The Economic Value of Wi-Fi®: a global view (2021 – 2025)

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Telecom Advisory Services LLC (URL: www.teleadvs.com) is an international consulting firm registered in the state of New York (United States), with physical presence in New York, Madrid, Bogotá and Buenos Aires. Founded in 2006, the firm specializes in the development of business strategies and public policies for digital and telecommunications companies, governments, and international organizations. Its clients include leading companies in the digital and telecommunications sectors, as well as international organizations such as the International Telecommunication Union, the World Bank, the Inter-American Development Bank, the World Economic Forum, the UN Economic Commission for Latin America and the Caribbean, CAF Development Bank for Latin America, the GSMA Association, the CTIA, the National Cable TV Association (U.S.), GigaEurope, Wi-Fi Alliance, and the FTTH Council (Europe), as well as the governments of Argentina, Brazil, Colombia, Ecuador, Costa Rica, Germany, Mexico, Peru, and Saudi Arabia.

This study was commissioned by Wi-Fi Alliance® and conducted by Telecom Advisory Services between August and December of 2020; an addendum was completed also by Telecom Advisory Services between May and July of 2021, covering selected countries in Sub-Saharan Africa, Asia, Middle East and North Africa. The authors of both studies are solely responsible for their content.

A summary of this economic study is available for review at www.valueofwifi.com.

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EXECUTIVE SUMMARY

In 2018, Telecom Advisory Services LLC (TAS) published a study assessing the worldwide economic value of Wi-Fi®.[1] The study's purpose was to measure Wi-Fi's economic surplus to consumers and producers, as well as Wi-Fi's direct net contribution to output (Gross Domestic Product, or GDP) and employment between 2018 and 2023. The result of that study estimated Wi-Fi's global economic value to be $1.96 trillion in 2018 and forecast that it would reach $3.47 trillion by 2023.[2]

Significant changes have taken place since 2018 in the Wi-Fi ecosystem, warranting a new study. First, in 2019, Wi-Fi equipment manufacturers began launching Wi-Fi 6 products for consumer and enterprise.[3] Wi-Fi 6 is the sixth generation of Wi-Fi, offering higher performance, lower latency, and faster data rates.

With the launch of Wi-Fi 6 and in anticipation of the recommendations presented at the 2023 World Radiocommunication Conference (WRC-23) of the International Telecommunication Union (ITU), regulators in many countries recognized the importance of unlicensed spectrum in driving Wi-Fi performance. In April 2020, the Federal Communications Commission (FCC) of the United States unanimously voted to open 1,200 megahertz of spectrum in 6 GHz available for unlicensed innovation, with a decision on low power unlicensed devices in the 6 GHz band pending final approval. In July 2020, the United Kingdom's Office of Communications (Ofcom) reached a decision to allocate the lower 6 GHz band for unlicensed use supporting Wi-Fi connectivity indoors with limited outdoor coverage. In October 2020, South Korea's Ministry of Science and ICT (MSIT) announced that it had approved the use of 1,200 megahertz of spectrum in the 6 GHz band for unlicensed use.

The initial 6 GHz spectrum allocation initiatives taken by regulators in the United States, the United Kingdom and South Korea spread around the world. In the Americas, Chile's regulator, Subtel, announced the release of the full 6 GHz band in November 2020. In December 2020, the Brazilian telecommunications regulator voted to release the entire 6 GHz band as well. The allocation of the full band was followed in Peru[4], Costa Rica, Guatemala, Honduras. In addition, Argentina, Colombia[5], and Mexico[6] have all launched public consultations on the need to allocate either the full band (Colombia and Mexico) or its lower part (Argentina).

[1] Katz, R. and Callorda, F. (2018a). *The Economic value of Wi-Fi: A Global View (2018 and 2023)*. New York: Telecom Advisory Services. October.
[2] All currency numbers in the study are reported in U.S. dollars.
[3] *Wi-Fi Alliance dubbed devices capable of 6 GHz band operation Wi-Fi 6E devices.*
[4] MTC (2021). *Propuesta de asignación de bandas de frecuencia 3.5 GHz, y 26 GHz e Identificación de la banda de frecuencia de 6 GHz para el desarrollo de servicios y tecnologías digitales 5G y más allá.*
[5] Gobierno de Colombia. Agencia Nacional de Espectro (2021). *Consulta Pública: Uso de la banda de frecuencias 5925-7125 MHz*. Bogotá.
[6] Instituto federal de Telecomunicaciones (2020). *El IFT abre Consulta Pública sobre uso de la banda de 6 GHz en México (Comunicado 85/2020*) 06 de noviembre. Retrieved in: http://www.ift.org.mx/comunicacion-y-medios/comunicados-ift/es/el-ift-abre-consulta-publica-sobre-uso-de-la-banda-de-6-ghz-en-mexico-comunicado-852020-06-de

Finally, Canada became the world's first country to allow all three—LPI, VLP, and standard power–device classes to operate in 6 GHz.[7]

In Asia, beyond South Korea's move, Australia and Japan are considering allocating the entire 6 GHz band, while New Zealand is considering a move limited to the lower part of the band. The European Union has also released approximately 500 megahertz of the 6 GHz band to unlicensed use by early 2021, although it is possible that more spectrum could be allocated in future. Arab States in the Middle East and North Africa have been also moving in this direction. Saudi Arabia has decided to allocate the entire 6 GHz, while Morocco, and the United Arab Emirates have decided to allocate the lower part of the band, and Jordan and Qatar are envisioning allocating the entire band. Finally, sub-Saharan Africa countries are also analyzing future unlicensed use of the 6 GHz band. The African Telecommunications Union (ATU) has formulated its recommendation on license-exempt access to the lower part of the 6 GHz band. If African administrations validate the recommendations, then the position of the continent will be like the one adopted by the European Union.

The combination of new technology and additional spectrum has enhanced the economic value of Wi-Fi since it was originally estimated in 2018. For example, assuming approval of VLP devices operating in 6 GHz in all countries, this new category will enable the deployment of a new generation of Augmented Reality/Virtual Reality (AR/VR) solutions and unlock even wider deployment of Internet of Things (IoT) devices.

Conversely, the COVID-19 pandemic has resulted in a downward adjustment in the macroeconomic forecast. While before the pandemic the world economy was projected to grow at 2.9 percent for 2020, the International Monetary Fund has estimated that the year closed with a contraction of 3.5 percent. This revised perspective impacted the base upon which Wi-Fi economic value is projected. At the same time, the global pandemic has demonstrated how critical Wi-Fi technology is in building social and economic resilience:

- Free Wi-Fi in public sites have provided Internet access to consumers that cannot purchase broadband service due to affordability;
- Residential Wi-Fi supports simultaneous access of multiple devices for distance learning, telecommuting, telemedicine, and information distribution at home;
- Prompted by isolation and confinement, consumers tend to rely more on wireless devices, with Wi-Fi being key to limiting wireless expenditures;
- Wi-Fi enabled Wireless Internet Service Providers (WISPs) offer Internet access for broadband in unserved[8] communities; and
- Wi-Fi technology enables digital transformation of businesses by supporting the virtualization of business processes, facilitating telecommuting.

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[7] Government of Canada (2021). *Government of Canada to make more spectrum available to support high-quality wireless service,* Ottawa, May 21.
[8] Broadband unserved is defined as the population that cannot access fixed broadband service because of lack of service coverage.

To trace the projections of this update vis-à-vis the 2018-2023 study, we have estimated the Wi-Fi economic value for two scenarios:

(i) Baseline: addresses the growth of Wi-Fi value in the 2.4 GHz and 5 GHz unlicensed bands, as well as equipment in the Wi-Fi 4 and Wi-Fi 5 generations; and
(ii) Accelerated: considers the effect of adding the 6 GHz spectrum band allocation and the release of new Wi-Fi 6 and Wi-Fi 6E equipment.[9]

Both scenarios reflect the changes in economic context. In addition, this report expands on the 2018 study, covering the following countries:

- North America: United States;
- Europe: United Kingdom and European Union;
- Asia Pacific: Australia, Japan, New Zealand, Singapore, South Korea and India;
- Latin America: Brazil, Colombia, and Mexico;
- Middle East and North Africa: Egypt, Jordan, Morocco, Oman, and Saudi Arabia;
- Sub-Saharan Africa: South Africa, Democratic Republic of Congo, Cameroon, Gabon, Nigeria, Senegal, Kenya, and Uganda.

As in the 2018 study, country and regional estimates are extrapolated to generate a global value.

Wi-Fi total global economic value, including worldwide availability of Wi-Fi 6 devices operating in 6 GHz, to reach $4.9 T by 2025

According to the baseline scenario of this updated study, which includes Wi-Fi devices up through Wi-Fi 5 operating in the 2.4 and 5 GHz spectrum bands, Wi-Fi's total global economic value is $3,244 billion, forecasting to reach $4,348 billion in 2025. However, assuming a worldwide availability of Wi-Fi 6 devices operating in the 6 GHz spectrum, the total value in 2021 would increase to $3,302 billion, or $3.3 trillion, reaching $4,876 billion, or 4.9 trillion, by 2025 (see Table A).

Table A. Global Wi-Fi Economic Value ($ billion)

	2021	2025
2018 Study	$2,840.7	$4,361.5
2021 Study: Baseline Scenario	$3,244.1	$4,348.3
2021 Study: Wi-Fi 6 / 6 GHz	$58.0	$527.6
Total 2021 Study	$3,302.1	$4,875.9

Source: Telecom Advisory Services analysis

The 2021 estimate represents a 16 percent increase from the prior study, even considering the global coronavirus pandemic. In fact, Wi-Fi drives digital resilience and innovation, significantly outweighing the negative effects of COVID-19 on a global scale.

The countries with the highest Wi-Fi economic value creation (including the baseline and Wi-Fi 6/6 GHz scenarios) in 2021 are the United States ($995.0 billion),

[9] Wi-Fi 6E devices are Wi-Fi devices capable of operating in the 6 GHz band.

followed by Japan ($251.1 billion), Germany ($134.5 billion), India ($131.3), Brazil ($105.2 billion), United Kingdom ($98.8 billion), South Korea ($89.3 billion), and France ($62.5 billion) (see Table B).

Table B. Wi-Fi Total Economic Value (Baseline and Wi-Fi 6 Scenarios)

Continent	Country	2021	2025
North America	United States	$995.0	$1,580.2
Europe	European Union*	$457.6	$637.2
	United Kingdom	$98.8	$108.5
Asia	Australia	$34.7	$41.7
	India	$131.3	$240.2
	Japan	$251.1	$325.0
	New Zealand	$6.7	$9.8
	Singapore	$10.6	$12.4
	South Korea	$89.3	$139.5
Latin America	Brazil	$105.2	$124.4
	Colombia	$18.9	$41.4
	Mexico	$56.7	$117.5
Middle East and North Africa	Egypt	$9.1	$17.2
	Jordan	$2.2	$4.1
	Morocco	$6.1	$7.5
	Oman	$2.6	$3.0
	Saudi Arabia	$17.3	$23.7
Sub-Saharan Africa	Cameroon	$1.0	$2.6
	Democratic Republic of Congo	$0.7	$1.8
	Gabon	$0.6	$1.2
	Kenya	$12.2	$16.3
	Nigeria	$16.1	$33.1
	Senegal	$1.2	$2.8
	South Africa	$30.9	$44.2
	Uganda	$1.4	$4.2
Rest of World		$944.5	$1,336.5
	Total World (*)	$3,302.1	$4,875.9

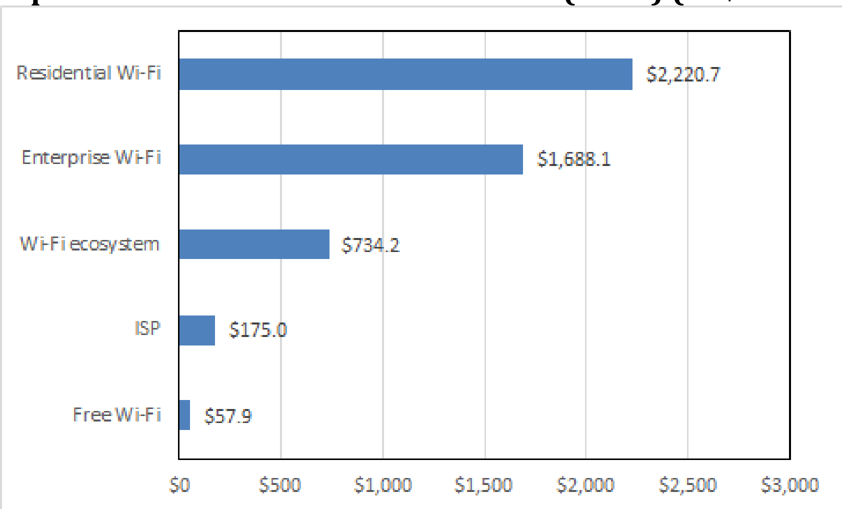
(*) The estimates for the European Union include detailed analyses for France ($62.5 billion), Germany (134.5 billion), Poland ($16.1 billion), and Spain ($40.4 billion).
(**) Including "Rest of the World" nations not estimated above
Note: Due to rounding, the sum of 2021 economic value does not add up precisely to the total.
Source: Telecom Advisory Services analysis

The main drivers of economic value include:

- Free Wi-Fi: benefit to consumers accessing Wi-Fi hotspots in public sites;
- Residential Wi-Fi: provision of Internet access and connectivity of devices at home;
- Enterprise Wi-Fi: use of Wi-Fi to support a significant portion of enterprise broadband traffic and productivity gains from Wi-Fi enabled IoT and AR/VR;
- Internet Service Providers (ISPs): savings for cellular providers who rely on Wi-Fi re-routing and revenues of Wi-Fi commercial providers; and
- Margins of manufacturing and Wi-Fi ecosystem companies, including manufacturers of Wi-Fi devices and equipment, IoT networks and AR/VR solutions.

The most important sources of economic value in 2025 are residential Wi-Fi and enterprise Wi-Fi. That said, the Wi-Fi ecosystem also benefits from Wi-Fi in terms of the profits received by manufacturers of equipment (access points, controllers, routers, gateways, sensors, AR/VR devices, smart speakers, home security systems, and the like), while ISPs generate savings by relying on the technology to offload traffic from their networks. Finally, Wi-Fi also generates economic value through social contributions: the technology represents a useful application to bridge the digital divide in rural and isolated geographies, while also providing an important platform for free Internet access (see Graphic C).

