by private monopoly cable operators, in both 1983 and 1989, can be attributed to monopoly rents." *Id.*

⁸⁴ See *Implementation of Section 3 of the Cable Television Consumer Protection and Competition Act of 1992; Statistical Report on Average Rates for Basic Service, Cable Programming Service, and Equipment*, Report on Cable Industry Practices, 28 FCC Rcd 9857, 9859 ¶ 3 (MB 2013). This estimate likely understates the impact of facilities-based competition because it is based on a statutory definition and regulatory finding of what constitutes "effective competition." See *id.* Similar results have been observed in previous surveys. See, e.g., *Implementation of Section 3 of the Cable Television Consumer Protection and Competition Act of 1992; Statistical Report on Average Rates for Basic Service, Cable Programming Service, and Equipment*, Report on Cable Industry Practices, 27 FCC Rcd 9326 (MB 2012).

⁸⁵ *Implementation of Section 3 of the Cable Television Consumer Protection and Competition Act of 1992; Statistical Report on Average Rates for Basic Service, Cable Programming Service, and Equipment*, Report on Cable Industry Practices, 20 FCC Rcd 2718, 2721 (2005).

⁸⁶ See YALE BRAUNSTEIN, EXPECTED CONSUMER BENEFIT FROM WIRED VIDEO COMPETITION IN CALIFORNIA (2006), available at <http://bit.ly/1lkdlIQ>; AM. CONSUMER INST., DOES CABLE COMPETITION REALLY WORK? A SURVEY OF CABLE TV SUBSCRIBERS IN TEXAS (2006) (ACI Study), available at <http://bit.ly/1clemij>. The ACI Study notes that "cable incumbents generally matched or beat the prices of their rivals in competitive markets, while charging prices between 40% and 75% higher in other markets." ACI Study at 6 (citing DAVID W. BARDEN ET AL., BANK OF AMERICA, BATTLE FOR THE BUNDLE 10 (2006)).

⁸⁷ See JAMES N. DERTOUZOS & STEVEN S. WILDMAN, NAT'L CABLE TELE ASSOC., COMPETITIVE EFFECTS OF BROADCAST SIGNALS ON CABLE (1990); ROBERT W. CRANDALL, TELECOMMUNICATIONS, INC., REGULATION, COMPETITION AND CABLE PERFORMANCE (1990).

⁸⁸ Since the divestiture of AT&T in 1984, the Incumbent Local Exchange Companies (ILECs, descendants of the Baby Bells that are currently owned by AT&T and Verizon) were precluded from offering long distance (interLATA) services. The Telecommunications Act of 1996 established a path for allowing ILECs into long distance competition under Section 271 of the Act. See 47 U.S.C. § 271. The ILECs began to file and were approved for access under this provision beginning in 1999 on a state-by-state basis. See Gregory L. Rosston et al., *Effect of Network Unbundling on Retail Prices: Evidence from the Telecommunications Act of 1996*, 56 J.L. ECON. 487 (2013).

⁸⁹ See JERRY HAUSMAN ET AL., THE CONSUMER-WELFARE BENEFITS FROM BELL COMPANY ENTRY INTO LONG-DISTANCE TELECOMMUNICATIONS: EMPIRICAL EVIDENCE FROM NEW YORK AND TEXAS (2002).

⁹⁰ See DAEGON CHO ET AL., THE IMPACT OF MOBILE NUMBER PORTABILITY ON PRICE, COMPETITION AND CONSUMER WELFARE (2013), available at <http://ssrn.com/abstract=2265104>; see also Lukasz Grzybowski, *Regulation of mobile Telephony across the European Union: An Empirical Analysis*, 28 J. REG. ECON. 47 (2005), available at <http://bit.ly/1emzadQ>.

⁹¹ See JEFFREY PRINCE & SHANE GREENSTEIN, DOES SERVICE BUNDLING REDUCE CHURN (2013), available at <http://bit.ly/1k7TbSc>.

⁹² Höffler studied a panel of European countries from 2000-2004. See Felix Höffler, *Cost and Benefits from Infrastructure Competition: Estimating Welfare Effects from Broadband Access Competition*, 31 TELECOMM. POL'Y, 401 (2007), available at <http://bit.ly/1puZgZE>.

⁹³ See GAO, WIRE-BASED COMPETITION BENEFITED CONSUMERS IN SELECTED MARKETS (2004), available at <http://1.usa.gov/1c9fVpj>.

