



The shift to 5G	1
The fuel for economic growth	2
The competition is fast	4
Speed matters; fuel is expensive	6
Winning takes a nation	9
Conclusion	12
Authors and acknowledgements	13

The shift to 5G

The world's economy is at another pivotal moment as artificial intelligence, the Internet of Things (IoT), and augmented reality are transitioning from buzz words to the basis for long-term national economic potential. The catalyst for this economic growth is wireless connectivity enabled by 5G—a new standard for wireless telecommunications. 5G is not simply an extension of 4G, nor is it merely a faster wireless capability. 5G makes possible the connection and interaction of billions of devices of almost any kind and collection of data from those devices. Indeed, 5G connectivity promises to lead consumers, industries, and governments to new frontiers of productivity and innovation.

However, an examination of how the United States compares internationally on investments critical to 5G surfaces a disturbing trend. Other countries are outspending the United States in both relative and absolute terms. In these countries, the execution is faster and more capital efficient than it is in the United States. Since 2015, China outspent the United States by approximately \$24 billion in wireless communications infrastructure and built 350,000 new sites,¹ while the United States built fewer than 30,000.² Looking forward, China's five-year economic plan specifies \$400 billion in 5G-related investment.³ Consequently, China and other countries may be creating a 5G tsunami, making it near impossible to catch up.

Being first to LTE afforded the United States macroeconomic benefits as it became a test bed for innovative mobile, social, and streaming applications.⁴ Being first to 5G can have even greater and more sustained benefits to our national economy given the network effects associated with adding billions of devices to the 5G network, enabling machine-to-machine interactions and utilizing data from such interactions.

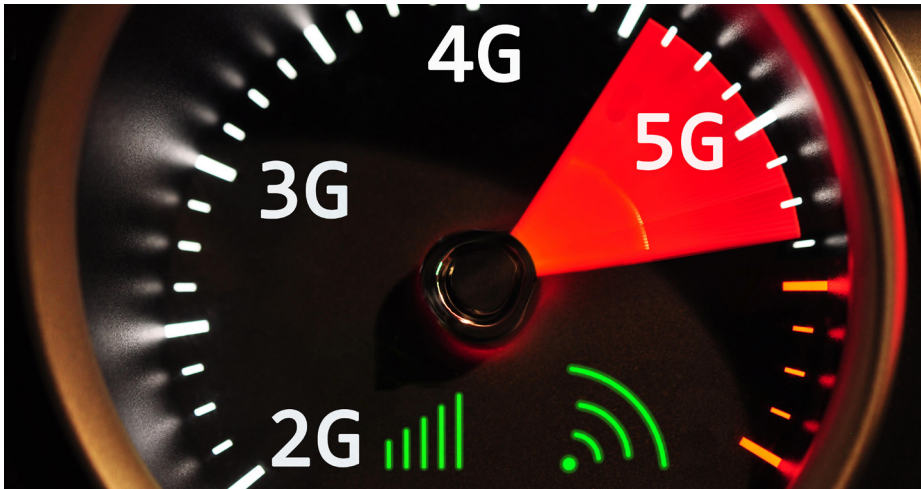
In this paper, we examine how the United States compares to other countries, revealing dramatic examples where it is losing ground in the race to be first to 5G. We also consider a range of actions and policies that may help overcome deployment challenges and enable rapid and extensive 5G deployment, including a light-touch policy framework that urges carriers and their ecosystem partners to negotiate solutions without government intervention and encourages carriers to operate at greater scale and economic efficiency.

1. Company financials; Deloitte analysis.

2. Company financials.

3. Bien Perez, "Why China is set to spend US\$411 billion on 5G mobile networks," South China Morning Post, June 19, 2017, <http://www.scmp.com/tech/china-tech/article/2098948/china-plans-28-trillion-yuan-capital-expenditure-create-worlds>, accessed May 16, 2018.

4. Craig Wigginton, Dwight Allen, Carl E. Steidtmann, Kevin Thompson, and Christine Brodeur, *The impact of 4G technology on commercial interactions, economic growth, and U.S. competitiveness*, Deloitte Development LLC, August 2011.



5G technology introduction

marks the beginning of a new era in connectivity that will impact almost every element of daily life.

The fuel for economic growth

5G technology introduction marks the beginning of a new era in connectivity that will impact almost every element of daily life. First-adopter countries embracing 5G could sustain more than a decade of competitive advantage. Countries that were first to adopt prior generations of wireless technology were also rewarded with broader macroeconomic benefits, but 5G has potential for an even larger first-mover advantage.