Graphic C. Global Wi-Fi Economic Value (2025) (in $ billions)

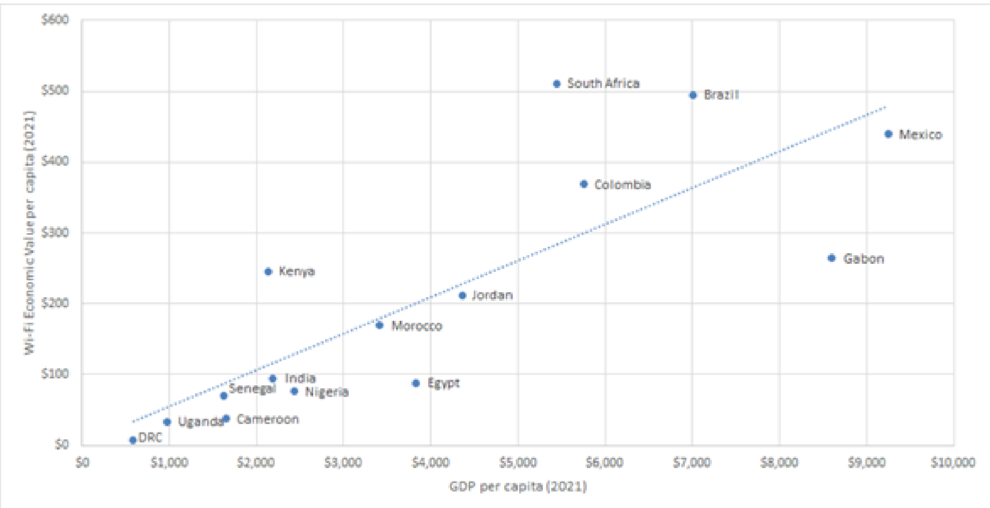


Source: Telecom Advisory Services analysis

The study also provides an estimate of Wi-Fi contribution to job creation by relying on Input / Output analysis. Global employment benefitting from Wi-Fi in 2021 amounts to 3.2 million jobs and is expected to reach 4.0 million jobs by 2025.

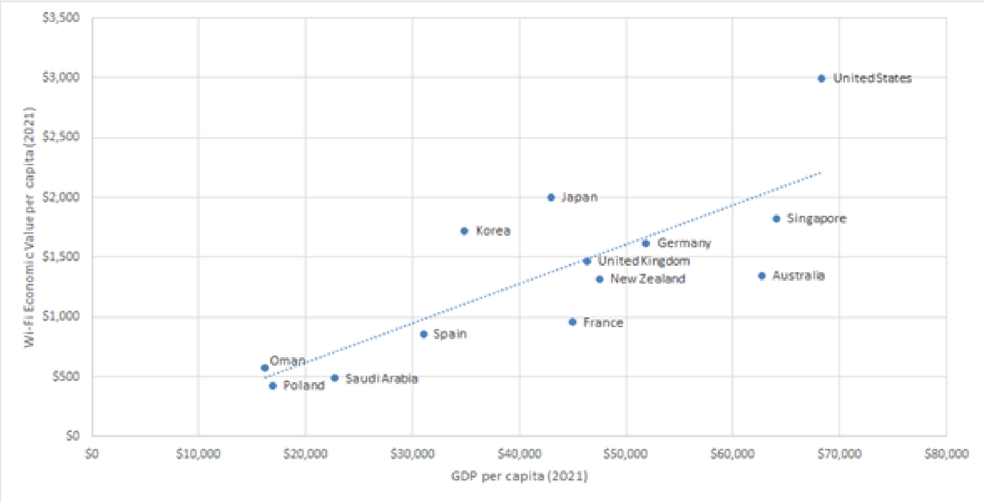
The addition of countries to the original list of nations studied in detail in the 2018 study is useful to draw some cross-national comparisons and insights. First, **a country's economic development is directly linked to the value of Wi-Fi.** Graphic D and Graphic E indicates that the higher the GDP per capita, the more important is the economic value of Wi-Fi per capita.

Graphic D. Economic Development and **Wi-Fi Value, Countries with GDP per capita lower than US$ 10,000 (*)**



(*) Including the baseline and Wi-Fi 6/6GHz scenarios)
Sources: International Monetary Fund; Telecom Advisory Services analysis

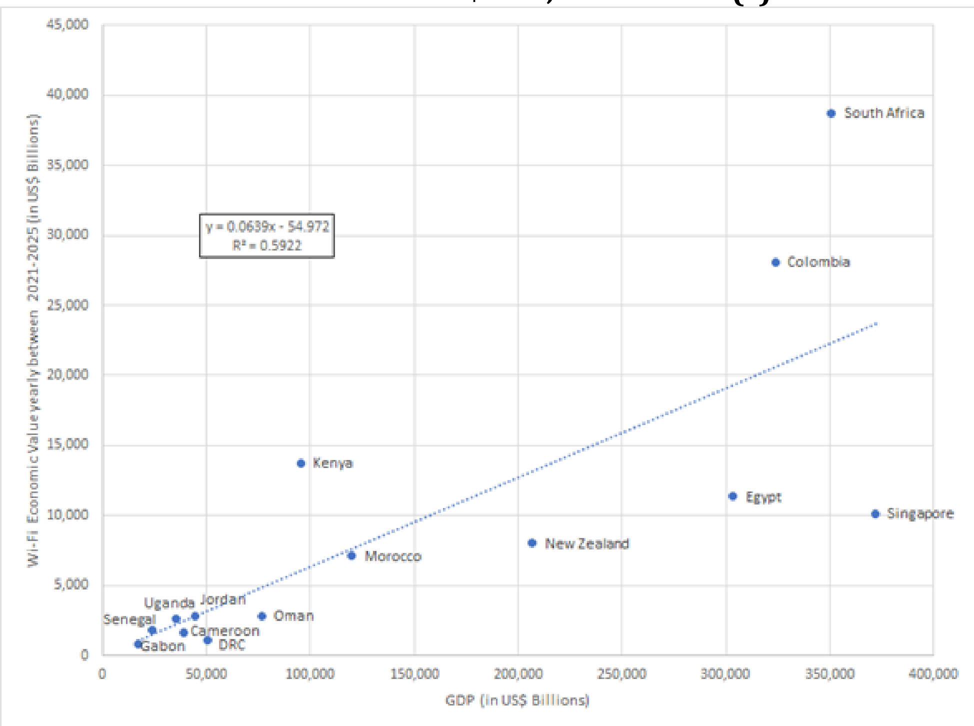
Graphic E. Economic Development and **Wi-Fi Value, Countries with GDP per capita higher than US$ 10,000 (*)**



(*) Including the baseline and Wi-Fi 6/6GHz scenarios)
Sources: International Monetary Fund; Telecom Advisory Services analysis

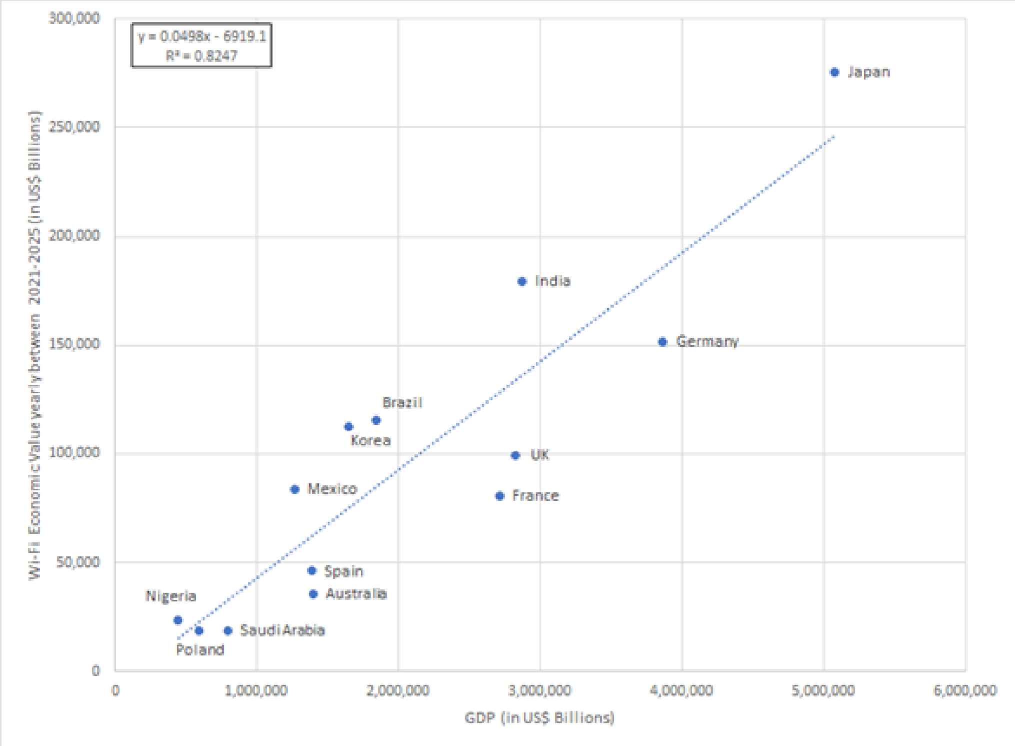
Second, while GDP per capita is associated with higher Wi-Fi economic value per capita, some developing countries display higher total Wi-Fi economic value than the size of their economy might predict (see Graphic F and Graphic G).

Graphic F. Size of the Economy and Total Wi-Fi Value, Countries with GDP lower than US$ 400,000 million (*)



(*) Including the baseline and Wi-Fi 6/6GHz scenarios)
Sources: International Monetary Fund; Telecom Advisory Services analysis

Graphic G. Size of the Economy and Total Wi-Fi Value, Countries with GDP higher than US$ 400,000 million (*)



Note: United States observation excluded to depict the difference among countries with lower aggregate value.
(*) Including the baseline and Wi-Fi 6/6GHz scenarios)
Sources: International Monetary Fund; Telecom Advisory Services analysis

As indicated in Graphics F and G, Brazil and India exhibit a higher total Wi-Fi economic value than some advanced economies such as the United Kingdom, France, and Germany. This is due to four factors:

- Emerging countries typically do not have fully developed cellular infrastructure (i.e., lower density of base stations), with average cellular speeds lagging significantly behind those of Wi-Fi. As a result, **the percentage gain in speed from routing traffic through Wi-Fi is greater in developing countries than in many advanced economies, and so is the implied economic impact.**

- Emerging nations have a larger digital divide (unserved and underserved[10] population) than advanced economies. As a result, **a higher number of households and economic units benefit from free Wi-Fi and Wireless ISPs in developing countries than in industrialized ones.**

- Cellular prices in developing countries are much higher in relative terms than in developed nations. The simple average of the most economic cellular data plan for the three Latin American countries included in this study (Brazil,

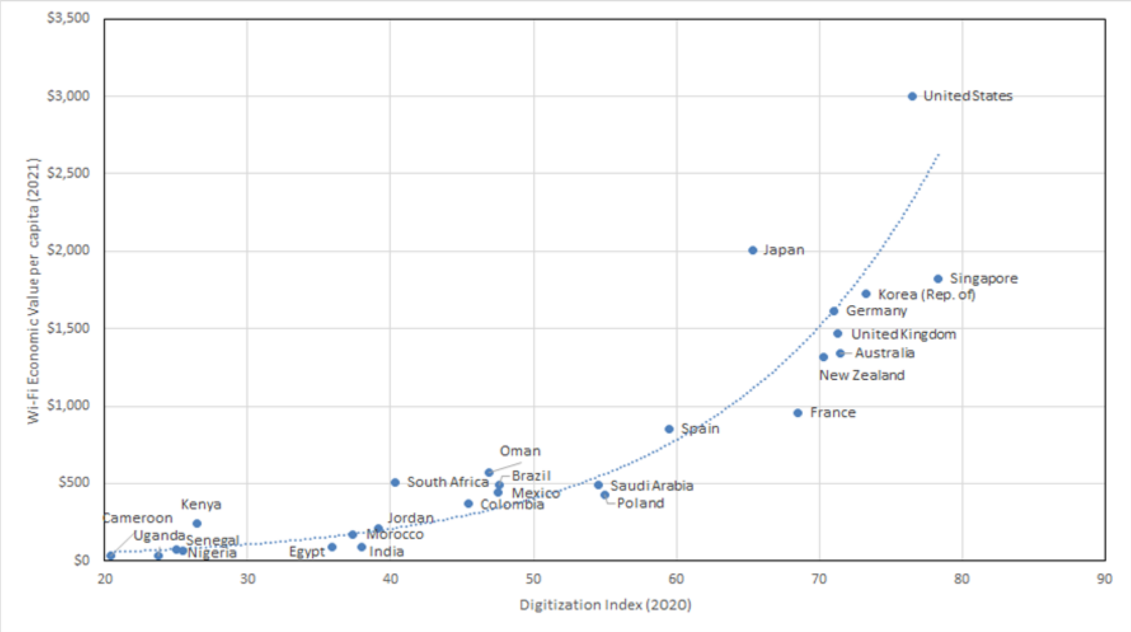
[10] Broadband underserved is defined as the population that has access to broadband service but at a significantly low level of service quality (i.e. slow download speeds, very high latency).

Mexico and Colombia) is $2.30 per gigabyte (GB) in 2020 and in Africa is $1.69, while in Europe it is $0.76, in Asia-Pacific $0.94 and in MENA $0.48. This considerably increases the economic value of routing residential and business traffic through Wi-Fi.

- To calculate the advantage Wi-Fi 6 and 6 GHz bring, we made assumptions based on spectrum allocation levels being considered in those markets. For instance, some country estimates are based on 1,200 megahertz (United States, South Korea, Mexico, Colombia, Australia, New Zealand, Japan, Singapore, Brazil, India, Jordan, and Saudi Arabia), while others are based on 500 MHz (Germany, France, United Kingdom, Spain, Poland, Egypt, Morocco, Oman, Cameroon, Democratic Republic of Congo, Gabon, Kenya, Nigeria, Senegal, South Africa, and Uganda).

Third, a country's level of digitization[11] is exponentially related to the economic value of Wi-Fi. In other words, **the digital transformation of the economy increases the value of Wi-Fi in a non-linear fashion** (see graphic H).

Graphic H. Digitization and Wi-Fi Value



Source: Telecom Advisory Services analysis

Based on this evidence, **Wi-Fi technology should be recognized as one of the dominant economic engines of the digital economy**. Governments around the world should develop incentives to stimulate the social and economic benefits of Wi-Fi. This includes assigning enough spectrum to avoid congestion, encouraging the private sector to create new applications using Wi-Fi, and relying on the technology to address the digital divide barrier.

[11] Digitization is measured through a composite index based on 64 indicators grouped in six pillars: digital infrastructure, connectivity, household digitization, digital economy, digitization of the state, and factors of digital production. See Katz, R. and Callorda, F. (2018b).

I. INTRODUCTION: IMPETUS TO UPDATE THE 2018 ECONOMIC VALUE STUDY

The study of the economic value of Wi-Fi and unlicensed spectrum has been an area of research since 2012.[12] In 2018, the authors of the present study published a report assessing, for the first time on a global basis, the economic value of Wi-Fi.[13] The study's purpose was to measure Wi-Fi's economic value, both to consumers and producers[14], as well as its direct net contribution to output (Gross Domestic Product, or GDP) and employment between 2018 and 2023. The study covered, in detail, an analysis of the United States, United Kingdom, France, Germany, Japan, and South Korea, and extrapolated Wi-Fi's global value. Based on data available through 2017, we estimated the economic value in 2018 for the six countries studied to be $930.8 billion, reaching $1,654.6 billion by 2023.

Significant changes have taken place since 2018 in the Wi-Fi ecosystem that warrant a new study. They comprise: (i) the launch of Wi-Fi 6, a new generation of high-performance Wi-Fi devices, (ii) new allocations of unlicensed spectrum for Wi-Fi use, and (iii) the consequent development of new sources of value, such as increasing deployment of IoT and growing adoption of AR/VR solutions. Additionally, the new economic context triggered by the COVID-19 pandemic represents a macro-economic variable influencing the final estimate. Each of these four factors will be reviewed in turn.

