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An Economic Analysis of 5G Wireless Deployment: Impact on the U.S. and Local Economies

by

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I. Introduction and Summary

The United States has never been a more connected nation than now, and 5G, the latest generation of wireless network technology, promises to make us even more so.[1] 5G offers higher transmission rates, more reliable connectivity, and lower latency, allowing businesses and consumers to perform existing tasks better and cheaper and to do entirely new things. This *Perspectives* examines the potential of 5G as a general-purpose technology to unleash improvements in economic productivity, employment, and consumer value – all of which are sorely needed to ensure a full recovery from the COVID-19 pandemic.

Both existing evidence and new estimates regarding the economic impact of 5G are presented. 5G is and will continue to be an important driver of economic growth in the nation. Investment to create 5G networks contributes directly to GDP, and $225 billion in capital expenditure will be needed over 2019–2025 to fully deploy 5G. However, the direct effect on GDP from capital expenditures (CAPEX) is only a small part of the total economic effects of broadband in general and 5G in particular.

5G will affect the labor market through direct and indirect means. The broadest impact on the labor market comes from new employment opportunities through the way 5G will enable new applications, services, and ways of doing business, along with the general growth of businesses. The additional labor required to build out the network to deploy 5G will create the most immediate demand for new jobs.

My analysis finds that 8.5 million jobs will be created over 2019-2025 compared to a counterfactual 4G-only world, with an average of 1.2 million new jobs each year. The workers filling these new jobs will earn more than $560 billion during that time, create $1.7 trillion in additional output, and add over $900 billion to U.S. GDP.

Of course, the positive economic impacts described above result from the fact that businesses and consumers will also benefit from 5G networks that meet their demands for new goods and services. The Internet of Things (IoT) – which requires 5G to realize its full potential – will be a major source of productivity improvements and competitive advantage for businesses. The 5G ecosystem will also create a significant amount of value for consumers, who can look forward to mobile broadband transmission speeds of about 10 to 20 times faster than 4G LTE, as well as much lower latency. The true promise of 5G and IoT for consumers lies in doing completely new things using mobile and fixed wireless and IoT technology devices, such as healthcare devices, autonomous vehicles and traffic management systems, the smart grid for revolutionizing energy management, smart home technology, and wearable devices.

Case studies involving four cities (Los Angeles, New York, Pittsburgh, and Roanoke) show that the direct economic impacts from deploying the 5G network are large. Employment created by network construction, complementary increases in CAPEX by private industry, and consumer spending on 5G-enabled devices and 5G service are expected to create about 250,000 jobs in Los Angeles, about 110,000 jobs in New York City, about 22,000 jobs in Pittsburgh, and about 2,700 jobs in Roanoke, Virginia. These estimates, along with the forecasted national economic impacts, are supported with careful economic modeling based on established methods for conducting regional economic analyses.

Without doubt, the importance of continuing to upgrade the nation's broadband network has become even clearer today because of the COVID-19 pandemic, as social distancing and quarantines have forced more business, commercial, and entertainment activity online than ever before. 5G will enable all of these activities to be done better, faster, and more reliably. At the same time, with the present sharp downturn in the economy, the economic benefits – jobs, wages, and GDP growth – computed in this study will be desperately needed over the next several years. Most of the economic benefits quantified here derive from wireless and other private industry deploying 5G networks and technology. This implies that, even in an unrealistic worst-case scenario in which the depressed economy leads *all* consumer spending on 5G devices to be postponed beyond 2025, 78% of the jobs, earnings, output and GDP growth estimated here would still accrue.