What's different this time? 5G is more than just a new wireless interface protocol offering more capacity and better performance for smartphones. It is that, but it is also a myriad of technology innovation like antenna designs and device communication protocols to standardize both the way licensed and unlicensed networks interact and the way network applications collaborate. With this array of capabilities, 5G technology will influence everything we do. Instead of just connecting people to people through their smartphones, 5G connects an unlimited number of things to other things, which can communicate all day, every day. As a result, the value that 5G can create is

not constrained by the number of people and the amount of time we have for consuming information. The opportunity for technology to influence productivity and automation could have a seismic impact on our macro economy. **Network effects, where the value of a product or service is dependent on the number of users, could grant a first-adopter sustained leadership and the potential to capture a greater share of the benefits associated with 5G.**

We know from social networking examples that the more people connect, the more useful or valuable the network becomes, which attracts even more connections. This "network effect" is also true for the connection of mobile phones and IoT devices. A network, for example, where only one phone is connected to it, is useless. But a network with millions of phones connected to it around the globe is extremely valuable. Expanding that concept to a common network that has many uses is even more valuable. The Internet is extraordinarily valuable because it supports a vast range of uses. Because it operates under a common set of protocols and standards, those use cases can also

interact, touching off unlimited potential for innovation.

Deloitte predicts 5G will expand the network effect dramatically by extending the reach of the Internet to almost any kind of connection, by almost any kind of device, anywhere a wireless signal can reach. Markets that attract the most users first will also influence further innovation as 5G networks mature and become ubiquitous. As different kinds of devices connect, new use cases will emerge for collections of devices previously considered unrelated, attracting even more investment and economic benefit.

Moreover, as devices connect to the 5G network, companies will be able to exploit what *The Economist* referred to as the "data-network effect" in a 2017 article: "a powerful economic engine ... using data to attract more users, who then generate more data, which help to improve services, which attracts more uses."⁵ Accordingly, countries that adopt 5G first are expected to experience disproportionate gains in macroeconomic impact compared to those that lag.

5. "Data is giving rise to a new economy," *The Economist*, May 6, 2017, <https://www.economist.com/briefing/2017/05/06/data-is-giving-rise-to-a-new-economy>, accessed June 22, 2018.



Voice and data

1G and 2G

The first era of wireless communications, in the 1970s and 1980s, was characterized by the introduction and early adoption of cellular communications, but as a niche product with only 2.1 percent of the US population having a mobile phone by 1990.⁶ Many US companies benefited with Motorola having 70 percent share of mobile phones globally in 1985. Europe pushed for mass adoption of mobile communications (personal communications networks) in 1990 using standardized (e.g., GSM) communications with 2G technology. This resulted in European leadership, with Nokia, Ericsson, and Alcatel becoming leading manufacturers, while Motorola's share of handsets fell to 15 percent by 2000. Similarly, by 2000, the United Kingdom had 70.2 percent mobile phone penetration versus 38.6 percent for the United States.⁷



Smartphones: Internet from everywhere

3G, 4G, and 4G LTE

With the advent of 3G and 4G networks and the launch of the modern smartphone in 2007, we moved to the era of data communications. The United States embraced this change and built on its existing Internet leadership to shift the center of gravity for the wireless industry back home. American tech companies displaced the European players as the new industry giants.



Hyperconnectivity between people and things

5G

5G will enable a new era of connecting machines, with the value of these connections being in the data interchange between them. While US companies are generally well positioned now, a slow rollout of these connected devices will impact the sustainability of their competitive position.

6. CTIA's Wireless Industry Survey, CTIA-The Wireless Association, 2015. https://api.ctia.org/docs/default-source/default-document-library/ctia_survey_ye_2014_graphics.pdf, accessed June 28, 2018.

7. Company financials; Deloitte analysis.

The competition is fast

The United States, Japan, and South Korea have all made significant strides toward 5G readiness, but none to the same extent as China. Infrastructure spend and tower density distinguish China's leap forward and highlight the degree to which China outpaces the United States during these early stages of 5G deployment.

5G's speed and coverage capabilities rely on network densification, which requires the addition of towers and small cells to the network. 5G standards provide for less spectral efficiency gains than previous generations of network technology. Instead,

improved speed and capacity stem from the ability to utilize large blocks of contiguous spectrum and higher frequencies. This requires carriers to add 3 to 10 times the number of existing sites to their networks.⁸ Most of this additional infrastructure will likely be built with small cells that use lamp posts, utility poles, or other structures of similar size able to host smaller, less obtrusive radios required to build a densified network.