I.1. Wi-Fi 6, a new generation

Starting in 2019, Wi-Fi equipment manufacturers started launching a sixth generation of devices offering higher performance, lower latency, and faster data rates. Categorized as Wi-Fi 6, the sixth generation of Wi-Fi equipment adopted the 802.11ax standard, offering a base speed of 1.2 Gbps, and up to 4.8 Gbps under a quad-stream configuration.

Following the release of the Wi-Fi 6 standard, a new generation of devices is being introduced that can operate in the 6 GHz spectrum band, as opposed to exclusively in the traditional 2.4 GHz and 5 GHz bands, and, consequently, take advantage of

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[12] Among the original studies, we can count Thanki, R. (2009). *The economic value generated by current and future allocations of unlicensed spectrum*. Perspective Associates; Milgrom, P., Levin, J., & Eilat, A. (2011). *The case for unlicensed spectrum*. Stanford Institute for Economic Policy Research Discussion Paper No. 10-036; Cooper, M. (2011). *The consumer benefits of expanding shared use of unlicensed radio spectrum: Liberating Long-Term Spectrum Policy from Short-Term Thinking*. Washington D.C.: Consumer Federation of America; Katz, R. (2014). *Assessment of the economic value of unlicensed spectrum in the United States*. New York: Telecom Advisory Services; Katz, R. (2014). *Assessment of the future economic value of unlicensed spectrum in the United States*. New York: Telecom Advisory Services; Katz, R. (2018). *A 2017 assessment of the current and future economic value of unlicensed spectrum*. Washington, DC: Wi-Fi Forward; Katz, R. (2020). *Assessing the economic value of unlicensed use in the 5.9 GHz and 6 GHz bands*. Washington, DC: Wi-Fi Forward.

[13] Katz, R. and Callorda, F. (2018a). *The Economic value of Wi-Fi: A Global View (2018 and 2023)*. New York: Telecom Advisory Services. October.

[14] Producers are defined as enterprises benefitting from Wi-Fi to reduce their telecommunications spending, companies delivering products and services in the Wi-Fi ecosystem, and Internet Service Providers that reduce their infrastructure costs by relying on Wi-Fi access points.

several 160 MHz channels. This additional spectrum addresses the congestion developing in the traditional bands by providing more contiguous spectrum blocks. The release of Wi-Fi 6E equipment is occurring simultaneously with the allocation of 6 GHz spectrum for unlicensed use that is currently occurring in many countries around the world.

I.2. New spectrum allocations for Wi-Fi use

With the launch of Wi-Fi 6, regulators in many countries have recognized the importance of unlicensed spectrum in driving the performance of Wi-Fi. In April 2020, the Federal Communications Commission (FCC) in the United States allowed low power unlicensed devices to operate in the 6 GHz band, although the authorization for VLP devices has not been approved yet.[15] In addition to the FCC decision, other countries in North America have also allocated spectrum for Wi-Fi use. In May 2021, Canada enacted a decision to allocate the entire 6 GHz band for unlicensed use.[16] In doing so, Canada became the world's first country to allow all three (LPI, VLP, and standard power) device classes to operate in 6 GHz.

Some countries have followed or are considering an approach to allocate the lower band – 5925-6425 MHz – which is adjacent to the currently used 5 GHz band, has similar mid-range propagation characteristics, and offers, wide, non-overlapping channels. The underlying rationale for investigating only the 5,925 to 6,425 band (500 MHz) is that some countries (especially in Europe) have critical services in the upper part of the 6 GHz band (e.g., large amounts of point-to-point fixed services, earth to space communications, road intelligent traffic systems and communication-based train control, and some radio astronomy sites). That said, those countries that have adopted the allocation of only the lower portion of the 6 GHz band, recognize that this can change in the future. For example, Ofcom made the final decision to make 500 MHz available for unlicensed use LPI and VLP outdoor use as an initial matter[17.] The purpose in limiting the allocation to 500 MHz is to initially show Wi-Fi can benefit from the lower part of the band and then investigate the upper part[18]. In the words of Ofcom, "…we will continue to review use of the upper 6 GHz band to determine what the optimal use may be".[19]

In Asia, South Korea's Ministry of Science and ICT (MSIT) issued a proposed "amendment of technical standards" in June 2020 for releasing the entire 6 GHz band for Wi-Fi indoor operation by the end of 2020, while outdoor use will follow in 2022.[20] In addition, Australia and Japan are considering allocating the entire 6 GHz band, while New Zealand is considering a move limited to the lower part of the band.

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15 Federal Communications Commission (2020). *Unlicensed Use of the 6 GHz band: Report and Order and Further Notice of Proposed Rulemaking*. Washington, DC: April.

16 Government of Canada (2021). *Government of Canada to make more spectrum available to support high-quality wireless service,* Ottawa, May 21.

17 OFCOM (2020). *Statement: improving spectrum access for wi-fi – spectrum use in the 5 and 6 GHz bands* (July 24).

18 Ebbecke, Ph. (2019). *Road to 6 GHz in Europe.* Presentation to WLPC Prague 2019

19 OFCOM (2020). *Improving spectrum access for Wi-Fi*. London, p.21.

20 Yonhap (2020). "Unlicensed frequency band to boost Wi-Fi speed, smart factory penetration: ministry", *The Korea Herald*, (June, 27).

In Latin America, the allocation of the 6 GHz spectrum for unlicensed use is accelerating. In November 2020, Chile's regulator, Subtel, announced the release of the full 6 GHz band.[21] In December 2020, the Brazilian telecommunications regulator voted to release the entire 6 GHz band as well. The allocation of the full band was followed in Peru, Costa Rica, Guatemala, and Honduras. In addition, Argentina, Colombia[22], and Mexico[23] have all launched public consultations on the need to allocate either the full band (Colombia and Mexico) or its lower part (Argentina).

Arab States in the Middle East and North Africa have also been moving in this direction. Saudi Arabia has decided to allocate the entire 6 GHz, while Morocco and the United Arab Emirates have decided to allocate the lower part of the 6 GHz band. Egypt and Oman are considering allocating the lower part of the 6 GHz band, while Jordan and Qatar are envisioning allocating the entire band.

Finally, some sub-Saharan Africa countries are also analyzing future unlicensed use of the 6 GHz band. The African Telecommunications Union (ATU) Emerging Technologies Task Group has formulated its recommendation on license-exempt access to the lower part of the 6 GHz band (5925-6425 MHz). The recommendation, sent to all ATU countries for written inputs, includes an annex containing the technical and regulatory conditions for operating unlicensed technologies in the lower 6 GHz band. If African administrations validate the recommendations, then the position of Africa will be like the one adopted by the European Union. Some African countries are likely to move quickly to open the lower 6 GHz to enable Wi-Fi 6E to bring enhanced connectivity to citizens and businesses.

The current state of the allocation of the 6 GHz around the world is rapidly changing. For example, as August 2021, the United States, Canada, Brazil, Chile, Costa Rica, Guatemala, Honduras, Peru, the European Union, the United Kingdom, Egypt, Morocco, Saudi Arabia, United Arab Emirates, and South Korea had already designated part or the whole 6 GHz band for unlicensed use.[24]

I.3. New sources of economic value

Triggered by the allocation of new Wi-Fi spectrum and the release of Wi-Fi 6 and Wi-Fi 6E devices, other sources have been confirmed as important drivers for future value growth. The creation of the LPI device categories, as implied by the decision of the United States regulator, will drive the development of additional sources of economic value. The 6 GHz band (jointly with the pre-existing unlicensed spectrum) will allow support for much wider channels in spectrum bands. Additionally, the

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[21] Gobierno de Chile. Ministerio de Transporte y Telecomunicaciones (2019). *Resolución 1985 EXENTA: Fije Norma Técnica de equipos de alcance reducido*. Santiago: 6 de octubre.
[22] Gobierno de Colombia. Agencia Nacional de Espectro (2021). *Consulta Publica: Uso de la banda de frecuencias 5925-7125 MHz*. Bogotá.
[23] Instituto federal de Telecomunicaciones (2020). *El IFT abre Consulta Pública sobre uso de la banda de 6 GHz en México (Comunicado 85/2020*) 06 de noviembre. Retrieved in: http://www.ift.org.mx/comunicacion-y-medios/comunicados-ift/es/el-ift-abre-consulta-publica-sobre-uso-de-la-banda-de-6-ghz-en-mexico-comunicado-852020-06-de
[24] For an updated state of designation of the band for unlicensed use, see tracker. https://www.wi-fi.org/countries-enabling-wi-fi-6e

increase in Wi-Fi speed and capacity will lead to a broader scale IoT deployment. While IoT roll-out has been proceeding for a number of years, large scale deployment has suffered from the risk of congestion. The additional unlicensed spectrum will mitigate congestion and, therefore, provide a boost to the growth of IoT. Finally, the creation of a VLP device category will enable the deployment of a new generation of AR/VR solutions. VR is already used within a wide array of areas, ranging from the gaming industry and entertainment, to training and simulation, including training in the medical field. Other areas of application include education and culture, sports, live broadcasting, real estate, advertising, architecture, and arts. AR has an almost limitless range of uses in a wide variety of areas, be it commerce, technical applications, work processes, or education. AR and VR can serve both consumers and professional users in the private and public sectors.

I.4. The new economic context resulting from COVID-19

In addition to changes in the Wi-Fi ecosystem, the global economy has undergone an unexpected disruption. The COVID-19 pandemic has triggered a worldwide downward adjustment in the economic forecast, although the projections for 2021 indicate the resumption of economic growth (see Table I-2).

Table I-2. Selected Countries: 2020 Downward adjustment in GDP growth (%)

		2019 Growth	2020 Growth	2021 Projection
Countries	Brazil	1.1	-4.5	3.6
	France	1.3	-9.0	5.5
	Germany	0.6	-5.4	3.5
	India	4.2	-8.0	11.5
	Japan	0.7	-5.1	3.1
	Mexico	-0.1	-8.5	4.3
	Nigeria	2.2	-3.2	1.5
	Saudi Arabia	0.3	-3.9	2.6
	South Africa	0.2	-7.5	2.8
	Spain	2.0	-11.1	5.9
	United Kingdom	1.4	-10.0	4.5
	United States	2.3	-3.4	5.1
Regions	Latin America and the Caribbean	0.1	-7.4	4.1
	Emerging and Developing Asia	5.5	-1.1	8.3
	Sub-Saharan Africa	3.1	-2.6	3.2
	Middle East and North Africa	0.3	-3.2	3.0
	World Growth Based on Market Exchange Rates	2.4	-3.5	5.5

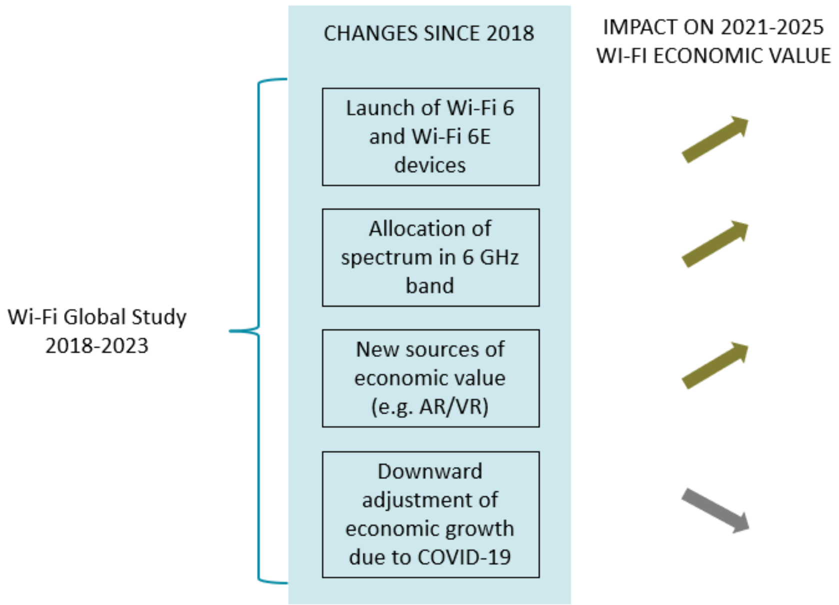
Source: International Monetary Fund (2021). Latest World Economic Outlook Growth Projections (January).

As indicated in Table I-2, 2020 economic growth declined from an average of 2.4 percent to -3.5 percent, and resumed growth to 5.5 percent. This change results in a downward adjustment on the economic baseline from which the contribution of Wi-Fi is estimated. That said, COVID-19 has put into perspective Wi-Fi's critical contribution to connecting households, as well as supporting telecommuting and distance learning.

I.5. A compilation of changes since 2018 affecting Wi-Fi economic value

A combination of changes and enhancements in the Wi-Fi landscape, as well as the changes triggered by the coronavirus pandemic have had an impact on our 2018 study. The launch of Wi-Fi 6, the allocation of additional unlicensed spectrum, and new sources of value have increased Wi-Fi aggregate economic contribution. Meanwhile, the recession triggered by COVID-19 has had a downward impact on the macroeconomic base from which the value of Wi-Fi is measured. The combined effects of these changes are depicted in Figure I-1.

Figure I-1. Changes in Wi-Fi Economic Value Since the 2018 study



Source: Telecom Advisory Services

The following report presents an assessment of economic value and growth between 2021 and 2025 for selected countries. To compare the changes that have taken place in the original study and consider the upside represented by Wi-Fi 6 and the allocation of the 6 GHz band for unlicensed use, the assessment differentiates between two scenarios (a baseline and one attributed to Wi-Fi 6 and 6 GHz). Chapter II presents the theoretical concepts and methodologies that frame the analysis. Chapters III and on present the results of the analysis for each market. Detailed explanation of the methodologies and models used to calculate the economic value by source are available in the Appendices of this document.

II. THEORETICAL FRAMEWORK AND METHODOLOGIES FOR ESTIMATING THE ECONOMIC VALUE OF WI-FI

II.1. Theoretical framework

Wi-Fi is what economists call a factor of production (or enabling resource) that yields economic value by complementing wireline and cellular technologies, enabling the development of alternative products and services that expand consumer choice, support the creation of innovative business models, and expand access to communications. The following chapter begins by defining the intrinsic value of Wi-Fi, both as a complementary technology that is part of the telecommunications ecosystem, enhancing the performance of networks and providing a platform for developing innovative applications. Following this, we put forward the concept of economic value, calculated as gains to consumer and producer surplus, a contribution to GDP, and job creation. Having formalized these sources of value, we then move to categorize the five economic agents that benefit from them: (i) individual consumers benefitting from access to free Wi-Fi service, (ii) consumer residences, (iii) enterprises, (iv) Internet Service Providers, and (v) manufacturers of communications equipment and consumer electronics. This categorization provides the framework to defining starting spectrum allocation assumptions and methodologies.