II. 5G Is a Powerful General-Purpose Technology for Economic Growth

5G refers to the collection of standards and technologies in the fifth generation of cellular communications networks. 5G wireless networks yield improvements in transmission speed,

latency, and reliability, but they use frequencies that do not propagate as far as lower frequencies. The "small cell" antenna, key to the 5G network architecture, is a lower-power antenna requiring deployments that are 10 to 100 times denser than 4G. Some of the most immediate impacts on the economy will come from the expenditure on construction of the small cell sites and related fiber-optic cables necessary to roll out the 5G network – work that has continued even during the pandemic. In fact, some broadband providers are even ahead of schedule building out their 5G networks.[2]

The capabilities of 5G allow businesses and consumers to perform existing tasks better and more efficiently, but – more importantly – allow entirely new types of productive activity to take place. Much of the great promise of 5G for economic growth stems from its role as a *general-purpose technology* (GPT). A GPT is pervasive, has high potential for technical improvements, is greatly useful to businesses, and can be employed to increase the productivity of R&D in downstream sectors.[3] Wireless broadband Internet access is a GPT with wide-ranging effects throughout the economy, and it is a necessary foundation for the "next production revolution" coming with the diffusion of the IoT, robotics, and mobile artificial intelligence. 5G is thus important to the economic health of a region and the national economy.

Much of the excitement about 5G is related to IoT, the system composed of interrelated computing devices, sensors, machines, data centers, objects, people, and even animals with the ability to transfer data among them without requiring direct human intervention. The key to IoT is connectivity, and thus the 5G wireless Internet is vitally connected to the future of IoT. IoT is growing at a high rate as more devices become connected and additional applications are developed. The increased capacity of the 5G network can accommodate more connected devices, moving more data through the network with lower latency,[4] thus enabling the continued growth of IoT.

5G will be an important driver of continued economic growth in the U.S. This is seen most obviously with the direct contribution to GDP of the investment that is necessary to deploy next-generation wireless infrastructure. Since 1996, broadband providers in the U.S. have invested over 1.7 trillion dollars in private capital expenditure, and over $720 billion in the last ten years alone.[5] Since the release from onerous net neutrality regulations, broadband providers invested $77 billion in 2017 and $80 billion in 2018, both higher than the previous two years under the more restrictive regulatory regime. Broadband Internet access also appears in GDP as a personal consumption item. In 2018, Americans spent $71 billion on Internet access services.[6] However, these direct entries in the national income accounts are only the tip of the iceberg. 5G will increase the productivity of businesses, create jobs and increase wages in the labor market, and create value for consumers far beyond what they pay for it.

III. Impacts on Labor Markets and Job Creation

5G will affect the labor market through direct and indirect means. The direct effects on jobs from building the 5G network is covered in the next section, but the broadest impact on the labor market will come from new employment opportunities through the way 5G enables businesses to grow by developing new applications, services, and ways of doing business. For example, IoT will involve a massive number of connected devices generating data for real-time responsiveness and adjustments, as well as the opportunity for the data to be collected, aggregated, and

analyzed. While many of these tasks will be automated, data analysis will often involve skilled workers, and even the necessary support for data collection and aggregation will depend on workers in the field of information and communications technology (ICT).

As another example, 5G will allow telemedicine, based in part on remote wearable or home-based health sensors, to expand in rural areas, creating opportunities for local and remote healthcare workers and technicians to assist patients. Indisputably, the importance of telemedicine has been heightened during the COVID-19 pandemic, and the full capabilities of telemedicine will be unleashed only with 5G.[7]

5G can also increase employment by drawing new workers into the labor force. The preference for a work environment that allows employees to dictate when and where they work is growing in popularity, particularly among younger workers, and 5G mobile broadband access will enable ever more creative forms of flexible working arrangements. The pandemic has also turned preferences for working from home into necessity for many Americans. Empirical studies have found that increases in local employment associated with broadband deployment arise mostly from new workers entering the labor force, not just from the unemployed finding new jobs.[8]

External estimates of job creation from these indirect aspects of 5G are large, ranging from 400,000 new jobs in the U.S. in the IoT value chain alone to 2.2 million jobs from adoption of 5G technology into the broader U.S. economy.[9] By 2035, 5G deployment will support 3.4 million jobs in the U.S.[10] The positive effects of broadband on the labor market are not limited to reducing unemployment. A large number of Americans dropped out of the labor force altogether after the previous recession, and the same is likely happening in today's uncertain economy. Broadband at home can draw people into the labor force through telework and saving time in home production. For example, one study found that high-speed Internet use in the home leads to a 4.1 percentage point increase in labor force participation for married women.[11] 5G and IoT will greatly enhance the prospects for remote employment and virtual workplaces.