China is building network site density at an unprecedented rate. China Tower is the leading provider of sites and owns

approximately 96 percent of macro towers, small cells, and DAS sites that serve China's wireless carriers. China Tower has invested \$17.7 billion in capital and added more than 350,000 sites since 2015.⁹

China Tower has a total of approximately 1.9 million wireless sites, compared to approximately 200,000 in the United States.¹⁰ This means the United States has 0.4 sites compared to China's 15.2 sites for every 10 square miles. Comparing tower density on a per capita basis is marginally more equitable, where the United States lags China by approximately three times.

During 2017, China Tower added approximately 460 sites per day, implying U.S. tower companies and carriers added fewer sites in the last three years than China Tower added in three months.



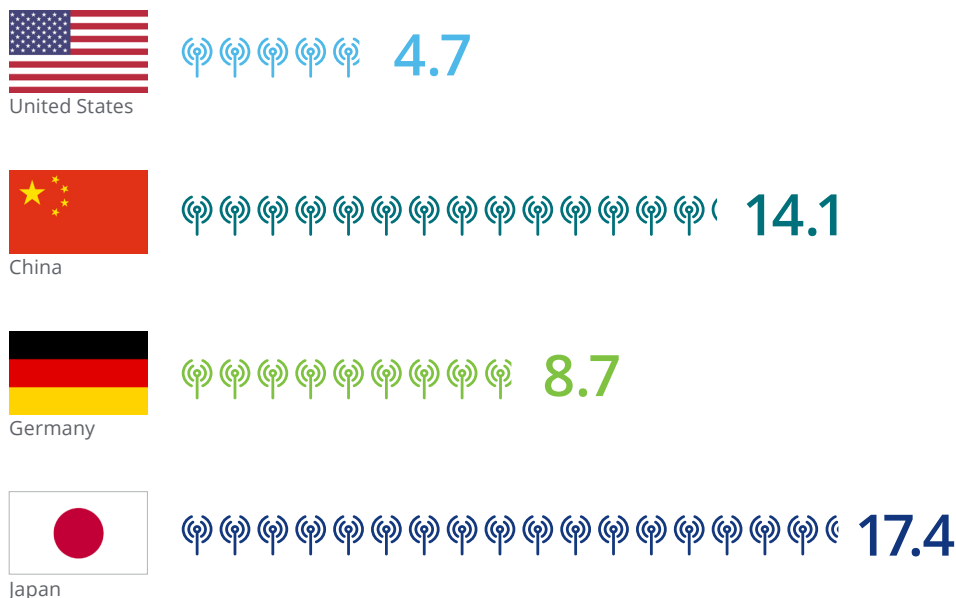
8. Small Cell Forum and Deloitte analysis.

9. Company financials.

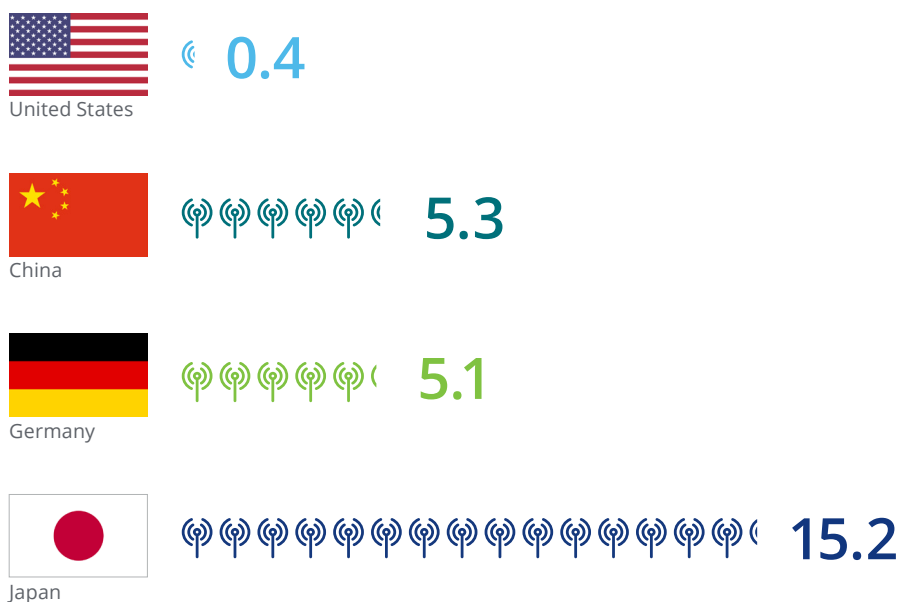
10. Includes largest US tower providers, which provide an estimated 65–75 percent of the total sites in the United States, according to the CTIA, which estimates 154,000 towers in the United States. "The Wireless Industry: Industry Data," CTIA, 2018, <https://www.ctia.org/the-wireless-industry/infographics-library>.