The intrinsic value of Wi-Fi

Considered as a factor of production, a complementary technology is a resource that, due to its intrinsic strengths, compensates for the limitations of another resource. For example, Wi-Fi can enhance the effectiveness of devices, such as smartphones, which use licensed spectrum. Wi-Fi access points can enhance the value of cellular networks by allowing wireless devices to switch to Wi-Fi hotspots, thereby reducing the cost of broadband access and increasing the access speed rate. Consumers accessing the Internet within the reach of a Wi-Fi access point can reduce their access costs by turning off their cellular service. They can also gain additional access speed as the transfer rate of Wi-Fi sites is generally faster than that offered by current cellular technology—even 4G LTE at current loads.[25] Likewise, many wireless operators reduce their capital spending by complementing their cellular networks with carrier-grade Wi-Fi access points, which are considerably less expensive than cellular network equipment with similar capacity.[26] In addition to reducing capital expenditures, wireless carriers can offer fast access to service without a base station congestion challenge.

In addition to complementing cellular networks, Wi-Fi can provide the required environment to enable the development and introduction of innovations such as Wi-Fi-enabled tablets, wireless security systems and household appliances, thereby

[25] For example, in 2020 the average mobile connection speed in the United States is estimated at 25.51 Mbps while the average Wi-Fi speed from a mobile device is 69.6 Mbps (Source: data interpolated from Cisco's Annual Internet Report Highlights Tool 2018-2023). Naturally, we can expect that speed gap to diminish with the progress of 5G deployments.

[26] The CAPEX savings resulting from Wi-Fi offloading for a cellular carrier in 1.5 million population cities is approximately 30 percent (Source: LCC Wireless).

providing consumers with a larger set of choices. By limiting transmission power and relying on spectrum with low propagation, Wi-Fi avoids interference, rendering irrelevant any barriers to innovation caused by the need to use licensed spectrum. In fact, some of the most important technological innovations in communications are intimately linked to Wi-Fi for gaining access. Numerous products and services, such as the multi-AP/mesh networking systems and smart speakers launched in the past ten years were developed leveraging Wi-Fi. By providing consumers with service choices in addition to those offered through cellular services, Wi-Fi also supports the development of innovative business models. Firms developing new applications that rely on Wi-Fi do not need approval from cellular operators, do not incur time-to-market penalties, and do not face financial disincentives derived from costly revenue splits with cellular service providers.

In addition to innovative applications, technologies relying on unlicensed spectrum used by Wi-Fi can help address the digital gap in broadband coverage. A large portion of the population that has not adopted the Internet around the world is located in rural and isolated areas. Many of them can gain access to broadband services provided by Wireless Internet Service Providers (WISPs), which typically operate through Wi-Fi. In addition, further developments in the areas of spectrum sensing, dynamic spectrum access, and geo-location techniques can improve the quality of Wi-Fi.

The derived value of Wi-Fi

There is a significant amount of research-based evidence that Wi-Fi technology has very high social and economic value. Prior research agrees that contrary to licensed bands where economic value could equate to whatever is paid at auction, the economic value of unlicensed spectrum, such as Wi-Fi, needs to be measured based on the concept of economic surplus.[27]

The concept of economic surplus is based on the difference between the value of units consumed and produced up to the equilibrium price and quantity, allowing for the estimation of consumer surplus and producer surplus.[28] Consumer surplus measures the total amount consumers would be willing to pay to have the service, compared to what they pay. Producer surplus measures the analogous quantity for producers, which is essentially the economic profit they earn from providing the service. Consumer and producer surplus together yield an economic surplus. Adding GDP contribution results in a total economic value estimate.

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[27] Thanki, R. (2009). *The economic value generated by current and future allocations of unlicensed spectrum*. London: Perspective Associates; Thanki, R. (2012). *The Economic Significance of License-Exempt Spectrum to the Future of the Internet.* London; Perspective Associates; Milgrom, P., Levin, J., and Eilat, A. (2011). *The case for unlicensed spectrum*. Stanford Institute for Economic Policy Research Discussion Paper No. 10-036; Katz, R. ibid.

[28] Following Alston (1990), we acknowledge that this approach ignores effects of changes in other product and factor markets; for example, Wi-Fi also increases the economic value of technologies operating in licensed bands (Alston, J.M. and Wohlgenant, M.K. (1990). "Measuring Research Benefits Using Linear Elasticity Equilibrium Displacement Models". John D. Mullen and Julian M. Alston, *The Returns to Australian Wool Industry from Investment in R&D*, Sydney, Australia: New South Wales Department of Agriculture and Fisheries, Division of Rural and Resource Economics).

Consistent with the concept presented above, this study measures the economic value of Wi-Fi by focusing first on the economic surplus generated after its adoption.[29] The underlying assumption is that Wi-Fi generates a shift both in the demand and supply curves, resulting from changes in how services are produced, as well as the corresponding willingness-to-pay for such services. On the supply side, the approach measures change in the value of inputs in the production of wireless communications. The most obvious example is, as mentioned above, whether Wi-Fi represents a positive contribution to wireless carriers' capital expenditures (CAPEX) and operating expenses (OPEX) insofar as they can control their spending, while meeting demand for increased wireless traffic. From an economic theory standpoint, the telecommunications industry can then increase its output, yielding a marginal benefit exceeding the marginal cost. This results in a shift in the supply curve by a modification in the production costs. The shift in the supply curve yields a new equilibrium price and quantity. Additionally, since the demand curve is derived from the utility function[30], the consumer benefits from stable Wi-Fi prices, yielding an increase in the willingness-to-pay, and consequently a shift in the demand curve. Under these conditions, total economic value is now represented by both changes in the consumer and producer surplus.

To quantify the incremental surplus derived from Wi-Fi adoption, we need to itemize all the effects linked to this technology. In addition, we complement the concept of economic surplus with an assessment of the direct contribution of the technologies and applications relying on Wi-Fi, such as Wi-Fi service providers, to national GDP. By including the GDP contribution measurement, we follow Greenstein et al. (2010) and prior research literature measuring the economic gains of new goods.[31] We focus on consumer and producer surplus, but also consider the new economic growth enabled by Wi-Fi. In measuring the direct contribution to GDP, we strictly consider the revenues added "above and beyond" what would have occurred had the Wi-Fi spectrum been licensed. After quantifying Wi-Fi's contribution to GDP, the impact on job creation can also be ascertained not only within the telecommunications industry but also in terms of the spillovers through the rest of the economy.

Source of value and economic agents that create value through Wi-Fi

The economic value of Wi-Fi is generated from multiple sources of value, including the capability to deliver traffic at faster speed than other networking technologies, provide Internet access, and interconnect devices. These sources of economic value are then channeled into economic gains for five economic agents:

- Individual consumers accessing free Wi-Fi sites;
- Residential consumers;

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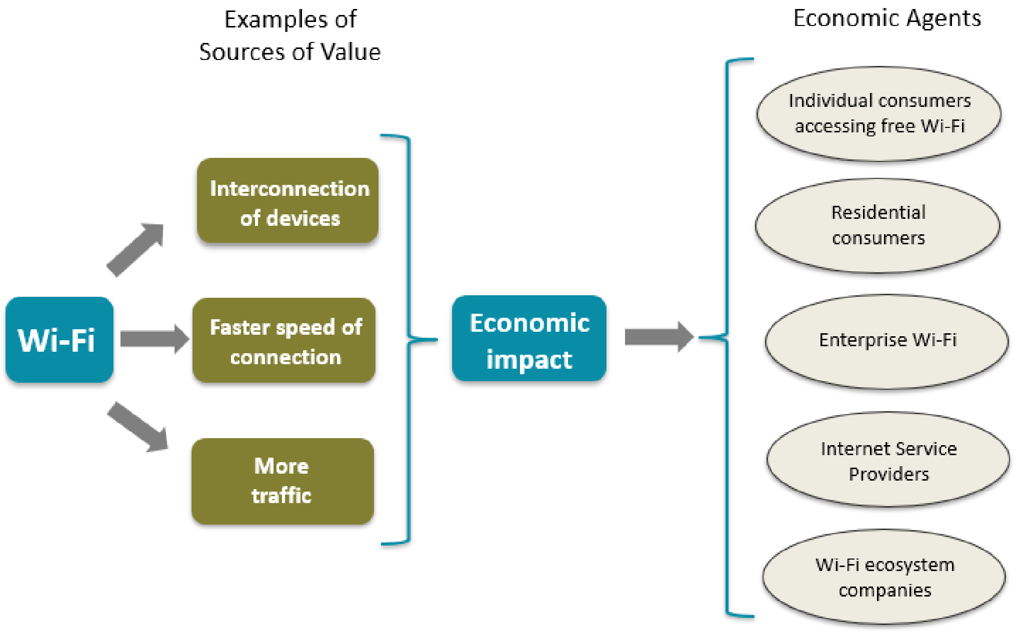
[29] See a similar approach used by Mensah and Wohlgenant (2010) to estimate the economic surplus of adoption of soybean technology (Mensah, E., and Wohlgenant, M. (2010). "A market impact analysis of Soybean Technology Adoption", *Research in Business and Economics Journal*).
[30] A utility function measures the consumer preference for a service beyond the explicit monetary value paid for it.
[31] Greenstein, S. and McDevitt, R. (2009). *The broadband bonus: accounting for broadband Internet's impact on U.S. GDP.* National Bureau of Economic Research Working Paper 14758. Cambridge, MA.

- Enterprises;
- Internet service Providers (ISPs); and
- Companies that provide Wi-Fi products and services or manufacture products enabled by Wi-Fi (members of the Wi-Fi ecosystem).

For each economic agent, the above-mentioned sources of value translate into cost savings, productivity gains, and expanded economic activity (see Figure II-1).

Figure II-1. Sources and agents of economic value of Wi-Fi



Source: Telecom Advisory Services

In terms of the detailed effects:

- **Free Wi-Fi:** The providers of free Wi-Fi service (i.e., coffee shops, retailers, municipalities) allow consumers to connect to the Internet without paying for access, creating a benefit measured as consumer surplus.[32] The consumer surplus measures the difference between the user's willingness-to-pay and the price paid for the service (which in this case equals to zero). For example, if a consumer accesses the Internet at a public hotspot for free, surplus would equate to the monetary value he or she would be willing to pay to a cellular carrier for gaining similar access.[33] Additionally, free Wi-Fi hotspots could also provide Internet access to those consumers that lack broadband service, thereby partially bridging the "digital divide". While less important in

[32] This category does not include providers of paid Wi-Fi access such as those operating in airports or hotels; this type of agent is included in the Internet Systems Providers category below.
[33] The introduction of what are called "unlimited" wireless plans does not invalidate this point since all of them include some explicit caps, such as speed throttling.

advanced economies, this effect could be critical to increasing broadband adoption in developing countries, and hence, the impact on GDP.[34]

- **Residential Wi-Fi:** As calculated in our 2018 study**,** residential Wi-Fi also drives consumer surplus. Routers installed in home dwellings provide Internet access for devices that lack a wired port (i.e., tablets, smartphones, netbooks), allowing consumers to avoid the investment in Ethernet wiring. Wi-Fi routers also support easy networking between devices (printers, storage devices, computers), allow for sharing and streaming media content (sound systems, home theaters, etc.), represent a network hub to handle home automation, and may interface with a smart grid. Additional surplus is generated as a Wi-Fi connection as last mile of fixed broadband is typically faster than that of a cellular network.[35] Finally, consumer surplus is generated if the willingness-to-pay (as a measure of benefit) exceeds the price paid for purchasing residential Wi-Fi devices and equipment. All these benefits can be aggregated in terms of the residential consumer surplus. Wi-Fi is also an appropriate technology to offer residential Internet access in rural and isolated areas. Since the technology allows for increasing broadband penetration without the need for more trenching and wiring, it becomes a key factor in driving service coverage and, consequently, GDP growth. This could have multiple positive effects, such as job creation, enhancing the productivity of rural businesses, and increasing access to public services.[36]

- **Enterprise Wi-Fi:** Wi-Fi in office buildings and on campuses allows for voice and data communications without incurring the cost of "capped" connectivity and avoids the limited in-building coverage of cellular networks, as well as the cost of enterprise wiring. Additionally, Wi-Fi supports communication between enterprises and their customers (i.e. customer/client access in financial services, employee/guest connections in the hospitality industry), while also improving internal production efficiencies (product/inventory tracking, remote control equipment, and POS ordering in the retail industry). This equates to a producer surplus, composed of the cost savings enjoyed by enterprises that rely on Wi-Fi technology, rather than wideband cellular service. In addition, Wi-Fi allows faster access to the Internet than cellular networks do. These faster speeds have a positive contribution to the economy in terms of increased overall productivity, efficiency, and innovation. Finally, Wi-Fi technology facilitates the expansion of Internet of Things (IoT) platforms and Augmented Reality and Virtual Reality (AR/VR) applications. Those developments generate productivity spillovers on the economy, thereby contributing to the growth of GDP.

[34] See Katz, R. and Callorda, F. (2020). *How broadband, digitization and ICT regulation impact the global economy*. Geneva: International Telecommunications Union. Retrieved from: http://handle.itu.int/11.1002/pub/81377c7f-en

[35] This effect is particularly important in 3G and 4G networks but could also be relevant in relation to indoor reception.

[36] Katz, R. and Beltran, F. (2015). *Socio-economic impact of alternative spectrum assignment approaches.* Presentation to the International Telecommunications Society Regional Conference, Los Angeles, CA.

- **Internet Service Providers (ISPs):** Due to the explosive growth in data traffic, wireless carriers operating in licensed bands deploy Wi-Fi access points to reduce both capital and operating expenses and reduce congestion challenges. Since ISPs monetize the Wi-Fi access they provide, the producer surplus measures the difference in capital and operating expenses for the traffic that is off-loaded. This model is critical to understanding Wi-Fi's contribution to 5G deployment. Wi-Fi allows service providers to launch paid Internet access in public places (such as venues, stadiums, airports, airlines, hotels, etc.). These access points generate new revenues that would not exist if Wi-Fi were not available. Similarly, Wireless Internet Service Providers (WISPs) rely on Wi-Fi to offer broadband connectivity in areas typically not served by wireline carriers, yielding additional revenues to be accounted for as part of the GDP.

- **Wi-Fi ecosystem**: Locally manufactured Wi-Fi devices generate revenues. The difference between the market price of these Wi-Fi enabled devices and the cost to manufacture them represents the manufacturer's profit margin (producer surplus). Such products include home networking devices, Wi-Fi enabled wireless speakers, routers, and security systems on the consumer side, and access points and controllers on the enterprise side. Similarly, as Wi-Fi facilitates the expansion of IoT, developing firms within the IoT ecosystem (hardware, software, and services), generate a producer surplus. Similarly, the economic effect of AR/VR is driven in part by an ecosystem that includes firms ranging from software development to hardware production and applications development. The profit margins of firms involved in this endeavor represent a producer surplus.