IV. Improved Productivity and Competitive Advantages for Businesses

IoT and 5G will be a major source of productivity improvements and competitive advantage for businesses. Productivity is enhanced by improved and cheaper monitoring, measuring, and managing of business activities. IoT sensors with remote monitoring capabilities lower such costs of controlling inputs and outputs. Of course, IoT and 5G are not just about devices themselves; connected devices and the enhanced communications experience offered by 5G will make possible increased engagement of employees.

The superior indoor and outdoor mobile broadband experience will make many workers more productive. 5G will further the move toward virtual and remote teamwork with enterprises by enabling streaming of ultra-high definition video and telepresence, augmented and virtual reality (smart glasses), and tactile Internet. And virtual teamwork will become even more important if social distancing requirements recur in coming years. Smart glasses can improve productivity, for example, by providing remote support from centralized specialists to workers in the field. IoT-based improvement in the management of mobile devices, inventory and assets, safety and security, and workers and their time can boost productivity as well.

Past experience with previous broadband, communications, and mobile technologies shows that we can expect 5G to usher new improvements in labor productivity. Some studies have considered the labor productivity impacts of broadband in general, including wired and wireless, fixed and mobile. One study indicated that increasing broadband availability by 10 percent raises a firm's output by 0.4 percent on average.[12] Other studies look specifically at mobile broadband. Mobile telephony and broadband usage have been found to increase labor productivity, contributing 0.19 percentage points to annual productivity growth in the United States.[13] Another study found that increasing the number of employees using the mobile Internet by 10 percentage points is associated with increased labor productivity in the range of 1.7% to 9.3%.[14]

V. Creating New Value for Consumers

The 5G ecosystem will also create much value for consumers. Video will take less time to load on mobile devices and can be of higher quality. 5G will be fast enough to replace wired broadband networks to access the Internet in many homes. In some areas of the country, 5G wireless will extend high-speed Internet service to places where the wired broadband network is lacking, as previous generations of mobile broadband have done. But in addition to doing the same things faster, the true promise of 5G and IoT for consumers lies in doing completely new things. Applications in healthcare include wearable home medical monitoring devices connected to IoT. Examples of such devices include heart rate monitors and fall-detection equipment for the elderly. The healthcare segment of IoT is forecast to grow to be a $180 billion market in 2022.[15]

5G also enables exciting applications in transportation. Autonomous vehicles of the future will rely on 5G networks to make driving smarter and safer. Autonomous vehicles will provide benefits to society of up to $4,000 per vehicle, after accounting for the value of crashes avoided.[16] IoT will also allow better management of the electricity energy network. The resulting Smart Grid enabled by 5G connections will better manage electricity demand and balance loads away from peak periods, thereby reducing electricity costs and ultimately prices. Other aspects of IoT for consumers include smart homes, personal asset tracking through the use of electronic tags, and wearable personal technology from fitness devices to smart glasses.

VI. Quantifying the Economic Impacts of 5G

To assess the impact of deploying a national 5G broadband network in the United States, a medium-term analysis covering 2019–2025 was performed. The following four economic activities were considered: capital expenditure in the mobile broadband provision industry to deploy 5G networks, spending in other industries to incorporate 5G into their businesses, additional spending by mobile broadband subscribers on 5G service (net of what they would have spent on 4G service), and additional spending by consumers on mobile broadband devices net of a "4G only" counterfactual. Standard methods of determining national or regional economic impacts based on input-output analysis were followed. Impacts are of three types: direct, indirect, and induced. Direct impacts are from extra output produced by the wireless communications service industry. Indirect impacts include those from upstream supporting industries. Induced impacts come from households spending the additional wages earned from creating the first two types of impacts.

