CRA Insights: The Economics of 5G

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The economics of 5G deployment in the "race" to 5G: The economic effects of adopting new technology

The history of the wireless telecommunications industry has been characterized by discrete improvements in the range of services, quality of services, and network efficiency produced by technological innovations known as wireless "generations." As mobile telecommunications service has grown to become one of the most important industries in the worldwide economy today, each new generation of wireless technology has fueled economic growth by bringing a unique set of service and network improvements and expanding the ecosystem of devices and services around it.

In this *Insights* we discuss the economic benefits brought by new wireless technologies. Taking an international view, we estimate the effect on national GDP from the transition from 3G to 4G wireless technology that occurred primarily in the 2010s—the most recent technological innovation wave to have reached majority penetration rates in the countries studied. Our results show that a one percentage point increase in the 4G penetration rate increased national GDP per capita by 0.035 percent, all else equal, over the countries studied. This is a statistically and economically significant effect.

The generational development of new wireless technologies: from 1G to 5G

Mobile wireless telephony has been around since the late 1970s. Early wireless telephony, known as First Generation, or "1G," was an analog technology that allowed for voice transmissions only. It required large and heavy mobile phones (the first mobile phone introduced in the US, the Motorola DynaTAC, weighed nearly two pounds and was over a foot long). Moreover, the service was expensive and billed by the minute to conserve scarce network capacity.

In the early 1990s, the advent of digital technology significantly expanded network capacity and enabled transformative new services such as texting, pricing innovations, and (albeit slow and rudimentary) internet access. These new digital technologies were known as Second Generation (2G) technologies, represented by several different standards. In the US, AT&T Wireless (then known as Cingular) adopted a standard known as Time Division Multiple Access (TDMA), which later evolved into a standard called Global System for Mobile Communications (GSM). T-Mobile (formerly VoiceStream Wireless) adopted the GSM standard. Sprint (now part of T-Mobile) and Verizon Wireless adopted a standard known as Code Division Multiple Access (CDMA).

As technology continued to develop in the early and mid-2000s, broadband services of increasing functionality and speed became available, with wireless carriers implementing a series of upgrades along GSM/TDMA and CDMA paths. Third generation (3G) technology emerged around 2001 in

Japan and was the first true step to high-quality mobile broadband. A first 3G standard, known as Universal Mobile Telecommunications System (UMTS), also referred to as wideband CDMA (WCDMA), was developed based on the GSM standard. A second 3G standard, known as CDMA2000, was developed based on the CDMA standard. A third 3G standard, Time Division-Synchronous Code Division Multiple Access (TD-SCDMA), which used Time Division Duplex technology, was developed and used only in China.[1] High-Speed Download/Upload Packet Access (HSPA) was an evolution of the UMTS 3G standard introduced in the early 2000s.

The divergence of technology paths came to a halt with the advent of the fourth generation wireless technology, which was introduced around 2008. Worldwide, companies largely converged on long term evolution (LTE) as the 4G technology that became widely adopted. LTE allows for substantially faster upload and download broadband speeds, lower latency, and improved spectrum efficiency than 3G. 4G technology also offers better voice quality and allows consumers to conveniently access social media, browse the internet, and stream videos in real-time on mobile devices.[2] The faster broadband speeds enabled a sea change in the video marketplace, as mobile devices came to be used to view content that had previously been viewed only on televisions and desk-top devices. New content markets proliferated and new platforms emerged for consumption of video content on mobile devices. In addition, the lower latency of 4G vastly improved the experience of mobile multi-player games and on-demand video content.

As we discussed in an earlier ***Insights***, the transition from 4G to 5G is expected to enable a new round of unique and revolutionary new services. Augmented and virtual reality, 8K (ultra-high definition) video, and new forms of social media are expected to evolve as real-time communications become available to consumers. It is expected that we will also see innovations in transportation, logistics, the Internet of Things (IoT), electricity distribution, public safety, health and wellness, robotics, and smart cities.[3]

As network technologies have evolved, an economic ecosystem has arisen not only of companies that provide retail wireless telecommunications services, but also companies that develop the next generation technologies: companies that design, build, and sell the numerous and varied components of network infrastructure equipment and facilities and companies that design, build, and sell the handsets, tablets, and other devices used with wireless technology.

The new services and network efficiencies brought by new generations of wireless technology have additional ripple effects throughout the economy. For example, the increased connection speed of 4G that improved the experience of gaming and on-demand video empowered the growth of the gaming and entertainment industry. Both the direct effects of new technologies and the ripple effects contribute to economic growth.