Figure 1. Country comparison

Sites per 10,000 people



Sites per 10 square miles



Source: Company financials; Deloitte analysis.

The United States has 4.7 sites compared to China's 17.4 sites per 10,000 people (Figure 1).

Of significant interest to US telecommunications operators is the speed at which China is constructing new wireless sites to add capacity to its digital infrastructure. During 2017, China Tower added approximately 460 sites per day, implying US tower companies and carriers added fewer sites in the last three years than China Tower added in three months.¹¹ This disparity between the speed at which China and the United States can add network infrastructure and capacity bodes well for China's prospects in the race to 5G and the services enabled.

Deloitte estimates that the equipment necessary to add a carrier in China is about 65 percent the cost of adding a carrier in the United States. Civil engineering and permitting in China is approximately 15 percent to 20 percent of the costs in the United States.¹² This suggests that the United States would need to spend 2.67 times the amount that China spends to generate an equivalent amount of wireless network capacity.¹³ This estimate can be normalized for China's population and wireless subscribers versus the United States. **However, even with such normalization, we conclude that the United States underspent China in wireless infrastructure by \$8 billion to \$10 billion per year since 2015.**

While the United States continues to enjoy strong technological and standardization leadership in mobile, social, and streaming applications, the disparity between speed and size of network expansion appears to already be having impacts on the number of connected devices as we migrate to IoT and massive 5G connectivity. The two Chinese carriers that report IoT devices (China Telecom and China Mobile) had 273 million IoT devices connected at the end of 2017, compared to 52.6 million for the two US carriers that report (Sprint and AT&T).¹⁴

11. Company financials; Deloitte analysis.

12. Deloitte Benchmarking Study; company financials.

13. Deloitte analysis.

14. Company financials.

Speed matters; fuel is expensive

The glaring disparities in US wireless infrastructure development and the potential of network effects inherent in 5G and the Internet of Things create the impetus for investment. But before carriers set budgets and deployment timelines, they should resolve how to monetize the billions in CapEx they will need to spend. What new use cases will 5G enable? What functionality within 5G will allow carriers to monetize their investment using new applications and new ecosystems? Carriers routinely pose these questions to their strategy groups, equipment vendors, industry consortiums, and consultants. While 5G will certainly enable new use cases that create entirely new products and services, growing national economies in the process, how much of that new value will flow to the carriers who enabled it is less certain.

This problem is not unique to 5G. Wireless industry leaders posed the same questions as they contemplated how quickly to roll out 4G/LTE almost a decade ago. LTE promised to bring new use cases and add new revenues to help carriers earn returns on their network investment. Released commercially in the United States in 2010, carriers expected LTE to provide

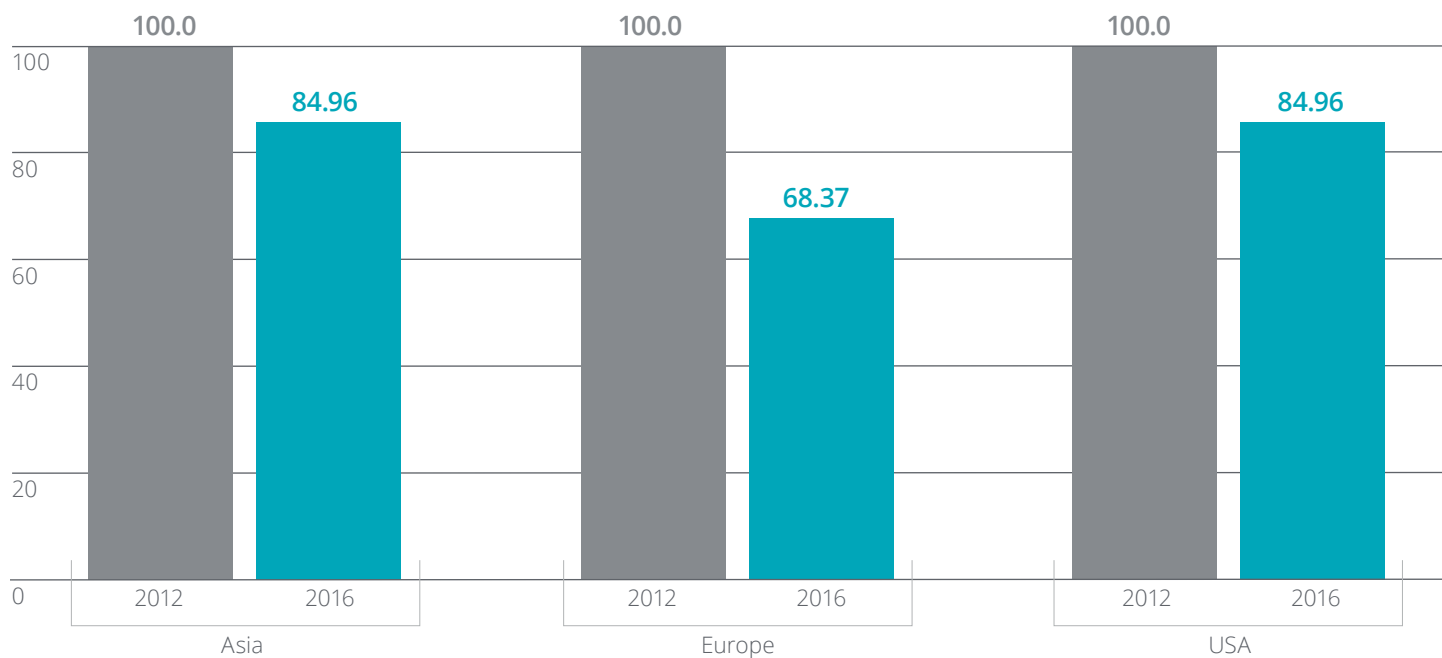
an immediate boost to smart cities, asset tracking, retail, manufacturing, health care, and many other industries. Many assumed that if carriers played an integral role shaping the ecosystems that comprised these use cases, then profits would follow.