The economic impacts are measured with employment, output (sales), value added (GDP), and labor earnings. Created jobs are counted as job-years. The value-added figures remove the double counting as commodities are passed up and down the supply chain. The methodology relies on multipliers computed from input-output analysis. The analysis does not include jobs created by the innovation resulting from the investment across private industry as businesses incorporate 5G technology and services into their products, services, and business methods. That is, the economic impacts from investment spending are from the capital expenditure, not the innovation following from it. Ultimately, such innovation might have highly important impacts on the economic outcomes studied here, but such impacts cannot be estimated precisely and would be highly speculative.

Detailed assumptions for the analysis are in the main report, but the broad outlines of the methodology are as follows. For capital expenditure by wireless network service providers, investment of $225 billion is required in communications equipment, network design services, and construction over the study period (2019–2025).[17] Investment in other private industries in 5G-related equipment and services, such as those related to IoT, is estimated from past linkages between CAPEX in the broadband industry and CAPEX in other industries.[18] The additional expenditure on the provision of 5G mobile wireless service is based on forecasts of the number of 5G subscribers and the premium paid over 4G.[19] The forecasted additional expenditure on 5G devices assumes that if 5G were not available, an otherwise equivalent 4G device would have been purchased and only the difference in expenditure between the two types of devices is counted.

Deployment of the nationwide 5G network will have large impacts on employment, output, sales, and labor earnings (see the Table below). In the national economy, about 8.5 million jobs are created over the study period compared to the 4G-only world, with an average of 1.2 million jobs each year. Workers in those jobs will earn a total of $564 billion total ($81 billion annually). The largest source of jobs is investment throughout the wireless industry (24% of all jobs created) and other private industry (45%). Incremental spending on 5G consumer devices is the next largest category, creating 22% of all jobs. Provision of 5G wireless service creates the remaining 9% of additional jobs. The 5G-related investment and spending will also create a yearly average of $237 billion in additional sales of output, adding an average of $130 billion each year to GDP in the U.S. economy during 2019–2025. Overall, 5G will add $1.7 trillion to output and $907 billion to GDP during the forecast period. This latter amount is expected to be about 0.6% of total GDP during that time.[20]

However, 5G will help support many more jobs than just these new ones, since wireless broadband affects so much economic activity. For example, the wireless ecosystem (including infrastructure builders, service providers, device makers, retailers and wholesalers, and content, app, and service creators) directly or indirectly supports between 2.4 to 4.7 million jobs in the U.S., depending on which economic activity is included in the calculations.[21]

To illustrate the importance of 5G for regional economic development, similar estimates were computed for four cities. For a subnational region, there are three types of economic impacts. The main impact is similar to those described for the national estimates (although more economic activity leaks out of the cities).[22] The second type of local economic impact is the positive spillover from economic activity elsewhere in the nation as 5G networks are deployed.

Such economic activity flowing into the area from investment outside the area is much smaller than the direct impact. A third local impact comes from apportioning employment in the national wireless telecommunications ecosystem to the city.

The results of the regional analysis are in the Table below.[23] In each case most of the jobs created stem from local network investment, investment by other local industries, and local spending on 5G devices and wireless service. Los Angeles benefits the most from jobs "leaking in" from 5G deployment elsewhere in the nation, since Los Angeles accounts for about 2.6% of apparatus such as telecom network switchgear manufactured in the U.S. The total jobs created range from almost 250,000 in Los Angeles to 2,700 in the much smaller local economy of Roanoke, Virginia. The additional labor earnings are $17 billion in Los Angles, about half that in New York City, $1.4 billion in Pittsburgh, and $136 million in Roanoke. In addition to the new jobs created, 5G services will help sustain existing local jobs related to wireless service in the area. The local wireless ecosystem is estimated to directly or indirectly support 95,600 to 200,700 jobs in Los Angeles, 69,000 to 144,900 jobs in New York City, 12,200 to 25,700 jobs in Pittsburgh, and 1,400 to 3,000 jobs in Roanoke. This wireless ecosystem employment is not included in the figures in the table.

