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POLICY MEMO

# The Value of Cellular Technology

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Cellular technologies, such as those embodied in the third generation (3G), fourth generation (4G), and fifth generation (5G) of cellular standards, have provided the foundation for a thriving mobile ecosystem that has benefited consumers and businesses all over the world. In the past 20 years, the number of mobile connections has grown almost 10-fold, reaching an ever-growing percentage of the global population. In 2017, the number of mobile connections surpassed the number of people on the planet.[1] In 2019, mobile technologies and services added $4.8 trillion of economic value to the global economy, and the mobile ecosystem employed (directly and indirectly) 30 million people.[2]

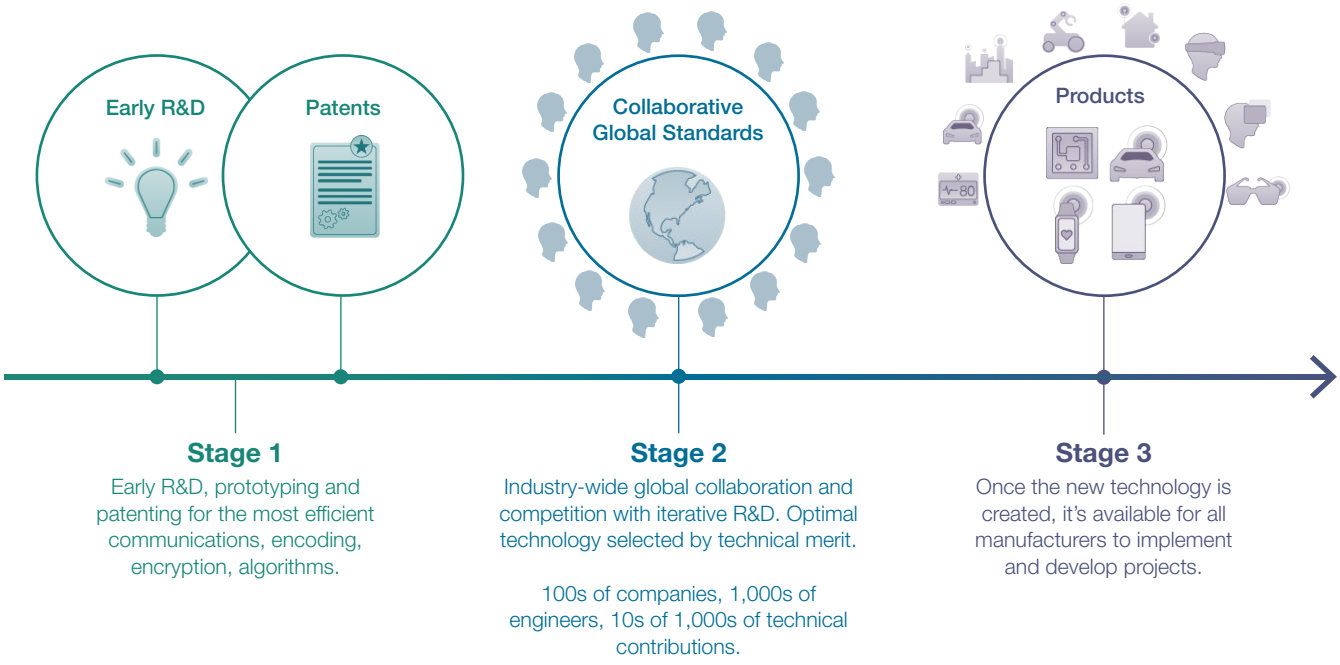
Although cellular technology has already transformed all facets of our society, the deployment of 5G will bring even broader and more radical changes. By connecting everything and everywhere, 5G will help us realize the full potential of connectivity and usher in the era of smart transportation, smart cities, smart factories, and smart homes. The new products and services enabled by 5G will change all aspects of our daily life, such as health care, energy, agriculture, automotive, manufacturing, and retail, among others. This will not only benefit consumers and businesses, but society as a whole.

Cellular technologies are central to this revolution. Without advances in the cellular space, none of the economic and societal benefits we see in the connected world would be possible. Therefore, it is important to understand how cellular technologies are developed and deployed, and what impact they have on the economy and on society more broadly. It is also important to understand why fairly compensating cellular innovators is essential to maintain a sustainable system where new technologies can be developed and brought to consumers.