II.2. Assumptions made regarding the regulatory context of spectrum use for Wi-Fi

The economic value of Wi-Fi is contingent upon the amount of spectrum available for use. This study was conducted in a regulatory context where the use of unlicensed spectrum is in a state of transition. In general terms, Wi-Fi is currently allowed to operate in two spectrum bands: 2.4 GHz and 5 GHz. The explosive growth in Wi-Fi traffic has stretched the capacity of existing bands. Considering this, the International Telecommunication Union (ITU) is considering some recommendations on the assignment of the 6 GHz band (5925-7125 megahertz) to be submitted at the 2023 World Radiocommunication Conference (WRC-23), which could potentially address part of the congestion. At the same time, national regulatory agencies are already making decisions about the use of the 6 GHz band. However, regulatory decisions are not consistent: some countries, such as China, support the use of the entire 6 GHz for 5G licensed use, while others, such as the United States, are proposing its full use for unlicensed applications (i.e., Wi-Fi). In addition, other nations are limiting the band use for unlicensed use to the bottom 500-megahertz part of the 6 GHz. The point at 6425 MHz is being considered as how the WRC-23 splits the band.

The process to decide the use of the 6 GHz band at the national level is still ongoing for most countries: at the publication of this report, several countries had already made their decision or had launched a consultation (see detail below). In this context, the analysis of the economic value of Wi-Fi must consider two interrelated methodological issues:

- Differentiate between estimates of economic value for the current (2.4 GHz and 5 GHz) and future spectrum assignments (6 GHz); and
- Make assumptions as to how much of the 6 GHz band is likely to be allocated in the countries studied, based on existing announcements and communications about upcoming regulatory decisions.

With regard to the first issue, value estimates in this study were conducted according to two scenarios. We first analyzed a "baseline scenario" estimating the economic value of Wi-Fi up to its fifth technological generation (Wi-Fi 5), which relies on the 2.4 GHz and 5 GHz unlicensed spectrum bands. In the second scenario, we identified the acceleration of the economic effects with the allocation of the 6 GHz spectrum band and the release of Wi-Fi 6 equipment. The final results combine both scenarios to provide an estimate of total economic value.

Regarding the second issue (use of the 6 GHz band), assumptions needed to be made as to how much spectrum will be allocated for unlicensed use by country. This issue is important, since the amount of allocated spectrum has implications for Wi-Fi's economic value. If the full 6 GHz band were to be allocated for unlicensed use and added to the existing unlicensed bands in 2.4 GHz and 5 GHz, the combined spectrum would be able to support eight 160 MHz channels, or three 320 MHz channels.[37] Conversely, if only the bottom part of the band were allocated for unlicensed use, the 500 MHz model allows for only three 160 MHz channels.[38]

Because 6 GHz spectrum allocation decisions have not been completed in most cases, we made the following assumptions for our analysis:

United States (1200 MHz)

In October 2018, the United States Federal Communications Commission (FCC) presented a Notice of Proposed Rulemaking (NPRM) that recommended opening the 6 GHz band to unlicensed operations. In particular, the FCC sought comments on its proposal to open the band's full 1,200 MHz (5.925-7.125 GHz) to unlicensed devices, categorized in two classes:

- Standard power access points: In the 5.925-6.425 GHz and 6.525-6.875 GHz sub-bands, unlicensed access points would be permitted to transmit both indoors and outdoors under the control of an automated frequency coordination system at power levels that are currently permitted in the 5 GHz band.

[37] This would allow a router with tri-band configuration (2.4 GHz, 5 GHz, and 6 GHz), to deliver 1.2 Gbps on 2.4 GHz, 4.8 Gbps on one 5 GHz radio, 4.8 Gbps on the other 5 GHz radio, and 2.2 Gbps on the 6 GHz channel. In sum, once consumers have 6 GHz, there should be no difference between what they get from a computer plugged into a fiber port and a Wi-Fi 6E signal in their home.

[38] Under the 500 MHz allocation model, a reduced number of channels has an impact on speed because routers may be forced to use narrower channels, such as 80 MHz, 40 MHz, and even 20 MHz, with which the capability to allow broadband speed to grow unencumbered is limited.

- Low Power Indoor (LPI) devices (restricted to indoor), operating approximately four times lower than standard Wi-Fi, and required to be non-weather proofed, plugged into the wall, and authorized to use only 1/4 of the power of standard-power Wi-Fi (i.e., 250 milliwatts conducted power), which excludes them from the need to be frequency coordinated. This is the closest designation to current Wi-Fi.

In April 2020, the FCC unanimously voted to allow the two classes of unlicensed devices to operate in the 6 GHz band. LPI devices are permitted to operate throughout the 1,200-megahertz band. Standard power access points are allowed to operate in 850 megahertz in the sub bands described above. As a result, the capacity available for Wi-Fi quadrupled. The higher capacity available with 6 GHz suggests that the actual signal speed would be higher than the current speeds at 2.4 and 5 GHz. Speeds of 1 or 2 Gbps could be reached with a smartphone capable of Wi-Fi 6E when using the 160 MHz channel. Under this configuration, routers have access to seven new 160 MHz channels.

Concurrent with its decision to permit standard power and LPI devices, the FCC proposed a third category of 6 GHz Equipment – Very Low Power devices (VLP), authorized to power levels 160 times lower than standard-power Wi-Fi, and permitted for indoor or outdoor use in certain sub-bands, and not requiring frequency coordination because they would operate with 60 times less power than standard-power Wi-Fi. These VLP devices would be capable of operating using multiple extremely wide channels (160 MHz) with sub-millisecond latency performance. The category includes AR/VR headsets, Ultra High-Definition Video Streaming, high-speed[39] tethering (watches, ear pods) or entertainment devices in the automobile. This proposal has not yet been voted on by the FCC.

The FCC decision has been challenged in the courts by some telecommunications operators and a diverse set of industry associations, but the courts have decided not to stand in the way of the decision.[40]

United Kingdom (500 MHz)

The United Kingdom telecommunications regulatory agency Office of Communications (Ofcom) reached a final decision allocating the lower 6 GHz band (5925-6425 MHz) for unlicensed use to support Wi-Fi connectivity indoors, as well as limited outdoor coverage and traffic hand-off.[41] The lower band is adjacent to the currently used 5 GHz band, has similar mid-range propagation characteristics, and offers, wide, non-overlapping channels.

Ofcom estimates that this band, in combination with currently used 2.4 GHz and 5 GHz frequencies, can handle between 200 and 400 client devices per access point

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[39] FCC ex parte notification from Apple Inc., Broadcom Inc., Facebook Inc., Google LLC, Hewlett Packard Enterprise, Intel Corp., Marvell Semiconductor Inc., Microsoft Corporation, Qualcomm Incorporated (July 2, 2019).
[40] Law 360 (2020). *DC Circuit won't block new FCC rules on 6 GHz for now* (October 1)
[41] Blackman, J. (2020). "UK to release 6 GHz and 100 GHz spectrum for Wi-Fi in smart homes, offices, factories". *Enterprise IoT insights* (January, 27).

with a maximum theoretical data rate of 6.6 Gbps. On 24 July 2020, Ofcom made the final decision to initially make 500 MHz available for unlicensed use LPI and VLP outdoor use.[42] The initial limited allocation to 500 MHz is to demonstrate how Wi-Fi can benefit from the lower part of the band, and then investigate the upper part.[43] In the words of Ofcom, "we will continue to review use of the upper 6 GHz band to determine what the optimal use may be".[44]

France, Germany, Spain, and Poland (500 MHz)

In response to a request from the European Commission to investigate spectrum between 5,925 to 6,425 MHz, the European Conference of Postal and Telecommunications Administrations (CEPT) issued a technical report to the European Commission on the feasibility of Wi-Fi use in the 6 GHz band.[45] The purpose of the recommendation is to develop a harmonized approach for the 48 CEPT countries, which includes the 28 European Union countries, Switzerland, Turkey, and Russia, among others. In this case, routers will have access to three 160 Mbps channels. The underlying rationale for investigating only the 5,925 to 6,425 band (500 MHz) is that European countries have critical services in the upper part of the 6 GHz band (i.e., a large amount of point-to-point fixed services, earth to space communications, road intelligent traffic systems and communication-based train control, and some radio astronomy sites).

In June 2021, the European Union decided that by December 1st 2021, EU Member States will be required to make the 5945-6425 MHz frequency band available on a non-exclusive, non-interference and non-protected basis for the implementation of wireless access services/radio local area access networks (WAS/RLANs).[46] Some Member States are likely to move before December. The German Federal Network Agency, Bundesnetzagentur, for example, has said it plans to allocate the 6 GHz band for license-exempt use during the second quarter of 2021.

Brazil (1200 MHz)

On 6 May 2020, ANATEL, the Brazilian telecommunications regulator approved the unlicensed use of spectrum in the 6 GHz band (5,925–7,125 MHz).[47] In reaching a decision to allocate the 6 GHz band for unlicensed use, ANATEL initially evaluated two options: (i) allocate the entire 6 GHz band (that is to say 1,200 MHz) for

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[42] Ofcom (2020). *Statement: improving spectrum access for wi-fi – spectrum use in the 5 and 6 GHz bands* (July 24).
[43] Ebbecke, Ph. (2019). *Road to 6 GHz in Europe.* Presentation to WLPC Prague 2019
[44] Ofcom (2020). *Improving spectrum access for Wi-Fi*. London, p.21.
[45] Hetting, C. (2019). "Europe's process to release 6 GHz spectrum to Wi-Fi on track, expert says", *Wi-Fi Now* (June, 2).
[46] Official Journal of the European Union (2021). *Commission Implementing Decision (EU) 2021/1067 of 17 June 2021on the harmonised use of radio spectrum in the 5 945-6 425MHz frequency band for the implementation of wireless access systems including radio local area networks* (WAS/RLANs)
[47] ANATEL (2020). Analise No 29/2020/CB. Processo no 53500.012176/2019-58.

unlicensed use, or (ii) allocate only 500 MHz. In December 2020, the regulator launched a public consultation focused only on the first option.[48]

Colombia and Mexico (1200 MHz)

The Colombian Ministry of ICT and *Agencia Nacional de Espectro* (ANE) have launched public consultations regarding the future allocation of the 6 GHz band.[49] In the case of Mexico, the Mexican *Instituto Federal de Telecomunicaciones* (IFT) started a similar process in November of 2020 for allocating 1100 MHz of the 6 GHz band.[50]

South Korea (1200 MHz)

In June 2020, the Ministry of Science and ICT (MSIT) issued a proposed "amendment of technical standards" for public consultation.[51] A decision had to take place later by the end of 2020 to release the entire 6 GHz band – meaning 5,925-7,125 MHz – for indoor operation, while outdoor use would follow in 2022.[52] On 15 October 2020 MSIT announced that it had approved the use of 1,200 MHz of spectrum in the 6GHz band—the 5,925MHz to 7,125MHz range—for unlicensed use. In the ministry's own testing, it demonstrated that 6GHz Wi-Fi could reach speeds of 2.1 Gbps, which is five times faster than currently available Wi-Fi speeds of around 400 to 600Mbps.[53] For South Korea, this will be the first Wi-Fi frequency upgrade in sixteen years.[54]

Australia, New Zealand, Singapore, Japan (1200 MHz)

The Australian regulatory agency, Australian Communications and Media Authority (ACMA) has recognized the economic and technological value of unlicensed spectrum and is monitoring developments in the 6 GHz band—particularly the matter of coexistence between Wi-Fi and similar uses of the band with other uses, such as satellite uplinks and fixed links.[55] The agency is consulting on a proposal to allow RLAN equipment, such as Wi-Fi devices, to operate in the lower 6 GHz band. It

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[48] ANATEL (2020). *Anatel aprova consulta pública sobre Wi-Fi 6.* December 12, 2020). Retrieved in: https://www.gov.br/anatel/pt-br/assuntos/noticias/anatel-aprova-consulta-publica-sobre-wi-fi-6, and https://sistemas.anatel.gov.br/SACP/Contribuicoes/TextoConsulta.asp?CodProcesso=C2427&Tipo=1&Opcao=andamento.

[49] MINTIC (2020). *MINTIC y ANE consultan a los interesados sobre los posibles usos de la banda de 6 GHz.* Retrieved in: https://www.mintic.gov.co/portal/inicio/Sala-de-Prensa/Noticias/160952:MINTIC-y-ANE-consultan-a-los-interesados-sobre-los-posibles-usos-de-la-banda-de-6-GHz.

[50] Instituto federal de Telecomunicaciones (2020). *El IFT abre Consulta Pública sobre uso de la banda de 6 GHz en México (Comunicado 85/2020*) 06 de noviembre. Retrieved in: http://www.ift.org.mx/comunicacion-y-medios/comunicados-ift/es/el-ift-abre-consulta-publica-sobre-uso-de-la-banda-de-6-ghz-en-mexico-comunicado-852020-06-de

[51] Hetting, C. (2020). "South Korea could become Asia's first 6 GHz nation". *Wi-Fi News* (June, 27).

[52] Yonhap (2020). "Unlicensed frequency band to boost Wi-Fi speed, smart factory penetration: ministry," *The Korea Herald*, (June, 27).

[53] Cho Mu-Hyun (2020). "South Korea makes 6 GHz band available for Wi-Fi", *ZDNet* (October 16).

[54] Hetting, C. (2020). "South Korea could become Asia's first 6 GHz Wi-Fi nation". *Wi-Fi Now* (June, 27).

[55] ACMA (2019). *Five-year spectrum outlook 2019-23*, Canberra (September), p. 22

is also reviewing the current arrangements for RLAN devices in part of the nearby 5 GHz band, to potentially reflect recent changes to international regulations.[56]

At the time of publishing this report, no decisions and/or specific plans to examine potential changes in allocation of the 6 GHz spectrum have been identified in New Zealand[57] or Singapore. Japan is considering allocating 1200 MHz.[58]

Middle East and North Africa (500 MHz)

In Saudi Arabia, the regulator CITC has released the entire 6 GHz band on a license-exempt basis in 2021. In a new spectrum roadmap, the CITC said it is making the 5925-7125 MHz band license-exempt because of the "importance of WLAN use in the Kingdom and substantial amount of Wi-Fi traffic, which was exemplified during the COVID-19 lockdowns, and the emergence of a promising device ecosystem that can be taken advantage of starting from 2021 to enable a wide range of innovative digital services." It added that a substantial amount of licensed TDD mid-band spectrum is already being made available for International Mobile Telecommunications (IMT) and 5G.

The Qatar Communications Regulatory Authority is consulting on plans to make the full 6 GHz band available for Wi-Fi 6E. The authority believes the spectrum could be used to complement the services provided by mobile operators during the 2022 FIFA World Cup.

Jordan has made the full 6 GHz band available for Wi-Fi technology (LPI devices and VLP devices) to meet the increasing demand for high bandwidth. In a submission to the ASMG plenary, Jordan's Telecommunications Regulatory Commission said it will release the technical conditions for such uses soon. The decision follows input into a questionnaire, published by the Commission in December 2020, which showed that overall opinion was in favor of making the entire 6 GHz band available for Wi-Fi technology.

The Telecommunications Regulatory Authority of Oman is running a consultation on making the lower part of the 6 GHz band (5925-6425 MHz) available for Wi-Fi 6E devices on a license-exempt basis, enabling indoor use only. The Authority says the measure "will help to overcome the problems of internet traffic congestion." The consultation also explains the current regulations and some advantages of Wi-Fi 6E.

In Egypt, the National Telecom Regulatory Authority (NTRA) is reviewing how to employ the 6 GHz band to meet future demand, and enable new, innovative applications. Through a public consultation, the NTRA is exploring the possibility of allowing RLAN operation in the 5925-6425 MHz band indoors.