Table: Economic Impacts of 5G Network Deployment in Four Cities

	Jobs	Jobs from Local 5G Deployment	Labor Earnings	Output	Value Added
	000s		$B	$B	$B
Los Angeles					
Total	248.3	94.8%	17.4	47.2	27.9
Annual (ave.)	35.5		2.5	6.7	4.0
New York City					
Total	109.7	96.0%	9.4	22.6	14.3
Annual (ave.)	15.7		1.3	3.2	2.0
Pittsburgh					
Total	21.64	99.6%	1.44	3.80	2.33
Annual (ave.)	3.09		0.21	0.54	0.333
Roanoke, VA					
Total	2,705	100.0%	0.136	0.440	0.225
Annual (ave.)	386		0.019	0.063	0.032

Los Angeles results are for the Metropolitan Statistical Area (L.A. and Orange Counties). Pittsburgh results are for Allegheny County. Roanoke results are for the City and County of Roanoke. Jobs from Local 5G Deployment are those that would be lost if the local area did not deploy 5G; the rest of the jobs come from 5G deployment elsewhere in the nation.

VII. Conclusion

In the near future, 5G wireless broadband will be an important part of the workplace and other parts of the economy. Many workers, not just those in the new jobs created by 5G, will benefit from increased flexibility in labor arrangements, better education, improved productivity, and higher wages. The importance of broadband technology to allow productive work out of the

office has been highlighted with the present economic disruption caused by COVID-19; 5G will make work from home or on the road even smoother. Consumers will enjoy the improvements in healthcare technology, transportation, energy, and other aspects of IoT that 5G will spur.

The impacts quantified here are only the first rising of the 5G wave, not its crest. The figures computed here do not include the broader impacts regarding how the new technology will create value for local businesses and the nation's economy through improving productivity, allowing the creation of entirely new goods and services, and improving the welfare of consumers. Also missing from the economic impacts are the undoubtedly huge amounts of consumer surplus (i.e., benefits enjoyed by consumers beyond what they pay for 5G-related goods and services) that will be generated. The many benefits of 5G for cities and the public sector more broadly are also in addition to the quantified impacts presented here. Smart city technology such as 5G-enabled smart public lighting and smart energy grid management will help municipalities become more energy efficient. Smart public transportation, parking metering, and traffic management systems will reduce costs and congestion while also encouraging patronage of downtown businesses. 5G technology will enhance public safety through applications such as gunshot detection networks and data collection and transmission that increases the effectiveness of fire and police services through enhanced real-time awareness.

The transformative nature of 5G technology implies that the benefits will be enormous. Three decades ago, few people anticipated how the Internet would fundamentally transform so many areas of economic and personal life. In the coming decades, 5G and succeeding generations of wireless broadband networks and the IoT likely will revolutionize and positively impact employment, production, consumption, and overall quality of life.

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[1] Note: This *Perspectives* summarizes Professor Prieger's research presented in longer form at https://actonline.org/wp-content/uploads/ACT-Report-An-Economic-Analysis-of-5G-FINAL.pdf. The research in that lengthy report was supported by Verizon, but all of the opinions there and herein are my own. Readers interested in more supporting detail should consult the main report, especially for those who enjoy reading footnotes.

[2] The president of Qualcomm, a major supplier of network equipment, stated on April 29, 2020 that "in the United States, some carriers are actually ahead of scheduling the build-out, taking advantage of probably less traffic." See seekingalpha.com/article/4341284-qualcomm-incorporated-qcom-ceo-steve-mollenkopf-on-q2-2020-results-earnings-call-transcript.