## I. The Development and Deployment of Cellular Technologies

Foundational cellular technology is developed and deployed through a lengthy process. As Figure 1 shows, the entire process—from initial technology development to final implementation into a product—can be divided into three main stages, each involving different stakeholders and requiring different types of investments. It typically takes a long time—often more than 10 years—from the time of early investment in research and development (R&D) to the stage where gains of a newly developed technology can be properly realized.

Figure 1: The process of cellular connectivity technology creation and commercialization




Source: Report authors.

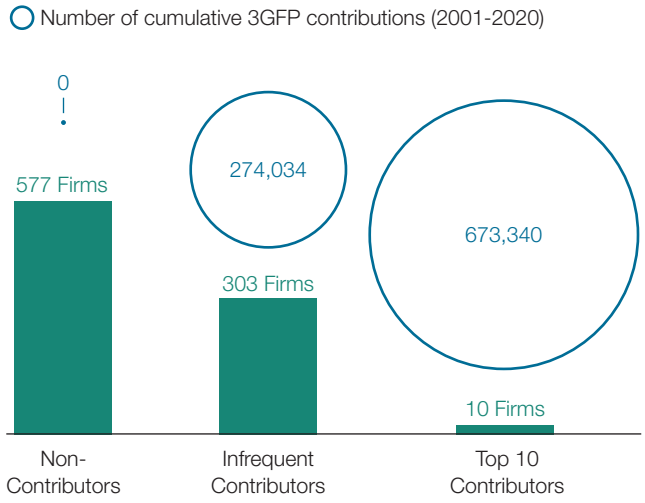
Private companies play an essential role in the initial development of cellular technologies (Stage 1). These companies make significant investments in R&D that ultimately produce the foundational technologies that underpin the cellular ecosystem. According to a 2015 analysis, companies developing cellular technologies invest a higher percent of their revenue in R&D than any other industry, except biotechnology.[3]

These investments are not without significant risk. Companies invest heavily in R&D without a guarantee that their research will yield commercial results. This is a risky venture for many companies, which is why there are so few who are willing to invest heavily in the development of foundational cellular technologies.

In the next stage (Stage 2), global technological standards, such as 4G and 5G, are developed through a collaborative process involving hundreds of companies and thousands of engineers. Participants in standard development organizations discuss the technical challenges, present the available solutions, and select the optimal technology based on technical merits.

Although many companies participate in the standards development process, only a small share are involved in contributing their technologies to these standards. For example, around 900 entities have participated in the 3rd Generation Partnership Project (3GPP), the private organization comprising seven standard development organizations that develop protocols for global mobile telecommunications.[4] However, 10 companies are collectively responsible for submitting 71% of all contributions made to the 3GPP, while more than half of the members have not made any contributions at all, as Figure 2 shows.[5]

Figure 2: Cumulative 3rd Generation Partnership Project contribution counts by category of contributors




Contribution counts are not a measure of significance or quality; this chart simply illustrates that a relatively small number of companies have done a disproportionately large amount of 3GPP work.

Source: Report authors.

Once technologies have been developed and cellular standards are finalized, mobile operators invest in the infrastructure for the cellular network. At the same time, manufacturers implement cellular technologies in their products and services. This is the stage (Stage 3) where connected products, such as smartphones, smart watches, or connected cars, are brought to the market and the value of connectivity is enjoyed by consumers.

## II. The Economic and Societal Impact of Cellular Technologies

The emergence of 3G, 4G, and 5G technologies has fundamentally transformed the way that people interact with each other. Connectivity has never been easier in our day-to-day activities. This has brought significant economic benefits to individual stakeholders as well as to society more broadly.

### a. Economic Value

Several studies have quantified the total value created by cellular technologies, both in the past and projected into the future. In 2014, the Boston Consulting Group estimated that the mobile value chain—including all stages from the initial development of core communication technologies to the sale and use of mobile content and apps—generated nearly $3.3 trillion in global revenue and directly contributed 11 million jobs worldwide, even in the midst of the then-ongoing global economic downturn.[6] In 2019, the Groupe Spécial Mobile Association reported that mobile technologies and services generated approximately $4.1 trillion of economic valueadded and projected that it would approach $5 trillion by 2024.[7]

The continued development and deployment of 5G alone is expected to have an even greater economic impact. The Swedish networking and telecommunications company, Ericsson, projects that 5G could be responsible for up to $3.7 trillion in cumulative revenue for service providers by 2030.[8] IHS Markit, a British research and analysis company, estimates that by 2035, 5G-enabled revenues from 16 industries—including manufacturing, agriculture, health care, and others—will total $13.2 trillion globally. This staggering figure is almost equivalent to all U.S. consumer spending in current dollars.[9] Similarly, the consulting company, Accenture, expects that the impact of 5G on the U.S. economy will boost total sales growth to an additional $2.7 trillion between 2021 and 2025, and that it has the potential to create or transform up to 16 million jobs across all sectors of the economy.[10]