However, the promise of new revenue streams for carriers enabled by LTE has remained largely unfulfilled. Instead of reaping the anticipated benefits of new revenue streams from LTE, carriers endured rapid traffic growth from over-the-top (OTT) video and declining average revenue per user (ARPU) from intense price competition. Ultimately, wireless carriers all but abandoned the notion of revenue growth from LTE-enabled applications and instead leaned on LTE to help lower cost per bit to fend off the risk of falling behind competitors. LTE became a capacity layer to help carriers grapple with the capital requirements imposed by exponentially growing traffic, making price, speed, and network capacity the bases of competition. Figure 2 depicts declining ARPUs across all regions during a period of rapid traffic growth, resulting in dramatic declines in revenue per MB (yield) (see Figure 3).

Almost everyone agrees, 5G will generate new products and services—**but how much of this value that will be captured by carriers is uncertain.**

Figure 2. ARPU Index

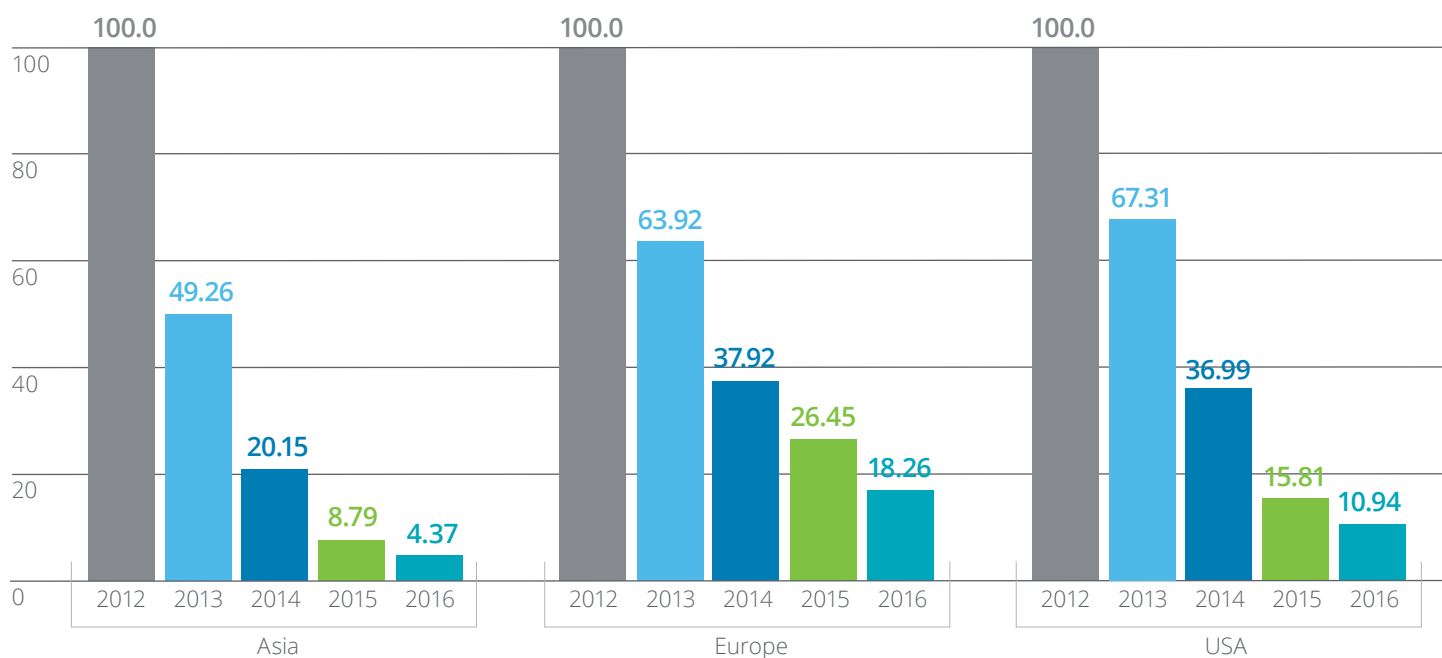
When indexed, ARPUs in Asia and the United States have declined the same amount from 2012 to 2016.



