The Economics of the Fifth Generation Cellular Network

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Abstract:

Fifth generation cellular services are expected to rapidly take off in the next few years. In combination with other advanced technologies, they are likely to transform key economic activities.

Keywords: 5G mobile communication | economics | couplings | artificial intelligence | companies | cellular networks

Article:

Fifth generation (5G) cellular services were first deployed on a trial basis in the 2018 Winter Olympics in South Korea.[1] Since then, some telecommunications operators have commercially launched 5G services. In May 2018, Qatar's Ooredoo reported that it launched what it referred to as the world's first 5G cellular services on a limited basis (https://venturebeat.com/2018/05/14/worlds-first-commercial-5g-network-launches-in-qatar/). In June 2018, the Finnish telecommunications provider Elisa reported that it launched 5G networks in Tampere, Finland, and Tallinn, Estonia. The company noted that it was already selling 5G subscriptions.

In the U.S., by December 2018, AT&T's 5G services had been offered in 12 U.S. cities. The offers were limited to customers with 5G devices. Verizon reported that it launched a commercial 5G network in some U.S. cities.[2] As of January 2019, T-Mobile had deployed 5G network equipment in 30 U.S. cities. However, it had not offered commercial 5G services.[3]

5G services are expected to rapidly take off in the next few years. According to Swedish networking and telecommunications company Ericsson, 20% of mobile data traffic worldwide will be on 5G networks by 2023 (https://www.fiercewireless.com/wireless/china-leads-iot-deployments-while-north-america-leads-5g-ericsson). The value-creating potential of 5G has significant implications for many industries. Many companies are developing products and services that would help enrich the global 5G ecosystem.[1]

According to the cellphone trade group GSMA, there will be 1.2 billion 5G connections worldwide by 2025 (https://rakuten.today/blog/10-things-learned-mobile-world-congress-2018.html). Asia and the U.S. are expected to take the lead (www.cnbc.com/2018/03/07/china-has-the-edge-in-the-war-for-5g-us-and-eu-could-fall-behind.html). Among Asian economies, China is likely to experience the fastest 5G growth. A report of the consultancy company EY indicated that China will have 576 million 5G users, more than 40% of the global total by 2025 (http://www.chinadaily.com.cn/a/201806/28/WS5b34486fa3103349141df708.html). Among European economies, the U.K. is likely to take a lead (https://5g.co.uk/news/uk-networks-could-beat-europe-5g-launch/4456/). It is estimated that 90% of the U.K. population will be covered with 5G by 2027 (https://www.sciencedirect.com/science/article/pii/S0308596117302781).

5G cellular networks have many attractive features, such as lower latency, higher bandwidth, and higher degree of reliability. 5G networks utilize millimeter wave, which is usually considered to be the range of wavelengths from 10 to 1 mm (https://ethw.org/Millimeter_Waves). Compared to the frequency spectrum used by previous wireless network technologies, the amount of bandwidth available at millimeter wave frequencies is significantly higher. Millimeter wave frequencies thus provide the massive bandwidth. This is especially important to transmit data created by a large number of Internet-of-Things (IoT) devices. In the 2018 Winter Olympics, South Korean telecommunications company Korea Telecom's peak 5G network speed was up to 3.5 GB/s on Samsung tablets (www.fiercewireless.com/5g/kt-s-millimeter-wave-5g-network-transmitted-3-800-tb-data-during-winter-olympics). In January 2018, South Korea's average mobile broadband download speed (which was the fourth highest in the world) was 133.05 Mb/s. This means that peak speeds in 5G networks during the 2018 Winter Olympics were more than 26 times the country's mobile broadband download speed.

4G/ Long-term evolution (LTE) networks have relatively high latency, which varies between 30 and 100 milliseconds (MS) (https://www.ecnmag.com/article/2018/08/breaking-psychological-barrier-autonomous-vehicle-adoption). 5G networks get closer to the user in terms of antennas, which reduces the latency. This feature is especially valuable and useful for services such as remote robotic surgery and autonomous vehicles (AVs).

Let us look at the cost-benefit tradeoffs of 5G networks. On the cost side, 5G networks, platforms, and devices certainly require high investments. According to technology advisory firm Xona Partners, in order to deliver a coverage comparable to existing 4G/LTE networks, 5G would need six times as much investment. The higher investment is needed because 5G networks improve performance by getting closer to the user in terms of antennas and computing power.[4] There are, however, important economic benefits associated with 5G networks. 5G networks enable a high data transfer rate. From an operator's standpoint, 5G networks have lower cost per bit of data compared to 4G networks (https://www.v3.co.uk/v3-uk/news/3062204/qualcomm-5g-mobile-broadband-will-launch-in-the-us-by-april-2019).

5G is likely to stimulate economic activities in a number of areas. For instance, for the AV industry, high latency is a concern with the 4G LTE networks (https://www.ecnmag.com/article/2018/08/breaking-psychological-barrier-autonomous-vehicle-adoption) (see Table 1). In order to maintain awareness of the surroundings and safely steer

through traffic with vehicle-to-everything communications, AVs need a 1 MS latency. With 5G networks, an autonomous car will be able to hit the brakes and stop it within 1 in, compared to 4.6 ft it takes with 4G (https://www.cta.tech/News/i3/Articles/2017/July-August/The-Promise-of-5G.aspx).