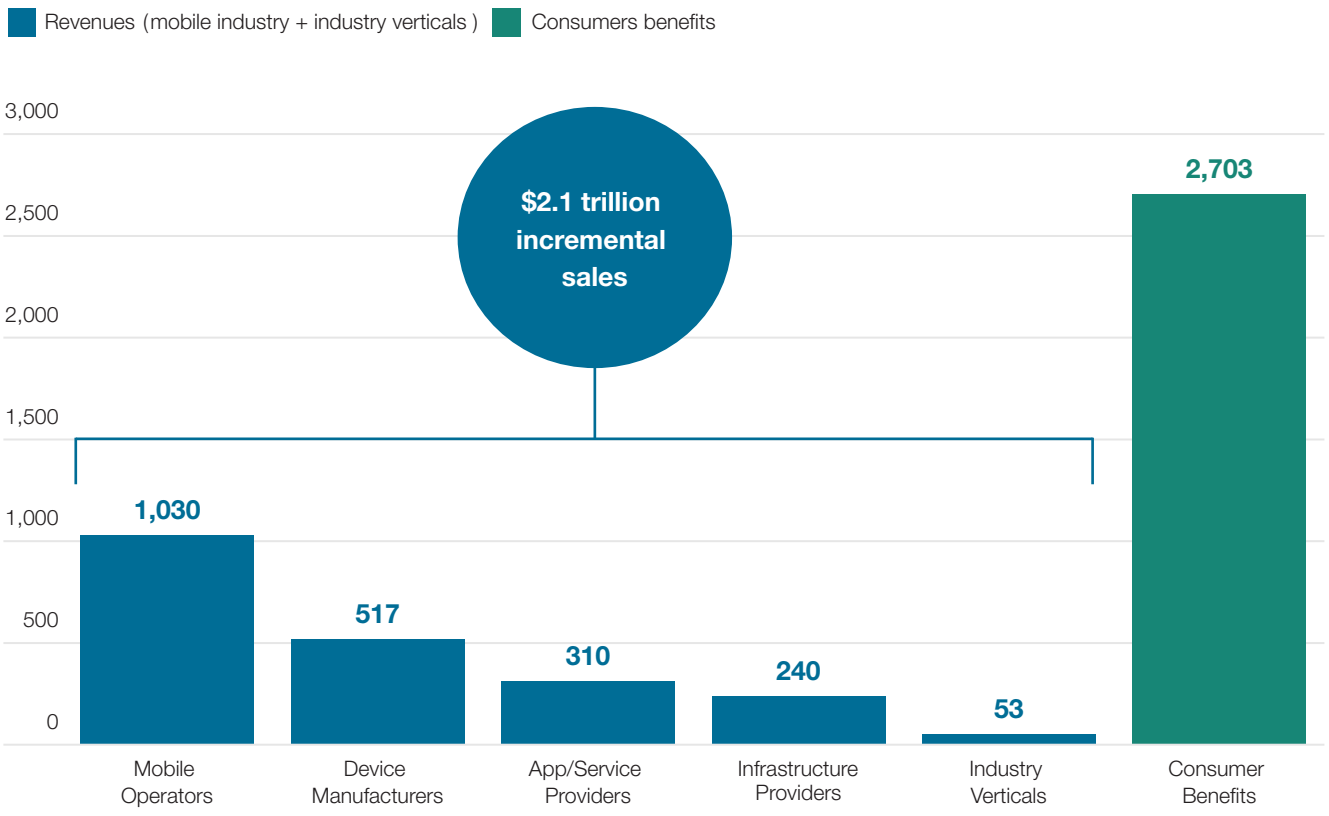
### b. Impact on Individual Stakeholders

Analysts have further provided a more granular assessment of the economic impact of connectivity, including the effect it has for individual stakeholders, such as consumers and businesses.

Data show that consumers are the group that has benefited the most from connectivity. Researchers estimate that in 2019 cellular technologies were responsible for $4.8 trillion in economic value, a majority of which is attributable to consumer benefits ($2.7 trillion).[11] As Figure 3 shows, consumer surplus represented more than 55% of the total economic value created by cellular technologies.