[3] Bresnahan, T. F. and M. Trajtenberg (1995), "General purpose technologies: 'Engines of growth'?" *Journal of Econometrics*, 65: 83–108.

[4] Network latency is delay in data communication over the network. Latency typically increases as more devices are added to the network, which degrades network performance.

[5] Data are from USTelecom. See ustelecom.org/wp-content/uploads/2019/07/USTelecom-Research-Brief-Capex-2018-7-31-19.pdf.

[6] Datum is from the US Bureau of Economic Analysis, National Income and Product Accounts.

[7] Drees, J. (Feb. 25, 2020), "Telemedicine needs 5G before it can transform healthcare," *Becker's Hospital Review*.
[8] Atasoy, Hilal (2013), "The Effects of Broadband Internet Expansion on Labor Market Outcomes." ILR Review 66(2): 315–45.
[9] See World Economic Forum (WEF) (2017), *Digital Transformation Initiative: Telecommunications Industry.* Geneva: World Economic Forum; and Al Amine, Majed, Kenneth Mathias, and Thomas Dyer (2017), *Smart Cities: How 5G Can Help Municipalities Become Vibrant Smart Cities*, Accenture Strategy.
[10] IHS (2017), *The 5G Economy: How 5G Technology Will Contribute to the Global Econom*, IHS Economics & IHS Technology London: IHS Markit.
[11]Dettling, Lisa J. (2017), "Broadband in the Labor Market: The Impact of Residential High-Speed Internet on Married Women's Labor Force Participation," *ILR Review* 70(2): 451–82.
[12] Akerman, A., I. Gaarder, and M. Mogstad (2015), "The Skill Complementarity of Broadband Internet," *The Quarterly Journal of Economics, 130*, 1781–1824).
[13] Gruber, Harald and Pantelis Koutroumpis (2011), "Mobile Telecommunications and the Impact on Economic Development," *Economic Policy: A European Forum*, 67:387–426.
[14] The study uses data from German firms; see Bertschek, I., and T. Niebel (2016), "Mobile and More Productive? Firm-level evidence on the productivity effects of mobile internet use," *Telecommunications Policy*, 40(9):888–898.
[15] Statista, "Size of the Internet of Things (IoT) market by application in North America from 2012 to 2022 (in billion U.S. dollars)."
[16] Fagnant, Daniel J., and Kara Kockelman (2015), "Preparing a Nation for Autonomous Vehicles: Opportunities, Barriers and Policy Recommendations," *Transportation Research Part A: Policy and Practice*, 77: 167–181.
[17] The CAPEX is assumed to be spent on wired and wireless network equipment, fiber optic cable, engineering, programming, systems design services, and construction.
[18] The estimated relationship shows that a 1% additional investment in telecom leads to a net 0.06% increase in investment in another private industry.
[19] Note that since IoT spending is expected to take off in a large way during the second half of the 2020s, IoT contributes only a small amount to this category during the study period.
[20] These figures were computed before the pandemic hit the economy in 2020, and so the size of the impacts relative to the entire economy may even be higher for this year (depending on how much consumer spending on devices affects the numerator).
[21] The low figure is from GSMA (GSMA Intelligence (2019), *The Mobile Economy: North America: 2018*. London: GSM Association), after adjusting their North American figures to reflect the U.S. only. The high figure is from: Safer, David, Farah Lalani, and William McCluskey (2018), *How the Wireless Industry Powers the U.S. Economy*, Accenture Strategy, Accenture.com.
[22] For example, spending on fiber optic cable in New York City benefits no local manufacturers.
[23] The figures derive from assumed wireless CAPEX needs of $8.4 billion for Los Angeles, $2.4-5.1 billion for New York City, $1.2 billion for Pittsburgh, and $205 million for Roanoke. For the assumptions regarding subscriber spending on service and devices and investment in other private industries, see the main report.