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[56] Roytblat, A. (2021). *Wi-Fi 6E Insights*. Retrieved in: https://www.wi-fi.org/download.php?file=/sites/default/files/private/Wi-Fi_Alliance_Wi-Fi_6E_Insights_Newsletter_202104.pdf

[57] O'Neill, R. (2020). "New Zealand won't rush a spectrum upgrade for next generation Wi-Fi". *New Zealand Reseller News* (April 28).

[58] https://www.soumu.go.jp/main_content/000716599.pdf

The Moroccan National Telecommunications Regulatory Agency (ANRT) has announced its decision to amend the current telecommunications framework when it comes to the spectrum unlicensed use with low-power short-range devices.[59]

Sub-Saharan Africa (500 MHz)

The African Telecommunications Union (ATU) Emerging Technologies Task Group has finalized its recommendation on license-exempt access to the lower part of the 6 GHz band (5925-6425 MHz). The recommendation, sent to all ATU countries for written inputs, includes an annex containing the technical and regulatory conditions for operating unlicensed technologies in the lower 6 GHz band, like those included in the European Union Decision. Assuming the African administrations validate the recommendations, then the position of Africa will be similar to that about to be adopted by the EU. Some African countries are likely to move quickly to open the lower 6 GHz to enable Wi-Fi 6E to bring enhanced connectivity to citizens and businesses.[60]

* * * * *

As the review of the regulatory context indicates, the use of unlicensed spectrum is in a state of transition around the world, with regulatory agencies recognizing that Wi-Fi is a critical component of a country's telecommunications infrastructure. As the analysis will show, the amount of spectrum allocated has an impact on Wi-Fi's economic value. Therefore, the assessment will be conducted according to two scenarios:

1. We first analyze a baseline scenario, estimating the economic value of Wi-Fi up to the fifth technological generation (Wi-Fi 5), which relies on the 2.4 GHz and 5 GHz unlicensed spectrum bands.

2. Then we identify the acceleration of the above-mentioned effects with the release of Wi-Fi 6 equipment and availability of the 6 GHz spectrum band allocation. Based on the review of the current state of regulatory decisions, we assumed 1200 Megahertz allocation for the United States, South Korea, Japan, Singapore, Australia, New Zealand, Brazil, Colombia and Mexico, and 500 megahertz for the United Kingdom, France, Germany, Spain, and Poland.

Total economic value will result from adding the estimates of scenarios 1 and 2.

II.3. Methodologies for estimating the economic value of Wi-Fi

Measuring the economic value of Wi-Fi requires a formal approach that can integrate the various economic gains, whether consumer or producer benefits, as

[59] Dumpis, T. (2021). "Morocco First Country in Africa to adopt faster Wi-Fi". *Morocco World News* (June 3). Retrieved in: https://www.moroccoworldnews.com/2021/06/342719/morocco-first-country-in-africa-to-adopt-faster-wi-fi
[60] Roytblat, A. (2021). *Wi-Fi 6E Insights*. Retrieved in: https://www.wi - fi.org/download.php?file=/sites/default/files/private/Wi-Fi_Alliance_Wi-Fi_6E_Insights_Newsletter_202104.pdf

well as their net direct contributions to the GDP.[61] The methodology used in this study is structured around the benefits captured by each of the five economic agents reviewed above (individuals benefitting from free Wi-Fi service, residential Wi-Fi, enterprise Wi-Fi, Internet Service Providers, and Wi-Fi ecosystem companies). As outlined above, the economic value for each agent will be measured based on three potential economic dimensions: consumer surplus, producer surplus, and GDP growth. The contribution to GDP growth will also be used to estimate the impact on job creation. Table II-1 formalizes each source of value creation by economic agent.

Table II-1. Sources of economic value of Wi-Fi by economic agent

Agents	Sources	Type of Economic Value	Scenarios	
			Baseline	Wi-Fi 6 & 6 GHz
1. Free Wi-Fi	1.1. Savings generated by free Wi-Fi traffic offered in public sites	Consumer Surplus	X	X
	1.2. Deployment of free Wi-Fi in public sites	GDP contribution	X	X
	1.3. Benefit of faster free Wi-Fi under with Wi-Fi 6E devices	Consumer Surplus		X
2. Residential Wi-Fi	2.1. Internet access for home usage of devices that lack a wired port	Consumer Surplus	X	
	2.2. Avoidance of investment in in-house wiring	Consumer Surplus	X	
	2.3. Benefit to consumers from speed increases	Consumer Surplus	X	X
	2.4. Residential Wi-Fi devices and equipment deployed	Consumer Surplus	X	X
	2.5. Closing digital divide: use of Wi-Fi to increase coverage in rural and isolated areas	GDP contribution	X	X
3. Enterprise Wi-Fi	3.1. Business Internet traffic transmitted through Wi-Fi	Producer surplus	X	X
	3.2. Avoidance of enterprise inside wiring costs	Producer surplus	X	
	3.3. Return to speed: contribution to GDP derived from an increase in average mobile speed	GDP contribution	X	X
	3.4. Wide deployment of IoT	GDP contribution	X	X
	3.5. Deployment of AR/VR solutions	GDP contribution	X	X
4. ISPs	2.1 CAPEX and OPEX savings due to cellular off-loading	Producer surplus	X	X
	2.2. Revenues of service providers offering paid Wi-Fi access in public places	GDP contribution	X	X
	2.3. Aggregated revenues of WISPs	GDP contribution	X	X
5. Wi-Fi ecosystem	5.1. Locally manufactured residential Wi-Fi devices and equipment	Producer surplus	X	X
	5.2. Locally manufactured Wi-Fi enterprise equipment	Producer surplus	X	X
	5.3. Locally produced IoT products and services	Producer surplus	X	X
	5.4. Locally produced of AR/VR solutions	Producer surplus	X	X

Source: Telecom Advisory Services

[61] See the prior research in Thanki, R. (Sept. 8, 2009). *The economic value generated by current and future allocations of unlicensed spectrum*. Perspective Associates; Milgrom, P., Levin, J., & Eilat, A. (2011). *The case for unlicensed spectrum*. Stanford Institute for Economic Policy Research Discussion Paper No. 10-036; Cooper, M. (2011). *The consumer benefits of expanding shared use of unlicensed radio spectrum: Liberating Long-Term Spectrum Policy from Short-Term Thinking*. Washington D.C.: Consumer Federation of America, Katz, R. (2014a). *Assessment of the economic value of unlicensed spectrum in the United States*. New York: Telecom Advisory Services. Katz, R. (2014b). *Assessment of the future economic value of unlicensed spectrum in the United States*. New York: Telecom Advisory Services. Katz, R. (2018). *A 2017 assessment of the current and future economic value of unlicensed spectrum*. Washington, DC: Wi-Fi Forward. Katz, R. (2018). *The global economic value of Wi-Fi 2018-2023*. New York: Telecom Advisory Services.

The above table presents an overview of the different sources of Wi-Fi economic value channeled to each economic agent. The detailed methodologies are presented in Appendix B.

III. ECONOMIC VALUE OF WI-FI IN THE UNITED STATES

The United States is the country with the widest Wi-Fi adoption and use in the world. In fact, Wi-Fi has become a pervasive feature in the U.S. telecommunications landscape. Cisco's Annual Internet Report Highlights Tool 2018-2023 estimates that there are currently 33,480,000 public Wi-Fi access points in the United States, [62] while according to Wiman (2020) there are 18,560,000 free Wi-Fi sites in the country.[63] In 2020, 85 percent of homes in the United States with broadband are equipped with a Wi-Fi router supporting access and interconnection of devices. [64]

Given the density of Wi-Fi access points, hotspots have become a very important connectivity feature. According to Opensignal[65], since the outbreak of COVID-19, wireless users in the United States have spent 59.9 percent of their communications time connected to Wi-Fi networks rather than relying on their cellular data connection. This has increased from 56.2 percent at the beginning of 2020.

The Wi-Fi standard has also created a world leading equipment manufacturing industry. Local manufacturing of Wi-Fi access points, external adapters, routers and controllers for consumers and enterprises is estimated to currently reach $7.4 billion. The importance of Wi-Fi technology in the digital ecosystem should have a significant contribution to its social and economic benefits. This chapter presents the results of the economic assessment.

In our prior 2018 study, Wi-Fi's economic value for 2021 was estimated at $801.8 billion. In April 2020, the United States Federal Communications Commission (FCC) unanimously voted to allow two classes of unlicensed devices to operate in the 6 GHz band. Low power indoor devices were permitted to operate throughout the 1,200 MHz band, while standard power access points were allowed to operate in 850 MHz in the sub bands described above. As a result, the capacity available for Wi-Fi was quadrupled.

Before even considering the additional effect of Wi-Fi 6 and allocation of the 6 GHz spectrum band for unlicensed use, the baseline (2.4 and 5 GHz Wi-Fi) economic value of Wi-Fi in the United States in 2021 is estimated at $979 billion. The increase of $177.2 billion since the 2018 study is due to the increased importance of four sources of economic value:

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[62] Cisco includes within this category, free hotspots, homespots, and paid hotspots. The report provides a value for 2018 (22.3 million) and 2023 (61.3 million), which allows for interpolating 2020 estimates.

[63] Retrieved in: https://www.wiman.me/united-states (November 17, 2020).

[64] Watkins, D. (2012). *Broadband and Wi-Fi Households Global Forecast 2012*. Strategy Analytics. Retrieved in: https://www.strategyanalytics.com/access-services/devices/connected-home/consumer-electronics/reports/report-detail/broadband-and-wi-fi-households-global-forecast-2012.

[65] Khatri, H. and Fenwick, S. (2020). "Analyzing mobile experience during the coronavirus pandemic: Time on Wi-Fi". *Opensignal* (March 30).

- The value of free Wi-Fi to address the needs of the population that cannot afford broadband service;[66]
- The increasing benefits of Wi-Fi technology broadband speed;
- A substantial boost to the deployment of IoT technology; and
- The growing adoption of AR/VR technology solutions.

The 2025 forecast of economic value will reach $1,392.7 billion—nearly $1.4 trillion—without considering the accelerating effect of Wi-Fi 6 and 6 GHz band allocation.

Adding to this baseline scenario, the allocation of the 6 GHz spectrum band for unlicensed use and the deployment of Wi-Fi 6 and Wi-Fi 6E devices will trigger an additional growth of economic value, reaching $187.4 billion in 2025. Considering that we forecast that by 2025 only 40 percent of Wi-Fi traffic will rely on 6 GHz channels, the accelerated effect derived from the new spectrum allocation and latest Wi-Fi technologies will continue to grow and still be far from reaching its maximum potential at this time. By combining the baseline and the Wi-Fi 6 and 6 GHz scenarios, the overall economic value of Wi-Fi for the United States will yield $1,580.1 billion—nearly $1.6 trillion—in 2025 (see Table III-1).

Table III-1. United States: Total economic value of Wi-Fi (in $Billions)

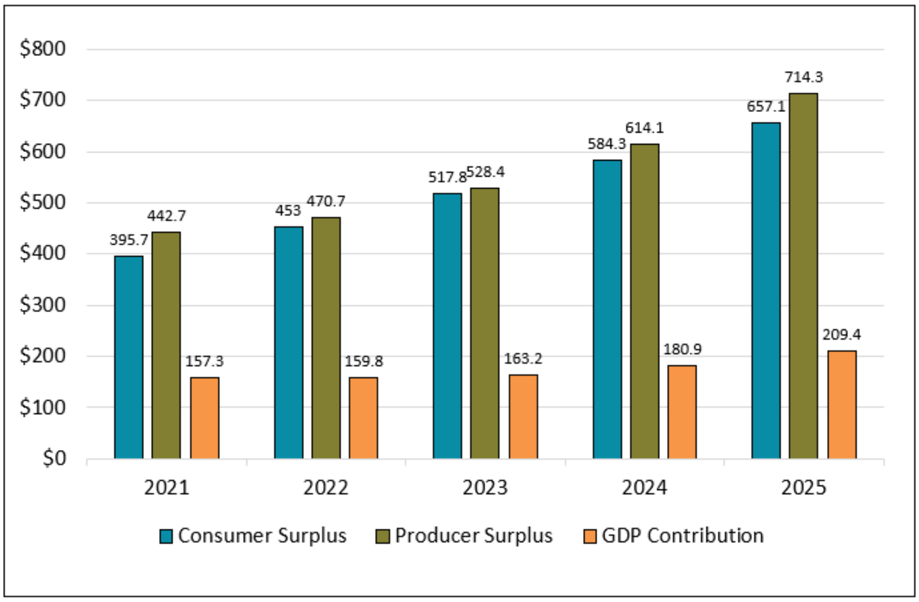
	2021	2022	2023	2024	2025
Baseline Scenario	$979.0	$1,026.0	$1,115.8	$1,243.8	$1,392.7
Wi-Fi 6 / 6 GHz Scenario	$16.0	$56.8	$93.1	$134.9	$187.4
Total	$995.0	$1,082.8	$1,208.9	$1,378.7	$1,580.1

Source: Telecom Advisory Services analysis

The primary source of economic value is producer surplus. This surplus is driven by the savings enjoyed by cellular operators who rely on Wi-Fi traffic rerouting, and the profit margins of an extremely vibrant ecosystem of Wi-Fi equipment manufacturers, software developers, and systems integrators. The contribution to producer surplus is closely followed by consumer surplus, because of the additional speed and capacity of Wi-Fi access points (see Graphic III-1).

[66] As a reference, a survey carried out by Connect Home stipulated that 10 percent of not connected households declare that they access Internet outside of home.

Graphic III-1. United States: Total economic value of Wi-Fi (by source) (in $Billions)



Note: Due to rounding, numbers presented in this graphic may not add up precisely to the totals above.
Source: Telecom Advisory Services LLC

The total economic value of Wi-Fi benefits five economic agents, of which residential Wi-Fi is the most important, followed by enterprises (see Table III-2).

Table III-2. United States: Total Economic Value of Wi-Fi (by agent) (in $Billions)

	2021	2022	2023	2024	2025
Free Wi-Fi	$25.7	$23.3	$19.7	$15.2	$13.8
Residential Wi-Fi	$407.4	$472.7	$544.9	$620.1	$705.6
Enterprise Wi-Fi	$337.3	$379.0	$422.6	$487.7	$565.2
Internet Service Providers	$71.8	$29.4	$12.7	$14.5	$16.9
Wi-Fi ecosystem	$152.8	$178.4	$209.0	$241.2	$278.6
Total	$995.0	$1,082.8	$1,208.9	$1,378.7	$1,580.1

Source: Telecom Advisory Services analysis

The economic value of consumer use of residential Wi-Fi is significant in terms of access and connectivity of home. The most important factor driving the value of Wi-Fi among enterprises is savings in wireless telecommunications, followed by the spillover of IoT applications, and enhanced speed of Wi-Fi access points. The boost in the development of manufacturers and service providers involved in the provision of Wi-Fi enabled solutions, such as AR/VR solutions, IoT networks, Wi-Fi access points, and household appliances, will result in producer surplus.[67]

Based on Wi-Fi's contribution to GDP, the technology will generate approximately 542,000 jobs in 2021, primarily in the communications sector (273,000), business services (134,000), and trade (58,000). By 2025, job creation estimates will reach 720,000.