Consumers' willingness to pay for connectivity is easily observed across many products. For example, in addition to their well-known smartphones, Samsung and Apple sell tablets, some with cellular connectivity and others without. The price difference for added connectivity ranges from $100 to $550 for Apple products and from $40 to $150 for Samsung products, and most consumers pay this additional cost.[12] Similarly, an increasing number of automobiles come equipped with cellular technology to send and receive information that enables a range of new features, including advanced safety tools, increased energy efficiency mechanisms, and navigational capabilities. Data suggest that consumers were willing to pay between $360 and $24,500 for added connectivity services in their automobiles over an

Figure 3. Economic value generated by cellular technologies in 2019 by incremental sales and consumer surplus




Source: Bowman Heiden, *The Value of Cellular Connectivity from Mobile Devices to the Internet of Things*, 35 (2020), https://dx.doi.org/10.2139/ssrn.3670222.

11-year period, with the amount depending on the vehicle brand (the median value was approximately $3,000).[13]

Of course, cellular technology brings significant value to a host of industries by creating efficiencies and generating new revenue opportunities throughout the innovation economy. For example, in health care, enhanced medication monitoring powered by 5G cellular technologies will result in an estimated $2,500 in cost savings per year per patient.[14] In manufacturing, the turbine engines used in airplanes, trains, ships, and electrical generators, real-time monitoring will lead to a $4,200 cost reduction in the production of bladed disks[15] (the disks of spinning blades inside turbine engines which are now manufactured by computer-controlled machines that are programmed with microscopic design specifications[16]). In the energy sector, smart grids will generate savings each year by avoiding power outages.[17] These three examples illustrate the wide-ranging impact that cellular technologies have across industries, regions, and communities.

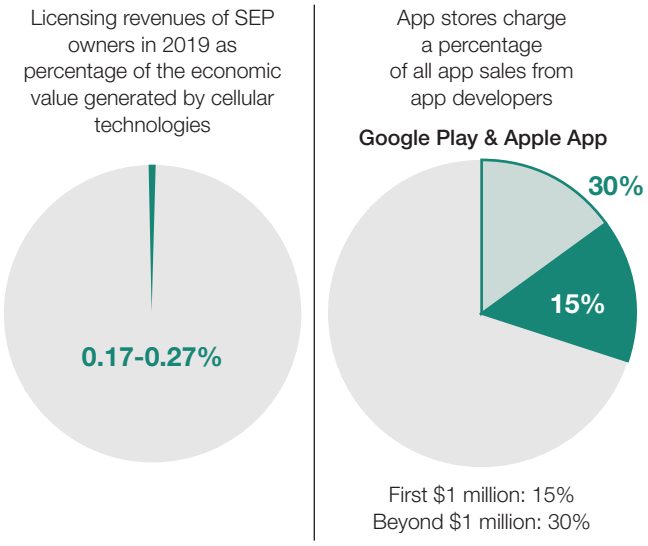
Finally, cellular technologies have created immense value for society beyond finances and economic data. For example, a study has shown that, particularly among poorer countries, the increased use of mobile phones is associated with lower gender inequalities, higher contraceptive use, and lower maternal and child mortality.[18] In the transportation sector, research suggests that increased connectivity has the potential to reduce car crashes by more than 30%, saving numerous lives and reducing the number of injuries.[19] Furthermore, connectivity has the potential to considerably improve traffic management and, through this, reduce CO2 emissions—in some instances up to 45%.[20] On a large scale, this could have a significant impact on the ongoing fight against climate change.

## III. Compensating Cellular Innovators

The economic and societal benefits of connectivity should not be taken for granted. For the connected ecosystem to be sustainable in the long run, it is necessary to ensure that cellular innovators—those responsible for producing the foundational technologies—are adequately rewarded for their contribution. Return on investment for R&D in foundational technologies is available to all via licensing of patented technologies that are included in industry standards.