Source: Company financials; Deloitte analysis.

Figure 3. Revenue per MB Index

When indexed, the revenue per MB has declined the fastest in Asia, as new technologies and networks were adopted during the period.



Source: Company financials; Deloitte analysis.



The ongoing pattern of steep declines in what customers pay per MB of mobile data makes the new investment needed for 5G difficult for many carriers to support. However, customers' ability to access more and more data for the same or lower price is a potential boon to other industries and the national economy.

The network effects associated with 5G may be even greater based on the billions of devices connected and communicating with one another. Various attributes of network effect have been long debated. But Metcalfe's law, which states that the value of a network is the square of the number of connections and thus each connection is "worth" more than the last, remains mostly uncontested in describing the effect of people connecting to the phone network or Internet.¹⁵ Whether this law extends to IoT is untested; however, Deloitte expects connected devices will more likely resemble Metcalfe's law in contrast to a linear rule model. Although no one has yet connected billions of machines to the same network or to each other,

comparisons to social networks imply Metcalfe's law will at least likely apply to the value of information that can be collected and exchanged between these billions of devices.

The network provider, however, generally does not realize this increasing value per connection. Revenue attributable to the carrier for each connection is essentially the same and thus each connection is "worth" the same once they achieve minimum efficient scale. Because the network provider receives the same revenue for each connection, these end-user benefits take the form of "externalities" to the service provider.

Positive benefits of these externalities can accrue to those who take advantage of the information connected and exchanged. The multitude of unique machines that connect and generate new and increasingly complex interactions will be able to generate new value. Indeed, for many situations the collection and processing of data allows

us to potentially see into the near-term future with some degree of certainty. It is this value of information and the creation of new uses of data that will likely be the foundation for economic leadership in the next few decades. However, it is unclear how these returns create incentives for wireless carriers to invest in the infrastructure that enables broader economic benefits.

Other countries, no doubt, recognize the demonstrated benefits of externalities on their macro economy and the predicament for carriers that may not realize the full benefits of their 5G investment. Often, governments focus on resolving negative externalities, such as pollution caused by a factory. The implications of delaying 5G deployment in the face of externalities make it likely that policy makers and governments around the world will propose government intervention, possibly in the form of subsidies or nationalized infrastructure, in an effort to improve the 5G business case and speed its deployment.

15. Robert Metcalfe, "Metcalfe's law: A network becomes more valuable as it reaches more users," *Infoworld* 17, no. 40 (October 1995): 53.

Winning takes a nation

In the face of 5G business case challenges and the potential for foreign subsidies, US carriers, policy makers, and investors should consider ways to reduce the friction inherent in the network deployment process, which causes long cycle times and higher costs relative to other countries. Deloitte examined a range of actions and policies that may help address deployment challenges and enable rapid and extensive 5G deployment.

First, the United States should consider establishing a light-touch policy framework to address 5G's inherent externalities that limit the value created by infrastructure investment from accruing to the carriers. Other countries may consider subsidizing, nationalizing, or otherwise regulating

Instead, carriers and their ecosystem partners can address the potential pitfalls of externalities by negotiating efficient solutions. Negotiated contracts between carriers and Internet content and applications providers more effectively attribute profits to those making infrastructure investments on behalf of the users.