[67] Detailed analysis is included in the "Theoretical Framework, Methodologies and Detailed Country Assessments for The Economic Value of Wi-Fi: A Global View (2021-2025)" section of this document.

IV. ECONOMIC VALUE OF WI-FI IN THE UNITED KINGDOM

As in the United States, Wi-Fi has also become a dominant component of the telecommunications infrastructure in the United Kingdom. According to the Cisco Annual Internet Report Highlights Tool 2018-2023, there were 200,000 paid Wi-Fi access points operating in the UK territory in 2018,[68] while Wiman reports 2,248,000 open Wi-Fi networks.[69] Eighty-nine percent of homes with Internet access in the United Kingdom are equipped with a Wi-Fi router.[70]

Given the Wi-Fi access point density, hotspots have become a very important connectivity feature. According to Opensignal[71], before the outbreak of COVID-19, UK wireless users were spending 65.1 percent of their connection time on Wi-Fi networks, rather than relying on their cellular data connection; that percentage increased to 68.9 percent by March 2020. The increasing importance of Wi-Fi in the British digital infrastructure should have a significant social and economic impact. This chapter presents the results of the economic assessment for the UK.

In the 2018 study of Wi-Fi's economic contribution[72], the value of Wi-Fi in the United Kingdom for 2021 was estimated at $64 billion. An updated baseline estimate for the same year according to the current study assumptions amounts to $96.9 billion. The increase of $32.9 billion is mainly due to the accelerated development of four sources of economic value:

- The increasing importance of free Wi-Fi;
- The contribution of Wi-Fi technology to improving broadband speed;
- A substantial boost to deployment of IoT technology; and
- The growing adoption of AR/VR technology use cases.

Wi-Fi 6 and the recent allocation of spectrum for unlicensed use will drive an additional increase in economic value. In July 2020, Ofcom, the British communications regulatory agency, decided to make 500 MHz of the 6 GHz band available for unlicensed low power indoor use and very low power outdoor use.[73] The purpose of limiting the allocation to 500 MHz was to initially to show that Wi-Fi can benefit from the lower part of the band, and then investigate the convenience

[68] Cisco reports that In the United Kingdom, total public Wi-Fi hotspots (including homespots) will grow 2-fold from 2018 to 2023 from 16.5 million in 2018 to 26.1 million by 2023." https://www.cisco.com/c/dam/m/en_us/solutions/executive-perspectives/vni-forecast-highlights/total/pdf/United_Kingdom_Network_Performance.pdf

[69] Retrieved in: https://www.wiman.me/united-kingdom. (November 17, 2020).

[70] Value extrapolated from Watkins, D. (2012). *Broadband and Wi-Fi Households Global Forecast 2012*. Strategy Analytics. Retrieved in: https://www.strategyanalytics.com/access-services/devices/connected-home/consumer-electronics/reports/report-detail/broadband-and-wi-fi-households-global-forecast-2012.

[71] Khatri, H. and Fenwick, S. (2020). "Analyzing mobile experience during the coronavirus pandemic: Time on Wi-Fi". *Opensignal* (March 30).

[72] Katz, R. and Callorda, F. (2018). *The Economic value of Wi-Fi: A Global View (2018 and 2023)*. New York: Telecom Advisory Services. October.

[73] Ofcom (2020). *Statement: improving spectrum access for wi-fi – spectrum use in the 5 and 6 GHz bands*.

of allocating upper part of the spectrum.[74] In the words of Ofcom, "we will continue to review use of the upper 6 GHz band to determine what the optimal use may be".[75]

In addition to the value generated from the unlicensed use of the 2.4 GHz and 5 GHz bands (referred to as the baseline scenario above), the allocation of 500 MHz in the 6 GHz spectrum band for unlicensed use, and the deployment of Wi-Fi 6 and Wi-Fi 6E devices, will trigger an additional boost in economic value, reaching $10.7 billion in 2025. By combining the baseline and the Wi-Fi 6 and 6 GHz scenarios, the overall economic value of Wi-Fi for the United Kingdom will yield $108.5 billion in 2025 (see Table IV-1).

Table IV-1. United Kingdom: Total economic value of Wi-Fi (in $Billions)

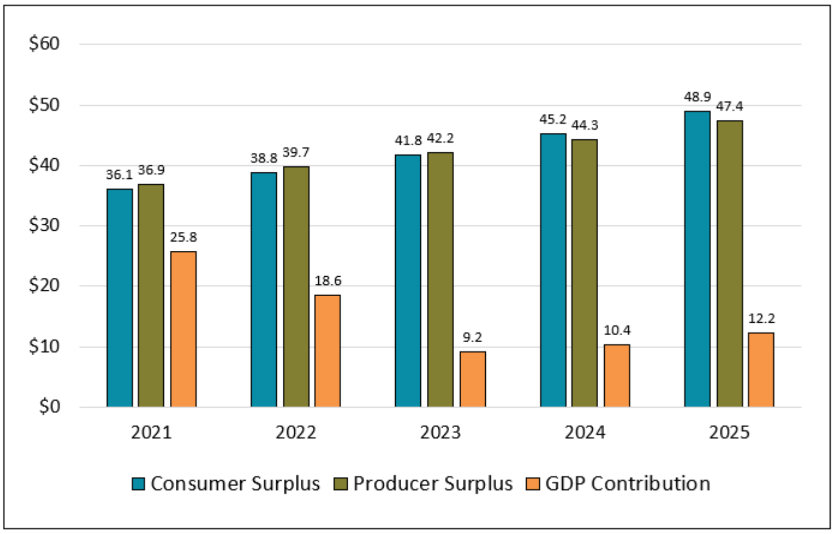
	2021	2022	2023	2024	2025
Baseline Scenario	$96.9	$93.2	$87.6	$91.9	$97.8
Wi-Fi 6 / 6 GHz Scenario	$1.9	$3.9	$5.6	$8.0	$10.7
Total	$98.8	$97.1	$93.2	$99.9	$108.5

Source: Telecom Advisory Services analysis

Average projected speed fluctuations indicated in Cisco Annual Internet Report Highlights Tool 2018-2I023 account for the reduction in value in 2022 and 2023, but the overall effect results in a nearly $10B increase over five years. If Ofcom decides to allocate the upper part of the spectrum to unlicensed use, Wi-Fi economic value would increase significantly beyond the values presented in Table IV-1.

The primary source of economic value through 2023 is producer surplus, closely followed by consumer surplus, while the order is reversed in 2024 (see Graphic IV-1).

Graphic IV-1. United Kingdom: Total economic value of Wi-Fi (by source) (in $Billions)



Note: Due to rounding, numbers presented in this graphic may not add up precisely to the totals presented above.
Source: Telecom Advisory Services LLC

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[74] Ebbecke, Ph. (2019). *Road to 6 GHz in Europe. Presentation to WLPC Prague 2019*
[75] Ofcom (2020). *Improving spectrum access for Wi-Fi*. London, p.21.

This total value benefits five economic agents, of which residential Wi-Fi is the most important, followed by use by enterprises (see Table IV-2).

Table IV-2. United Kingdom: Total economic value of Wi-Fi (by agent) (in $Billions)

	2021	2022	2023	2024	2025
Free Wi-Fi	$1.1	$1.2	$1.2	$1.3	$1.4
Residential Wi-Fi	$35.4	$38.0	$41.1	$44.4	$48.1
Enterprise Wi-Fi	$41.2	$34.7	$26.5	$28.8	$31.7
Internet Service Providers	$9.9	$9.6	$8.0	$6.6	$5.5
Wi-Fi ecosystem	$11.2	$13.6	$16.4	$18.8	$21.8
Total	$98.8	$97.1	$93.2	$99.9	$108.5

Source: Telecom Advisory Services analysis

The economic value of consumer use of residential Wi-Fi is significant in terms of the cost savings gained by avoiding inside wiring and wireless device access at home. The most important factor driving the value of Wi-Fi among enterprises is savings in wireless telecommunications, followed by the enhanced speed of Wi-Fi access points, and the spillover of IoT applications[76]. According to the contribution to GDP, Wi-Fi will generate approximately 95,000 jobs in the UK in 2021, primarily in the communications sector (48,000), and business services (19,000). In 2025, the job creation effect will amount to 45,000.

[76] Detailed analysis is included in the "Theoretical Framework, Methodologies and Detailed Country Assessments for The Economic Value of Wi-Fi: A Global View (2021-2025)" section of this document.

V. ECONOMIC VALUE OF WI-FI IN FRANCE

Wi-Fi has also become a pervasive feature in the French telecommunications infrastructure. According to Wiman, there are currently 1,219,000 open public Wi-Fi access points in France.[77] Given the density of Wi-Fi access points, hotspots have become a very important connectivity feature. Furthermore, 87 percent of French homes with broadband are estimated to be equipped with a Wi-Fi access point.[78] The increasing importance of Wi-Fi technology in the country's digital infrastructure should have a significant social and economic impact. This chapter presents the results of the economic value assessment.

In the 2018 study of Wi-Fi's economic contribution[79], its value in France for 2021 was estimated at $55 billion. An updated projection for the same year, under the baseline scenario including the 2.4 and 5 GHz bands, estimates an economic value of Wi-Fi in France will be $61.2 billion. The increase of $6.2 billion is mainly due to the development of four sources of economic value:

- The increasing importance of free Wi-Fi;
- The increasing benefits of Wi-Fi technology broadband speed;
- A substantial boost to the deployment of IoT technology;
- The growing adoption of AR/VR technology.

The baseline forecast of economic value for 2025 is estimated to reach $95.0 billion.

These projections do not consider the acceleration effect resulting from the allocation of 500 MHz in the 6 GHz band. In response to a request from the European Commission to investigate spectrum between 5,925 to 6,425 MHz, the European Conference of Postal and Telecommunications Administrations (CEPT) has issued a technical report to the European Commission on the feasibility of using Wi-Fi in the 6 GHz band.[80] The recommendation for investigating only the 5,925 to 6,425 band (500 MHz) is due to the fact that European countries have critical services in the upper part of the 6 GHz band (i.e. large amount of point to point fixed services, earth to space communications, road intelligent traffic systems and communication-based train control, and some radio astronomy sites).

In addition to the value generated from the unlicensed use of the 2.4 GHz and 5 GHz bands (baseline scenario), by adding 500 MHz in the 6 GHz spectrum band for unlicensed use and the deployment of Wi-Fi 6 and Wi-Fi 6E devices will trigger an

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[77] Of this installed base of Wi-Fi hotspots in France, 418,000 are deployed in Paris, 43,000 in Lyon, 29,000 in Nice, and 23,000 in Marseille (Retrieved in: https://www.wiman.me/france, November 17, 2020).

[78] Extrapolated value based on Watkins, D. (2012). *Broadband and Wi-Fi Households Global Forecast 2012*. Strategy Analytics. Retrieved in: https://www.strategyanalytics.com/access-services/devices/connected-home/consumer-electronics/reports/report-detail/broadband-and-wi-fi-households-global-forecast-2012.

[79] Katz, R. and Callorda, F. (2018). *The Economic value of Wi-Fi: A Global View (2018 and 2023)*. New York: Telecom Advisory Services. October.

[80] Hetting, C. (2019). "Europe's process to release 6 GHz spectrum to Wi-Fi on track, expert says", *Wi-Fi Now* (June, 2).

additional boost of $9.0 billion in economic value, reaching a total of $104.0 billion in 2025 (see Table V-1).

Table V-1. France: Total economic value of Wi-Fi (in $Billions)

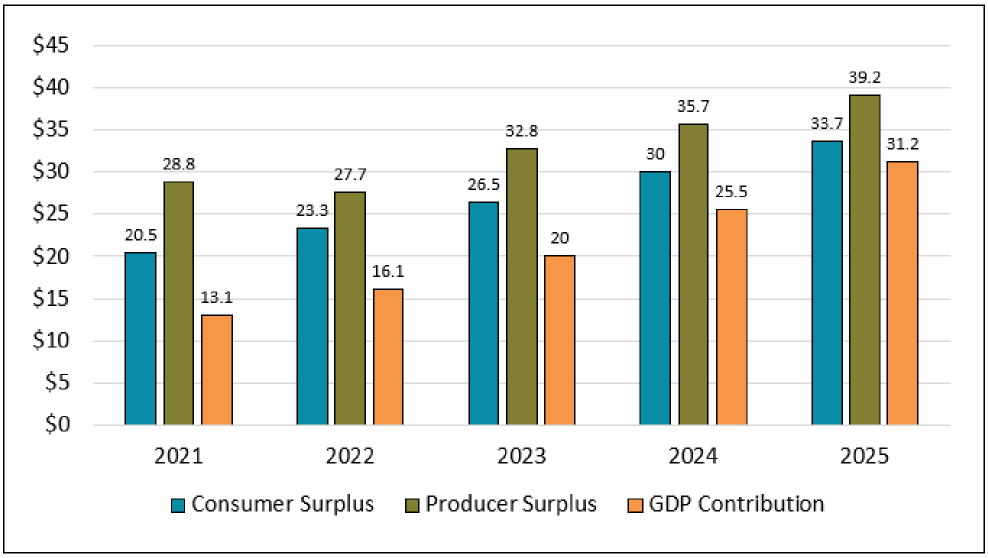
	2021	2022	2023	2024	2025
Baseline Scenario	$61.2	$63.4	$73.2	$83.0	$95.0
Wi-Fi 6 / 6 GHz Scenario	$1.3	$3.7	$6.2	$8.2	$9.0
Total	$62.5	$67.1	$79.4	$91.2	$104.0

Source: Telecom Advisory Services analysis

Considering that by 2025 only 40 percent of Wi-Fi traffic will rely on 6 GHz channels, the accelerated effect derived from the new spectrum allocation and latest Wi-Fi technologies will still be far from reaching its maximum potential at this time. Therefore, If the French telecommunications regulatory agencies decides to allocate the upper part of the spectrum to unlicensed use, Wi-Fi economic value would increase significantly beyond the values presented in Table V-1.

The initial primary source of economic value is producer surplus, followed by consumer surplus (see Graphic V-1).

Graphic V-1. France: Total Economic Value of Wi-Fi (by source) (in $Billions)



Note: Due to rounding, numbers presented in this graphic may not add up precisely to the totals presented above.
Source: Telecom Advisory Services LLC

This total value benefits five economic agents, of which residential Wi-Fi is the most important, followed by enterprises (see Table V-2).

Table V-2. France: Total economic value of Wi-Fi (by agent) (in $Billions)

	2021	2022	2023	2024	2025
Free Wi-Fi	$1.0	$0.9	$0.8	$0.6	$0.5
Residential Wi-Fi	$20.7	$23.3	$26.6	$30.0	$33.6
Enterprise Wi-Fi	$18.7	$22.2	$26.3	$32.2	$38.3
Internet Service Providers	$10.0	$7.4	$10.5	$11.7	$13.4
Wi-Fi ecosystem	$12.1	$13.3	$15.2	$16.7	$18.2
Total	$62.5	$67.1	$79.4	$91.2	$104.0

Source: Telecom Advisory Services analysis

The economic value of consumer use of residential Wi-Fi is significant in terms of the cost savings gained by avoiding inside wiring and wireless device access at home. The most important factor driving the value of Wi-Fi among enterprises is savings in wireless telecommunications, followed by the enhanced speed of Wi-Fi access points and the spillover of IoT applications.[81] According to the contribution to GDP, Wi-Fi will generate approximately 35,000 jobs in France in 2021, primarily in the communications sector (17,000), trade (32,000) and business services (9,000) and is expected to create 82,000 in 2025.