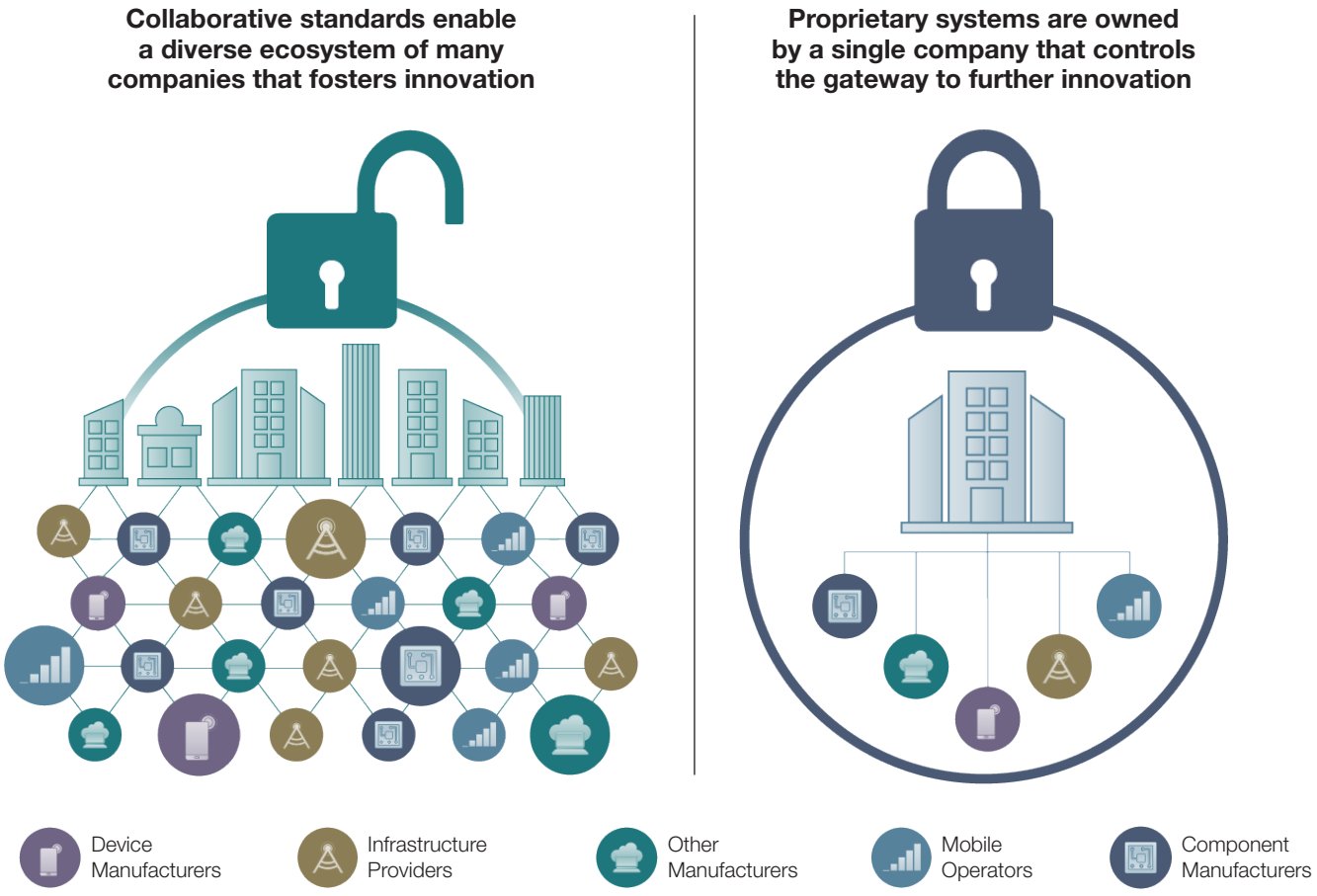
Although foundational cellular technologies underpin the entire connectivity-based ecosystem, studies have shown that

Figure 4: Licensing revenues of standard-essential patent owners as percentage of total economic value generated by cellular technologies (left) and fees charged by app stores as percentage of sales from app developers (right)




Source: SEC Filings/ Public Statements for Qualcomm, InterDigital, Ericsson, Nokia, and Huawei. (The licensing revenue of these five SEP owners was adjusted upwards to extrapolate the total licensing revenue for all SEPs); App Stores: https://techcrunch.com/2021/03/16/google-play-drops-commissions-to-15-from-30-following-apples-move-last-year/.

Figure 5. Comparison of business models for standards and proprietary technologies




Data source: Padilla, J., Davies, J., & Boutin, A. (2017). Economic Impact of Technology Standards. *Compass Lexecon*. Graphic source: Report authors.

patent licensing revenues make up only a small percentage of the total economic value generated by those technologies for all stakeholders. In fact, licensing revenues for cellular technologies account for only 0.17–0.27% of the total $4.8 trillion in economic value created by those technologies.[21] This is a relatively small fee, considering the value that cellular technologies create for everyone.