We have already seen examples of such negotiated solutions with LTE. Unlimited usage of video streaming applications come with service-level conditions that help curtail network congestion. In some cases, content providers agreed to reduce video resolution and steaming speeds in return for carriers granting unlimited access to that content for their subscribers. These conditions, negotiated between commercial entities,

Internet innovators. For example, carriers could negotiate a contract with health care or automotive providers to fund edge computing services that allow for lower latency and higher reliability. Carriers could also negotiate solutions that help share data from the billions of devices from various companies and sectors that reside on their network to strengthen the investment case for 5G. Such agreements, negotiated at low cost, can continue to create triple-win scenarios for carriers, consumers, and the growing landscape of industries that use communications infrastructure to further revenue growth and profitability.

However, this light-touch regulatory framework does not absolve policy makers of responsibility to inspire US leadership in 5G. Policy makers at the state, local, and federal levels can help reduce the friction associated with deploying next generations of communication infrastructure. **Specifically, reducing the cost and deployment cycle times for small cells will help remove a major obstacle to network densification and allow carriers to add desperately needed low-cost capacity to our nation's wireless networks.**

Subsidizing, nationalizing, or otherwise regulating aspects of a nation's communications infrastructure risks disrupting a communications and technology ecosystem that has proven symbiotic and resilient over the past decade.

aspects of a nation's communications infrastructure to speed 5G deployment. However, such interventions in the United States could risk disrupting a communications and technology ecosystem that has proven symbiotic and resilient over the past decade. Policy intervention in the same ecosystem of carriers, suppliers, Internet innovators, and consumers that enabled LTE leadership could inflict unintended consequences on competition and innovation.

can offer a win-win-win for carriers, content providers, and consumers. Consumers receive access to as much content as they want without overage fees. Content providers get unlimited access to their viewer base. In turn, carriers can better plan for and/or avoid traffic increases that necessitate costly upgrades.

5G capabilities that allow for ultra-low latency, network slicing, and traffic prioritization support even more creative contractual solutions between carriers and

Most small cells utilize public or utility-owned infrastructure (such as lamp posts or utility poles) given their relatively easy access to power and proximity to fiber backhaul. In all cases, small cell deployment, even on existing sites, requires municipal and power utility approval to provide for public safety, aesthetics, and construction coordination. However, the permitting process for these pre-existing sites may be equal to or lengthier and more cumbersome than that needed to build new macro towers. Cycle times for municipal permit approval can be greater than 120 days, forcing delays in consumer access to wireless capacity and inflicting significant costs on carriers.

Many cities continue to use the same approval standards and processes for small cell equipment deployed at the top of an existing city lamp post as they would for deployment of a new 70-foot macro tower in the public right of way; an unsustainable solution if the United States aims to keep pace with other countries’ 5G deployment.

A national database of small cell deployment statistics and leading practices could be created to motivate small cell approvals while maintaining municipal authority.

This database would utilize publicly available permit application, resubmittal, and approval data to provide visibility into small cell approval rates, cycle times, and reasons for permit rejections. Maintained and administered by federal government agencies, the database would cast a light on what works and doesn’t work to get small cells deployed. National or third-party reporting on small cell progress in various municipalities can create the right incentives for cities and carriers while also providing a gauge for US progress on 5G infrastructure deployment.

The potential economic benefits of 5G will soon become a differentiator for cities looking to attract businesses and residents. The ability to compare progress between municipalities and learn lessons from the successes or costly delays of others may generate constructive cooperation between cities and carriers to become more efficient when deploying 5G infrastructure. Cities that provide accelerated and lower-cost mechanisms for wireless infrastructure deployment are likely to get rewarded by providing their residents and businesses access to game-changing 5G services faster than cities that fail to address costly or unreasonable delays.

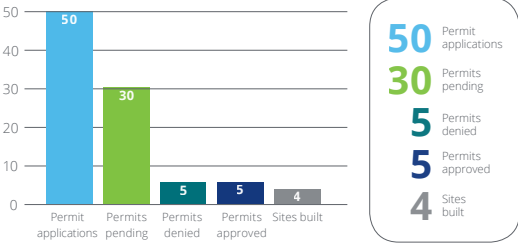
Create a national communications infrastructure database



The United States should consider establishing a national database to provide deployment statistics, leading practices, and visibility into small cell approval and denial rates.