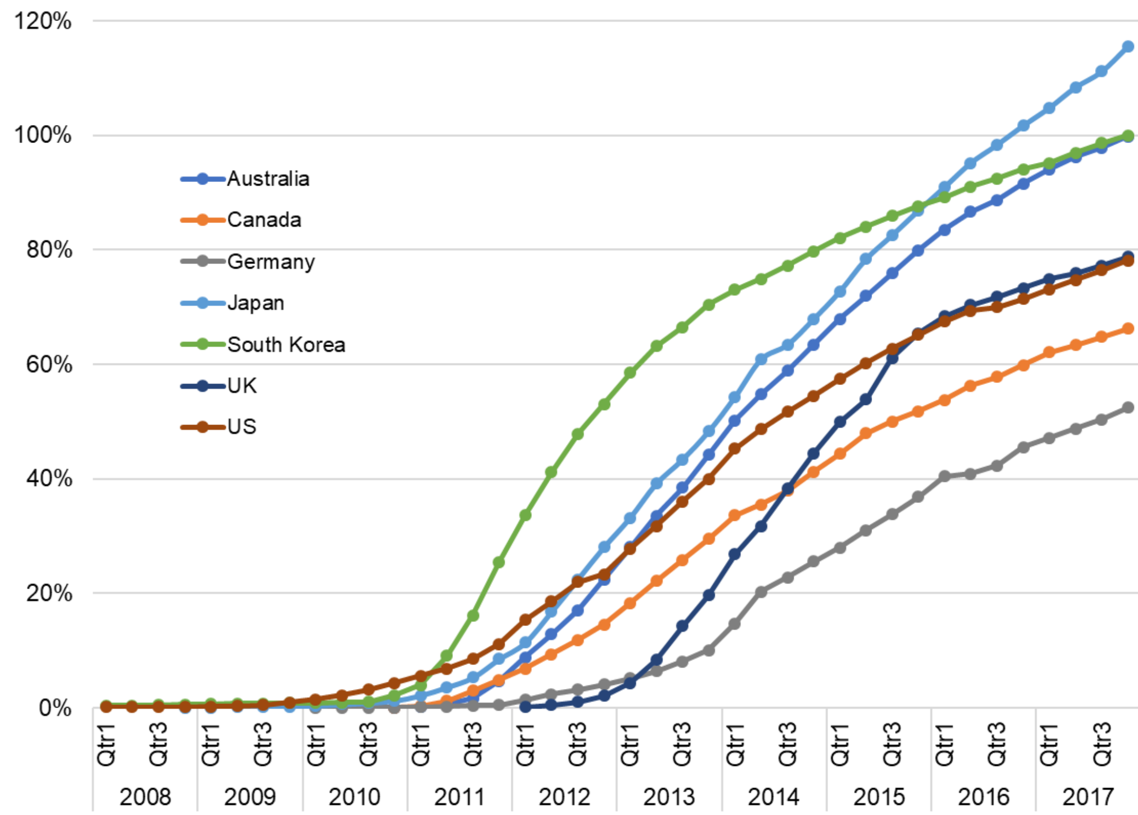
Transition to a new generation of wireless technology brings economic benefits

There is substantial evidence that speed of deployment and adoption of mobile wireless technologies affect a country's overall economic development. For example, a 2011 study analyzing data from 192 countries covering the period from 1990 to 2007 found that the contribution of mobile telecommunications infrastructure to economic growth is much greater for countries with higher mobile penetration.[4] It also found that mobile telecommunications infrastructure contributed 0.11 percent to annual GDP growth in low income countries and 0.20 percent to annual GDP growth in high income countries. In another study, the authors examined the role of wireless technology leadership across the globe. They concluded that Europe's leadership in 2G yielded benefits in balance of trade, employment, and intellectual capital, including the development of the European tech industry, embodied most notably in Nokia and Ericsson becoming global leaders in wireless equipment.[5] The study also concluded that the US's leadership in 4G led to an increase in GDP of $43.6 billion between 2011 and 2014. Consistent with those conclusions, a May 2020 study relying on US data from 2010 to 2014—the early years of 4G deployment—showed that increases in 4G adoption had a strong positive impact on employment and real GDP.[6]