Likewise, 5G will create a rich e-commerce ecosystem and a better customer experience. Especially 5G networks in combination with other advanced technologies such as the IoT, machine learning (ML), artificial intelligence (AI), virtual reality, augmented reality, and blockchain are bound to transform e-commerce and other economic activities.[5]

Table 1. Predicted economic impacts of 5G cellular networks in major economies.

Economy	Forecast year	Study conducted by	Economic impact
China	2025	China Academy of Information and Communications Technology	5G market: U.S. $167 billion (3.2% of GDP) (https://variety.com/2017/digital/asia/china-to-become-world-leader-in-5g-political-controls-damp-content-industry-1202624028/).
India	2035	A committee on India's 5G road map	Cumulative economic impact U.S. $ 1 trillion (https://www.moneycontrol.com/news/business/panel-on-5g-road-map-sees-1-trillion-impact-on-economy-2875251.html).
The U.K.	2030	King's College London	U.S. $226 billion (https://www.kcl.ac.uk/newsevents/news/newsrecords/2018/02-February/British-universities-debut-world's-first-5G-end-to-end-network-at-Mobile-World-Congress.aspx).
The U.S.	2024	Accenture	Boost GDP by U.S. $500 billion, create 3 million new jobs (Amine et al., 2017).[8]
World	2035	Qualcomm	5G value chain will create 22 million jobs, generate U.S. $3.5 trillion in revenue, full economic benefit: U.S. $12 trillion (https://www.qualcomm.com/invention/5g/economy).

ECONOMIC IMPACTS OF 5G CELLULAR NETWORKS IN MAJOR ECONOMIES

Among mature economies and large and developed countries, McKinsey Global Institute's analysis of data indicated that the Internet accounted for 21% of the GDP growth during 2006–2010. It accounted for 3.4% of the GDP in 2009, which was more than communication, utilities, agriculture and mining.[6] These benefits can be further improved with 5G networks. Qualcomm predicted that by 2035, the 5G value chain will create as many as 22 million jobs worldwide and generate U.S. $3.5 trillion in revenue worldwide (http://www.newschinamag.com/newschina/print.do?article_id=4133&section_id=5&magazine_id=33). By that time, 5G's full economic benefit will amount U.S. $12 trillion (https://www.qualcomm.com/invention/5g/economy). Similar findings have been reported by studies conducted in other major economies. Table 1 presents the predicted economic impacts of 5G cellular networks in major economies.

A number of mechanisms can contribute to the ability of 5G to stimulate economic activities. First, lower generation networks are mainly used to connect cellular phones. 5G networks are used to connect a wide range of devices such as home appliances, industrial automation equipment, cars, laptops, and televisions (https://www.extremetech.com/mobile/271665-5g-standard-finalized-for-standalone-deployments).

5G networks support significantly larger numbers of devices per cell compared to previous generations. A working party developing 5G standards has specified at least one million devices per square kilometer (https://www.itu.int/md/R15-SG05-C-0040/en).

It is possible to optimize each slice in order to provide the required resources and quality of service (QoS) in terms of latency, data flow rate (throughput), capacity, and coverage (https://www.cablelabs.com/network-slicing-building-next-generation-wireless-networks/). 5G providers, thus, can address the difficulties with the one-size-fits-all nature of the 4G/LTE networks in which all customers are likely to receive the same types of services irrespective of the needs. For instance, 5G service providers can provide different types of networks with different levels of bandwidth, security, or latency for diverse applications, such as smart homes, smart workplaces, or smart cities.

Despite tremendous economic benefits, big data's use has not been as widespread as many had expected. According to IDC, only 0.5% of the world's information was analyzed in 2012. More recent studies have indicated that 5% of created data is actually utilized. Currently it is not possible to transmit the data to a place where it can be processed and analyzed. Data creation is growing more than twice as fast as bandwidth (www.ibm.com/blogs/research/2017/02/bringing-edge-computing-to-life). 5G networks can address this bottleneck by increasing data transmission rates. Estimates suggest that 5G will make it possible to utilize 35% of digital data.[7]

In 5G, using software-defined networking, a single network can provide a variety of heterogeneous services or "slices." Network operators can provide specific capabilities for varying use cases (https://www.cio.com/article/3234373/networking/5g-network-slicing-what-is-it-and-why-you-should-care.html). Indeed, it is argued that 5G networks are less about speed and more about capacity and the ability to provide targeted services for various use cases that are most in need (https://www.ft.com/content/1279a1e8-8110-11e8-af48-190d103e32a4). Each slice can be managed independently. Network slicing can reduce operating expense (OPEX). Network slicing can promote flexibility, scalability, and efficiency from the resource management perspective. Operators can analyze each slice's OPEX and revenue independently (https://www.cablelabs.com/network-slicing-building-next-generation-wireless-networks/). They can, thus, increase revenue and profitability.