⁹⁴ See Gerald R. Faulhaber et al., *Assessing Competition in US Wireless Markets: Review of the FCC's Competition Reports*, 64 FED. COMM. L.J. 319 (2011).

⁹⁵ The equivalent change since 2010 is -5% for the wireless CPI and +6% for the overall CPI, representing a net real decline in wireless prices of -11%. See BLS, CPI DETAILED REPORT Tbl. 25 (2013) (providing data for 2005-2013), available at <http://www.bls.gov/cpi/cpid1312.pdf>; BLS, CPI DETAILED REPORT (2005) (providing data for 1997-2005), available at <http://www.bls.gov/cpi/cpid0512.pdf>.

⁹⁶ See Andrew Odlyzko, *Internet Pricing and the History of Communications*, 36 COMPUTER NETWORKS 493 (2001).

⁹⁷ Verizon was the first to offer an unlimited wireless plan in 2008. See, e.g., Saul Hansell, *Verizon Stabs Sprint with Unlimited Wireless Plan*, N.Y. TIMES, Feb. 19, 2008, available at <http://nyti.ms/1cROkXn>. By 2009, Verizon and AT&T had cut prices, and then Sprint responded by reducing the price of its unlimited calling plan from \$150 to \$100—a reduction of 33%. See Niraj Sheth, *Sprint Squeezed by Rival Price Cuts; Carrier's Lower-Price Lure May Be Undercut by Reductions at AT&T, Verizon*, WALL ST. J., Jan. 21, 2010.

⁹⁸ If it is feasible for the firm to sustain such a SSNIP without attracting entry or competitive responses that would make this unprofitable, then the firm is presumed to have market power. See, e.g., DOJ AND FTC, HORIZONTAL MERGER GUIDELINES (2010), available at <http://1.usa.gov/1fSaLt3>.

⁹⁹ See J.R. Hicks, *The Valuation of the Social Income*, 7 ECONOMICA 105 (1940).

¹⁰⁰ Hausman (1997, 1999) recognized that a new good may be regarded as a good with a price for which demand would be zero in the time preceding its introduction, and then with assumptions about the functional form of aggregate demand, it is possible to estimate the demand curve and compute consumer surplus with only very limited data about the actual market. See Jerry A. Hausman, *Valuing the Effect of Regulation on New Services in Telecommunications*, 28 MICROECONOMICS 1 (1997); Jerry A. Hausman, *Cellular Telephone, New Products, and the CPI*, 17 J. BUS. & ECON. STAT. 188 (1999).

¹⁰¹ Erik Brynjolfsson et al., *Consumer Surplus in the Digital Economy: Estimating the Value of Increased Product Variety at Online Booksellers*, 49 MGMT. SC. 1580 (2003).

¹⁰² See Lukasz Grzybowski & Pedro Pereira, *The Complementarity Between Calls and Messages in Mobile Telephony*, 20 INFO. ECON. & POL'Y 3, 279 (2008).

¹⁰³ The price elasticity of demand is the percent increase in quantity demanded per percent change in price. Because demand and prices move in opposite directions, it is negative.

¹⁰⁴ See RALF DEWENTER & JUSTUS HAUCAP, DEMAND ELASTICITIES FOR MOBILE TELECOMMUNICATIONS IN AUSTRIA (2007), available at <http://bit.ly/1emdej6>.

¹⁰⁵ See Grzybowski & Pererira, *supra* n. 1022.

¹⁰⁶ See Hausman, *supra* n. 1000.

¹⁰⁷ See Philip Parker and Lars-Hendrik Röller, *Collusive Conduct in Duopolies: Multimarket Contact and Cross-Ownership in the Mobile Telephone Industry*, 28 RAND J. Econ. 207 (1997).

¹⁰⁸ See CTIA Survey.

¹⁰⁹ See DAVID BARDEN ET AL., BANK OF AMERICA AND MERRILL LYNCH, 3Q13 US WIRELESS MATRIX: TABLETS BOOST SUBS, HURT ARPU Tbl. 6 (2013).

¹¹⁰ See USB EQUITY RESEARCH, US WIRELESS 411: VERSION 50 – TOP 10 U.S. WIRELESS TRENDS IN 3Q13 Fig. 19 (2013).

¹¹¹ \$20 Billion = 0.11(\$184B). Reasonable modifications to the assumptions generate annual consumer benefits of \$18 to \$27 billion.