Increases in new wireless technology penetration increases a country's GDP

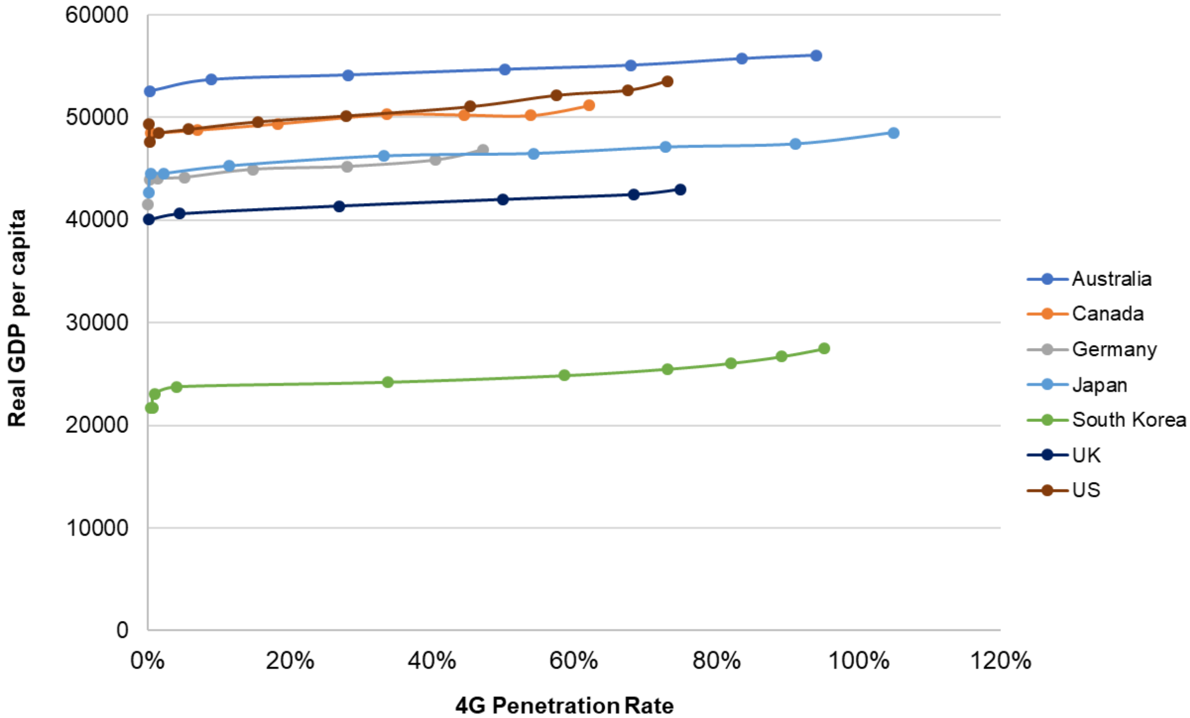
Different countries have adopted new generations of wireless technologies, and diffused them throughout their networks and populations, at different times and rates. As a result, the benefits of new technologies have not been experienced simultaneously in each country. In our analysis, we examine wireless deployment and adoption across countries to provide further insights into the effects of technology on economic growth and the anticipated effects of the nascent global transition from 4G to 5G. We applied data from GSMA Intelligence and the World Bank on 4G penetration rates, total mobile penetration rates, and real (i.e., inflation adjusted) GDP in Australia, Canada, Germany, Japan, South Korea, the United States, and the United Kingdom over the years 2012 to 2017.[7] The 4G penetration rates for these seven countries are shown in Figure 1. The relationship between 4G penetration and real GDP per capita is shown in Figure 2. As Figure 2 shows, real GDP per capita demonstrates a visually positive relationship with the country's 4G penetration rate.

Figure 1: 4G Penetration Rate, Q1 2008–Q4 2017



Source: GSMA Intelligence database

Figure 2: 4G Penetration Rate v. Real GDP per capita, 2008–2017



Sources: GSMA Intelligence database; World Bank

To isolate the effect of 4G wireless penetration on each country's real GDP we controlled for other factors, including the country's overall wireless penetration rate, the country's net investment in nonfinancial assets, the country's total supply of labor, and the country's volume of trade measured as the sum of imports and exports. These variables, as well as data on real GDP per capita, were taken from the World Bank's World Development Indicators (WDI) database.[8]

The econometrics bear out the positive relationship between wireless penetration and GDP suggested by Figure 2. We find that a one percentage point increase in the 4G penetration rate was associated with increased real GDP per capita of 0.035 percent over the countries studied, after controlling for other factors just mentioned.[9] According to this estimate, a one percentage point increase in 5G penetration in the US in 2020 would result in a more than $7.5 billion increase in US GDP in 2020.[10]