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ECONOMIC LINKAGES AND THE DIFFUSION OF 5G NETWORKS

The success of 5G networks hinges on the development of related industries. Development and diffusion of 5G are tightly linked to the forward linkages (demand), backward linkages (supply), and horizontal or intersectoral linkages. Table 2 presents the roles of linkage mechanisms.

Table 2. Roles of linkage mechanisms in the development of 5G networks.

Linkage mechanism	Explanation	Some examples
Forward linkages	The 5G services are used as the raw material of another industry. New industries/businesses are formed or existing industries grow faster.	5G will stimulate the growth of the AV industry (e.g., South Korea).
Backward linkages	Industries or businesses that support 5G by creating various forms of positive externalities.	Costs and availability of labor, equipment, and other factors affect 5G development (e.g., China).
Horizontal or intersectional linkages	Interaction between interdependent firms in two or more economic sectors: Actions taken by 5G network providers in partnership with other sectors outside 5G.	The development of 5G networks facilitated by related technological sectors such as AI and blockchain.

Forward Linkages

The strength of forward linkages between 5G networks and the rest of the economy is a critical factor. The demand of 5G is higher in economies that focus on advanced use cases that require reliable, fast, and low latency networks. For example, the AV industry produces forward linkages. In South Korea, Hyundai and Korea Telecom developed 5G-equipped autonomous buses for the 2018 Winter Olympics. Hyundai's aim is to start selling self-driving vehicles by 2021. Hyundai is also expected to launch self-driving taxis. Korea Telecom's self-driving bus was referred to as the "5G Bus." They operated in the town of Gangneung, where ice hockey and skating matches took place.

Backward Linkages

The development of industries that supply various ingredients needed for 5G helps to foster backward linkages. Low labor costs and other inputs are an important source of backward linkage. In this regard, China has a cost advantage. Deloitte estimated that the equipment necessary to develop a wireless network capacity cost about 35% less in China than in the U.S. According to Deloitte, from 2015 until the mid-2018, China spent U.S. $24 billion more than the U.S. in 5G technology. China built 350 000 new cell sites during this period compared to fewer than 30 000 in the U.S.[9]

More importantly, 5G-related R&D activities can provide strong backward linkages. As of March 2018, China accounted for 32% of the world's 5G standard contributions. By then, it had submitted over 8700 related documents to the third generation partnership project, which is a collaboration between groups of telecommunications standards associations (https://technode.com/2018/03/30/5g/).

Local handset and device manufactures also provide backward linkages. China-based technology companies ZTE and Huawei announced that they would release 5G in 2019. South Korean device maker Samsung released its 5G tablet in early 2018. In the 2018 Winter Olympics, Samsung's 5G-equipped tablets allowed viewers to switch among multiple cameras placed along

the cross-country skiing route so they could track an athlete's real-time location on a three-dimensional map of the entire skiing course.[1]

Horizontal or Intersectoral Linkages

An intersectoral linkage is said to exist between two economic sectors if activities in one can provide a stimulus to another. Higher benefits can be derived by combining 5G with other technologies such as big data and AI. For instance, network operators need to use advanced analytics, ML and AI in order to manage service quality and predict failures.[10]

Some mobile operators have taken initiatives in this direction. China Mobile announced its plan to enhance 5G's operational efficiency with AI (http://www.chinadaily.com.cn/a/201806/28/WS5b34486fa3103349141df708.html). Another telecom company, i.e., China Unicom and Chinese tech conglomerate Tencent, have established a joint laboratory to focus on R&D efforts related to key technologies and business applications. They include edge computing, network slicing, and high-accuracy positioning services (http://usa.chinadaily.com.cn/a/201806/29/WS5b3575fda3103349141dfa05.html). Likewise, China Unicom's laboratory with the Chinese search provider Baidu aims to integrate AI with 5G. The two companies have placed special emphasis on the internet of vehicles and big data (http://usa.chinadaily.com.cn/a/201806/29/WS5b3575fda3103349141dfa05.html).

CONCLUDING COMMENTS

From the perspective of data transmission, 5G networks perform significantly better than the previous generations both in terms of capacity as well as cost effectiveness. 5G is, thus, a key missing link in the utilization of relevant data in order to make informed decisions based on data. The diffusion of 5G cellular networks is likely to lead to major economic and social impacts. Specifically, 5G, in combination with other advanced technologies, is bound to transform many industries and fundamentally alter consumption patterns. For instance, blockchain's technical potential as a means of creating trust, transparency, and accountability can be realized by using 5G networks to provide reliable data.

The benefits of 5G can be enhanced by giving more attention to the economics of linkage effects, including the processes by which 5G can be combined with other technologies to deliver higher value to the end users. Many small developing countries lack linkages, as well as necessary resources and capabilities, that are essential to respond to the needs of the 5G era. Full potential of this technology cannot be realized without developing capabilities in areas such as advanced analytics, AI, and ML.

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