Report for Anytown, USA

Permit Status



Key Metrics

Average days for permit approval	120 days
Overall approval rate	30%
Average rounds of permit redlines	3 rounds

Plan Check Comments

Load calculations	10%
Formatting	20%
References	5%
Specificity	5%
Location	30%
Design modifications	30%



Finally, carriers' ability to realize economic returns is essential to induce rapid 5G deployment. Using LTE deployment as an example, larger carriers that benefited from scale economies were first movers on upgrading to LTE. While factors beyond financials contribute to the speed in which carriers upgrade to the next generation of technology, the two largest carriers in the United States were first movers while smaller carriers lagged by as much as two to three years.¹⁶ For example, at the end of 2012, the two largest carriers covered more than 250 million people, which was approximately 80 percent of the population, with LTE. While coverage is similar today, it took an extra year for the two smaller carriers to cover approximately 200 million

people.¹⁷ Although carriers' LTE coverage varied initially, the United States was well on a path to LTE leadership, which enabled the rapid economic development that followed.

Viable carrier economics and scale may be of even greater importance in 5G deployment, which will likely demand that US carriers absorb billions in incremental labor and equipment costs. With 5G, the required investment may be greater and the returns less certain which could delay the investment needed for carriers and the United States to supply the next generation of communications infrastructure. Being first to 5G matters, especially when competing on a global scale.

16. Marguerite Reardon, "Sprint officially launches 4G LTE in 15 cities," *CNet*, July 16, 2012, <https://www.cnet.com/news/sprint-officially-launches-4g-lte-in-15-cities/>, accessed June 22, 2018. Jessica Dolcourt, "AT&T launching LTE on Sept. 18, at long last," *CNet*, September 15, 2011, <https://www.cnet.com/news/at-t-launching-lte-on-sept-18-at-long-last/>, accessed June 22, 2018. Marguerite Reardon, "Verizon to launch 4G wireless network December 5," *CNet*, December 1, 2010, <https://www.cnet.com/news/verizon-to-launch-4g-wireless-network-december-5/>, accessed June 22, 2018. Marguerite Reardon, "T-Mobile launches 4G LTE network," *CNet*, March 26, 2013, <https://www.cnet.com/news/t-mobile-launches-4g-lte-network/>, accessed June 22, 2018.

17. Phil Goldstein, "Sprint's LTE rollout hampered by lack of backhaul and Network Vision issues," *FierceWireless*, July 24, 2013, <https://www.fiercewireless.com/wireless/sprint-s-lte-rollout-hampered-by-lack-backhaul-and-network-vision-issues/>, accessed June 22, 2018.

Conclusion

Innovation in applications that organize our lives, reconnect us with friends, simplify shopping, or increase our productivity combined with the connected devices, sensors, and data that have made this possible has become the fuel powering our economic leadership. **None of this would have been possible without massive investments in the country's underlying communications infrastructure.** As another era of untapped economic potential emerges with the adoption of

5G technology—where the number of subscribers and the amount of information they can consume is no longer a limiting factor, but where an unlimited number of devices and applications can exchange, process, and synthesize massive amounts of data for our benefit—investment in upgrading the underlying communications infrastructure becomes even more critical. But unless tangible steps are taken to help rebalance the private investment case for the upgrade with the demonstrated external

benefits to other industries and the public good, the United States may risk losing the leadership it gained in the previous era. The negative consequences could take decades to overcome, and other countries are already making their moves. Policy makers, carriers, and industries with the most at stake should move now to streamline policies and processes and collaborate with ecosystem players to help create efficient solutions to investment barriers.



The negative consequences could take decades to overcome, and other countries are already making their moves.

Authors

Dan Littmann

Principal

Deloitte Consulting LLP
dlittmann@deloitte.com

Phil Wilson

Managing Director

Deloitte Consulting LLP
phwilson@deloitte.com

Craig Wigginton

Partner

Deloitte & Touche LLP
cwigginton@deloitte.com

Brett Haan

Principal

Deloitte Consulting LLP
bhaan@deloitte.com

Jack Fritz

Senior Manager

Deloitte Consulting LLP
jacfritz@deloitte.com

Acknowledgements

Brad Hunt

Tim Krause

Erica Sivertson

Violette Zhu



As used in this document, "Deloitte" means Deloitte Consulting LLP, a subsidiary of Deloitte LLP. Please see www.deloitte.com/us/about for a detailed description of our legal structure. Certain services may not be available to attest clients under the rules and regulations of public accounting.

This publication contains general information only and Deloitte is not, by means of this publication, rendering accounting, business, financial, investment, legal, tax, or other professional advice or services. This publication is not a substitute for such professional advice or services, nor should it be used as a basis for any decision or action that may affect your business. Before making any decision or taking any action that may affect your business, you should consult a qualified professional advisor. Deloitte shall not be responsible for any loss sustained by any person who relies on this publication.

Copyright © 2018 Deloitte Development LLC. All rights reserved.