By comparison, fees charged to consumers to access proprietary systems—app stores, for example—that are part of the mobile economy, are significantly higher. App stores that directly control the access to their platforms receive between 15% and 30% of all app sales within their proprietary system.[22] As Figure 4 shows, the Google Play and Apple App stores charge a fee that is, in relative terms, more than 50 times higher than the one charged

by cellular innovators, even though the development of their proprietary systems requires fewer resources, both in terms of time and necessary financial investments.

But relative price savings is not the only advantage of collaborative standards over proprietary systems. Collaborative standards create an open ecosystem that allows a diverse and wide range of firms and individuals to participate in, and add to, the economy of the connected world. In contrast, proprietary systems are controlled by a single company that controls the gateway to further innovation, as Figure 5 shows.

In sum, collaborative standards facilitate the growing reach of connectivity around the world and bring the benefits of the mobile revolution to an ever-increasing proportion of the global population.

## Conclusion

Cellular technology has been essential to enabling the development of a thriving mobile ecosystem. The rapid rise of global connectivity has already provided a myriad of benefits to consumers, businesses, and society, and these benefits will only continue to increase as we begin to realize new and unexpected ways to leverage next-generation technology, such as 5G. To maintain a sustainable mobile ecosystem, it is important to ensure that companies that have invested (and continue to invest) billions of dollars and tens of thousands of person-hours in the development of foundational technologies are properly compensated for their innovative labors. Without this, we risk losing out on the innumerable benefits that enhanced connectivity brings to bear on all facets of our society.

# Endnotes

1 GSMA Intelligence, Custom-Search-Country (2020) (database on file with the author).

2 GSMA, "The Mobile Economy 2020," https://www.gsma.com/mobileeconomy/wp-content/uploads/2020/03/GSMA_MobileEconomy2020_Global.pdf; and Bowman Heiden, "The Value of Cellular Connectivity—from Mobile Devices to the Internet-of-Things," September 21, 2020, https://dx.doi.org/10.2139/ssrn.3670222.

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4 See "About 3GPP," https://www.3gpp.org/about-3gpp.

5 The analysis is based on 3GPP membership and contribution data. See "3GPP," https://www.3gpp.org/.

6 Bock, "The Mobile Revolution," note 4, at 4.

7 GSMA, "The Mobile Economy," note 3, at 4.

8 Ericsson, "Harnessing the 5G Consumer Potential: The Consumer Revenue Opportunity Uncovered," 2020, https://www.ericsson.com/4ac9d8/assets/local/reports-papers/consumerlab/reports/2020/harnessing-the-5g-consumer-potential.pdf.

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11 Heiden, "The Value of Cellular Connectivity," note 3, at 36.

12 Heiden, "The Value of Cellular Connectivity," note 3 at 47.

13 Sunil Arya, "The Value of Standardized Technology to Connected Cars, *GRUR International* 69, no. 4 (April 2020): 365–79.

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15 Heiden, "The Value of Cellular Connectivity," note 3, at 50; *see also* Ericsson, "A Case Study on Real-Time Control in Manufacturing," April 2018, https://www.ericsson.com/4aad73/assets/local/reports-papers/consumerlab/reports/2018/5g_for_industries_report_blisk_27062018.pdf.

16 *See* Simon Winchester, *The Perfectionists: How Precision Engineers Created the Modern World* (New York: Harper Perennial, 2018), 173–213.

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20 Eleni Charoniti et al., "Environmental Benefits of C-V2X for 5GAA -5G Automotive Association E.V.," TNO, 2020, https://5gaa.org/wp-content/uploads/2020/11/Environmental-Benefits-of-C-V2X.pdf.

21 Sources and methodology for licensing revenue: SEC Filings/ Public Statements for Qualcomm, InterDigital, Ericsson, Nokia, and Huawei. The licensing revenue of these five SEP owners was adjusted upward to extrapolate the total licensing revenue for all SEPs. The upward adjustment is based on the method developed in this paper: Alexander Galetovic, Stephen Haber, and Lew Zaretzki, "An Estimate of the Average Cumulative Royalty Yield in the World Mobile Phone Industry: Theory, Measurement and Results," *Telecommunications Policy* 42 (2018): 263–76. Note: The listed licensing revenue dollar range does not reflect the overall licensing or other value generated by patent portfolios that is unobservable, that is, the value due to cross-licensing, the defensive value of portfolios, other technical know-how, etc.

22 See, for example, Manish Singh, "Google Play Drops Commissions to 15% from 30%, Following Apple's Move Last Year," TechCrunch, March 16, 2021, https://techcrunch.com/2021/03/16/google-play-drops-commissions-to-15-from-30-following-apples-move-last-year/.

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