Quantifying the effect of new wireless technology deployment provides guidance for answering public policy questions. For example, as we noted in the previous ***Insights***, Canadian regulators are currently determining the amount of mid-band spectrum that should be allocated for flexible use, including 5G. They are also considering the timeline of the spectrum reallocation. As we showed in the previous ***Insights***, countries that allocated sufficient amounts of mid-band spectrum for 5G (>80 MHz) per carrier on average have, or are predicted to have, a faster rate of 5G service adoption than countries that did not allocate sufficient amounts of mid-band spectrum for 5G. Using the regression results just discussed, we estimate that reallocating 200 MHz of spectrum in the 3800 MHz band by December 2023 instead of December 2025 would accelerate the deployment of 5G networks in Canada and, in turn, would increase Canadian GDP by CAD$7.4 billion over the period 2024 through 2026.[11]

As another example, in another study the effect of delayed allocation of mid-band spectrum and subsequent delayed 5G rollout in the US on the US economy was estimated. The study found that delaying the allocation of mid-band spectrum in the US by half a year would reduce US GDP by $133 billion over the six-year period from 2019 through 2024.[12]

Concluding remarks

Mobile wireless technology has had profound effects on social interaction, politics, and technology beyond the economic effects measurable in real GDP. That the effects are measurable in GDP is, however, a notable tribute to the importance of modern communications technology in our lives and the lives of others around the world. Quantifying the anticipated benefits from adoption of new wireless technologies is a necessary step in performing realistic and responsible cost/benefit analysis of public policies that can advance or retard wireless innovation and deployment.

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[3] "Smart city" refers to the use of technologies such as the IoT to connect city components and make everyday life easier for its citizens. Examples of smart city 5G applications include smart grid, smart lighting, 5G vehicle-to-vehicle communications. See more details in Sanjay Dhar et al., "Smart Cities: How 5G Can Help Municipalities Become Vibrant Smart Cities," Accenture Report, February 27, 2017, at https://www.accenture.com/us-en/insights/strategy/smart-cities; 3rd Generation Partnership Project; Technical Specification Group Services and System Aspects; Release 15 Description; Summary of Rel-15 Work Items (Release 15), TR 21.915 v1.0.0 (2019-03), pp. 9-10, at https://www.3gpp.org/release-15.

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[6] Jeffrey A. Eisenach and Robert Kulick, "Economic impacts of mobile broadband innovation: Evidence from the transition to 4G," American Enterprise Institute Economics Working Paper, May 2020, at https://www.aei.org/wp-content/uploads/2020/06/Eisenach-Kulick-Mobile-Broadband-Innovation-WP.pdf.

[7] The year 2012 was the first year in which all countries in the data had positive penetration rates. The year 2017 was the last year of available data at the time of our analysis.

[8] Our model specification follows the model specification developed in the 2012 Deloitte study. See "What is the impact of mobile telephony on economic growth? A Report for the GSM Association." Deloitte, November 2012, pp. 13-14, at https://www.gsma.com/publicpolicy/wp-content/uploads/2012/11/gsma-deloitte-impact-mobile-telephony-economic-growth.pdf.

[9] This result is statistically significant and robust to modifications in the model specification. Details of this estimation are provided in the reply comments of SES S.A. on the Consultation on the Technical and Policy Framework for the 3650-4200 MHz Band and Changes to the Frequency Allocation of the 3500-3650 MHz Ban issued by Innovation, Science and Economic Development Canada's on August 27, 2020. Debra J. Aron, Andy Baziliauskas, and Olga Ukhaneva, "The Impact of Accelerated 3800 MHz Band Repurposing on the Canadian Economy," November 30, 2020, p. 24, at https://www.ic.gc.ca/eic/site/smt-gst.nsf/vwapj/SLPB-002-20-SES-SA-ReplyComments.pdf/$FILE/SLPB-002-20-SES-SA-ReplyComments.pdf.

[10] Using US GDP of $21,487,876,000,000 for Q4 2020, the estimated effect on GDP is calculated as follows: $21,170,252,000,000*0.035*0.01=$7,520,656,600.

[11] Debra J. Aron, Andy Baziliauskas, and Olga Ukhaneva, "The Impact of Accelerated 3800 MHz Band Repurposing on the Canadian Economy," November 30, 2020, pp. 24-25, at https://www.ic.gc.ca/eic/site/smt-gst.nsf/vwapj/SLPB-002-20-SES-SA-ReplyComments.pdf/ $FILE/SLPB-002-20-SES-SA-ReplyComments.pdf.

[12] Debra J Aron, "The Impact on the U.S. Economy of Excluding Huawei from Participation in the U.S. Market for Wireless Network Equipment," October 7, 2019, Exhibit B.2, ¶ 20, at https://ecfsapi.fcc.gov/file/1011236282523/Final%20-%20Huawei%20Ex%20Parte%20re%20Economic%20Report%20(10-11-2019).pdf.