[81] Detailed analysis is included in the "Theoretical Framework, Methodologies and Detailed Country Assessments for The Economic Value of Wi-Fi: A Global View (2021-2025)" section of this document.

VI. ECONOMIC VALUE OF WI-FI IN GERMANY

Wi-Fi technology and networks have become a dominant component of the German telecommunications infrastructure. According to Wiman, there are 1,950,000 open Wi-Fi sites currently operating in the German territory.[82] Cisco Annual Internet Report Highlights Tool 2018-2023 estimates that there are 300,000 public commercial hot spots operating in the country. Eighty-five percent of homes with broadband have already installed a Wi-Fi access point; this number is expected to reach 100 percent by 2025.

Given the Wi-Fi access point density, the technology has become a very important connectivity infrastructure. According to Opensignal[83], before the outbreak of COVID-19 German wireless users spent 64.7 percent of their communications time connected to Wi-Fi networks rather than relying on their cellular data connection. In March 2020 that number reached 71.4 percent. This chapter presents the results of the economic assessment for Germany.

In the prior study of Wi-Fi's economic contribution[84], its value for 2021 in Germany was estimated at $115.3 billion. The update conducted in the current study estimates that the economic value for the same year in 2.4 and 5 GHz bands—the baseline scenario—will amount to $132.6 billion. The increase of $17.3 billion in the updated estimate is mostly due to four sources of economic value:

- The increasing benefits of Wi-Fi technology broadband speed;
- A substantial boost to deployment of IoT technology; and
- The growing adoption of AR/VR technology.

The baseline 2025 forecast will reach $158.0 billion.

This value will increase further due to the addition of 500 MHz in the 6 GHz band. As was the case for France, Germany is also expected to follow the recommendation of the European Conference of Postal and Telecommunications Administrations (CEPT) and allocate the 5,925 to 6,425 band (500 MHz) to Wi-Fi use. In addition to the baseline scenario, the allocation of the 6 GHz spectrum band for unlicensed use and the deployment of Wi-Fi 6 devices will trigger a growth of economic value, reaching $15.3 billion in 2025 (see Table VI-1).

[82] Of this installed base of Wi-Fi hotspots in Germany, 95,000 are deployed in Berlin, 68,000 are deployed in Hamburg, and 116,000 in Munich (Retrieved in: https://www.wiman.me/germany, November 17, 2020)
[83] Khatri, H. and Fenwick, S. (2020). "Analyzing mobile experience during the coronavirus pandemic: Time on Wi-Fi". *Opensignal* (March 30).
[84] Katz, R. and Callorda, F. (2018). *The Economic value of Wi-Fi: A Global View (2018 and 2023)*. New York: Telecom Advisory Services. October.

Table VI-1. Germany: Total economic value of Wi-Fi (in $Billions)

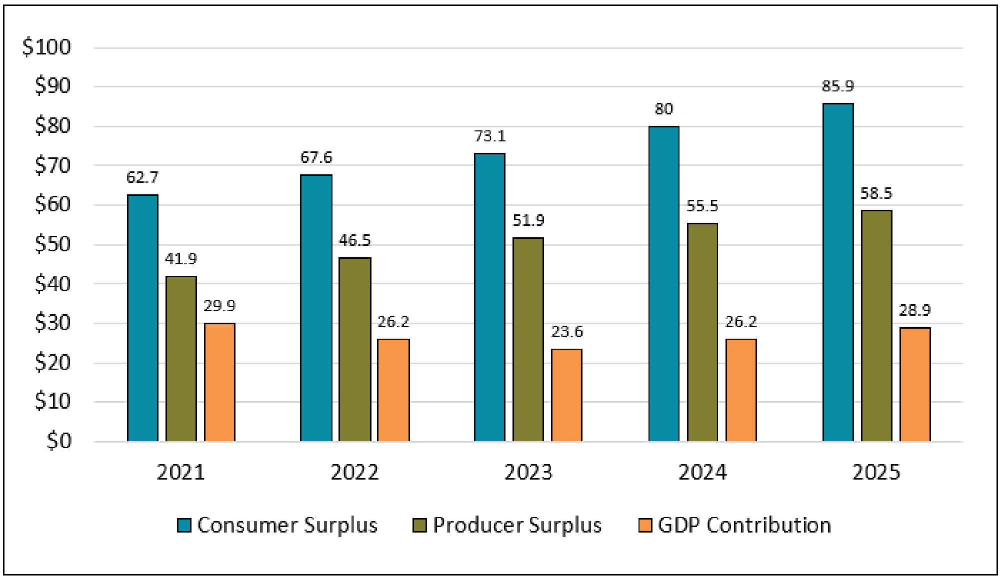
	2021	2022	2023	2024	2025
Baseline Scenario	$132.6	$135.4	$140.2	$149.9	$158.0
Wi-Fi 6 / 6 GHz Scenario	$1.9	$5.1	$8.4	$12.0	$15.3
Total	$134.5	$140.5	$148.6	$161.9	$173.3

Source: Telecom Advisory Services analysis

Considering that by 2025 only 40 percent of Wi-Fi traffic will be relying on 6 GHz channels, the accelerated effect derived from the new spectrum allocation and latest Wi-Fi technologies will still be far from reaching its maximum potential at this time. If the German telecommunications regulatory agencies decides to allocate the upper part of the spectrum to unlicensed use, Wi-Fi economic value would increase beyond the values presented in Table VI-1.

The initial primary source of economic value is producer surplus, followed by consumer surplus and GDP contribution (see Graphic VI-1).

Graphic VI-1. Germany: Total economic value of Wi-Fi (by source) (in $Billions)



Note: Due to rounding, numbers presented in this graphic may not add up precisely to the totals presented above.
Source: Telecom Advisory Services LLC

This total value benefits five economic agents, of which residential Wi-Fi is the most important, followed by use by enterprises (see Table VI-2).

Table VI-2. Germany: Total economic value of Wi-Fi (by agent) (in $Billions)

	2021	2022	2023	2024	2025
Free Wi-Fi	$0.9	$0.8	$0.8	$0.9	$0.9
Residential Wi-Fi	$62.4	$67.5	$72.7	$79.9	$85.5
Enterprise Wi-Fi	$55.4	$52.7	$50.9	$54.2	$57.9
Internet Service Providers	$5.0	$7.5	$10.5	$11.9	$12.4
Wi-Fi ecosystem	$10.8	$12.0	$13.7	$15.0	$16.6
Total	$134.5	$140.5	$148.6	$161.9	$173.3

Source: Telecom Advisory Services analysis

The economic value of consumer use of residential Wi-Fi is significant in terms of the cost savings gained by avoiding inside wiring and allowing for wireless device access at home. The most important factor driving the value of Wi-Fi among enterprises is savings in wireless telecommunications, followed by the enhanced speed of Wi-Fi access points and the spillover of IoT applications.[85]

According to the contribution to GDP, Wi-Fi will generate approximately 92,000 jobs in Germany in 2021, primarily in the communications sector (50,000), and business services (20,000). Wi-Fi is expected to generate almost 90,000 jobs by 2025.

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[85] Detailed analysis is included in the "Theoretical Framework, Methodologies and Detailed Country Assessments for The Economic Value of Wi-Fi: A Global View (2021-2025)" section of this document.

VII. ECONOMIC VALUE OF WI-FI IN SPAIN

As in other European nations, Wi-Fi has become a pervasive feature in the Spanish telecommunications landscape. The Cisco Annual Internet Report Highlights Tool 2018-2023 estimates that 200,000 public commercial hot spots are deployed in the country,[86] while Wiman estimates that there are currently 986,000 free Wi-Fi hotspots.[87] In addition, 87 percent of Spanish households with broadband are equipped with a Wi-Fi router.

Given the public and private Wi-Fi access point density, the technology has become a very important feature of broadband connectivity. According to Opensignal[88], before the outbreak of COVID-19, Spanish smartphone users spent 61.9 percent of their communications time connected to Wi-Fi networks rather than relying on their cellular data connection. Underlining the importance of Wi-Fi during the pandemic, that number reached 73.1 percent in March 2020—one of the highest in Europe.

The extensive deployment and use of Wi-Fi in Spain should result in a significant social and economic contribution. This chapter presents the results of the economic assessment.

As in the case of other European countries, the technical recommendation of the European Conference of Postal and Telecommunications Administrations (CEPT) to the European Commission[89] would influence Spain's decision to allocate the spectrum band between 5,925 to 6,425 MHz for unlicensed use.[90] Before considering the additional effect of Wi-Fi 6 and allocating the 6 GHz spectrum band for unlicensed use, the total economic value of Wi-Fi in Spain in 2021 for only the 2.4 GHz and 5 GHz bands—the baseline scenario—will amount to $39.8 billion. The 2025 forecast of economic value for this baseline scenario is expected to reach $49.6 billion.

The allocation of 500 MHz in the 6 GHz spectrum band for unlicensed use and the deployment of Wi-Fi 6 and Wi-Fi 6E devices will trigger an additional growth of economic value, reaching $4.5 billion in 2025. By combining the baseline and the Wi-Fi 6 and 6 GHz scenarios, the overall economic value of Wi-Fi for Spain will yield $54.1 billion in 2025 (see Table VII-1).

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[86] Cisco reports that in 2018 there were 2.9 million hotspots in Spain, of which 2.7. million were homespots. Retrieved in: https://www.cisco.com/c/en/us/solutions/executive-perspectives/annual-internet-report/air-highlights.html#

[87] Of this installed base of Wi-Fi hotspots in Spain 192,000 are deployed in Madrid, 201,000 in Barcelona, 41,000 in Valencia, and 29,000 in Seville (Retrieved in: https://www.wiman.me/spain , November 17, 2020).

[88] Khatri, H. and Fenwick, S. (2020). "Analyzing mobile experience during the coronavirus pandemic: Time on Wi-Fi". *Opensignal* (March 30).

[89] Hetting, C. (2019). "Europe's process to release 6 GHz spectrum to Wi-Fi on track, expert says", *Wi-Fi Now* (June, 2).

[90] The recommendation for investigating only the 5,925 to 6,425 band (500 MHz) is that European countries have critical services in the upper part of the 6 GHz band (i.e. large amount of point to point fixed services, earth to space communications, road intelligent traffic systems and communication-based train control, and some radio astronomy sites). In addition to the baseline scenario.

Table VII-1. Spain: Total economic value of Wi-Fi (in $Billions)

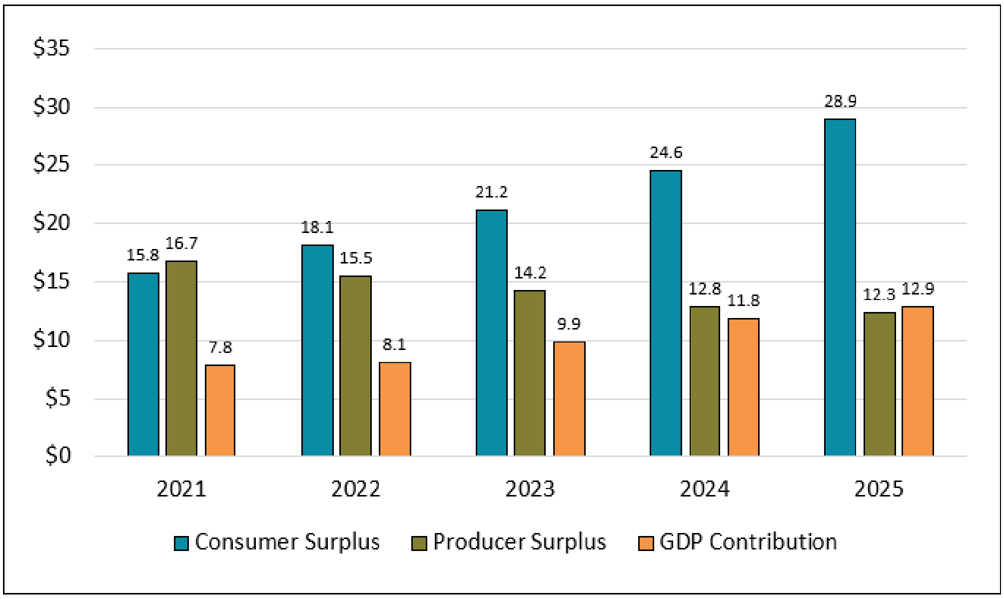
	2021	2022	2023	2024	2025
Baseline Scenario	$39.8	$39.6	$41.8	$44.7	$49.6
6 GHz Scenario	$0.6	$2.1	$3.5	$4.5	$4.5
Total	$40.4	$41.7	$45.3	$49.2	$54.1

Source: Telecom Advisory Services analysis

Considering that it is assumed that by 2025 only 40 percent of Wi-Fi traffic will be relying on the 6 GHz spectrum, the accelerated effect derived from the new spectrum allocation and latest Wi-Fi technologies will still be far from reaching its maximum potential at this time. If the Spanish telecommunications regulatory agencies decides to allocate the upper part of the spectrum to unlicensed use, Wi-Fi economic value would increase significantly beyond the values presented in Table VII-1.

The primary source of economic value is consumer surplus, while producer surplus stabilizes at approximately $13 billion and GDP contribution gradually increases over time reaching $12.9 billion by 2025 (see Graphic VII-1).

Graphic VII-1. Spain: Total economic value of Wi-Fi (by source) (in $Billions)



Note: Due to rounding, numbers presented in this graphic may not add up precisely to the totals presented above.
Source: Telecom Advisory Services LLC

This total value benefits five economic agents, of which residential Wi-Fi is the most important followed by use by enterprises (see Table VII-2).

Table VII-2. Spain: Total economic value of Wi-Fi (by agent) (in $Billions)

	2021	2022	2023	2024	2025
Free Wi-Fi	$0.3	$0.3	$0.3	$0.3	$0.3
Residential Wi-Fi	$15.8	$18.2	$21.2	$24.7	$28.7
Enterprise Wi-Fi	$15.3	$16.0	$18.2	$20.4	$21.9
Internet Service Providers	$7.1	$5.2	$3.4	$1.5	$0.5
Wi-Fi ecosystem	$1.9	$2.0	$2.2	$2.3	$2.7
Total	$40.4	$41.7	$45.3	$49.2	$54.1

Source: Telecom Advisory Services analysis

The economic value of free Wi-Fi service is generated through savings to consumers who access the Internet via free Wi-Fi sites, rather than incurring cellular costs, the use of Wi-Fi by households that cannot afford broadband service and the speed of Wi-Fi compared to the use of cellular service. Additionally, the economic value of consumer use of residential Wi-Fi is significant in terms of the cost savings gained by avoiding inside wiring and wireless device access at home. The most important factor driving the value of Wi-Fi among enterprises is savings in wireless telecommunications (enterprises use Wi-Fi for 57 percent of their total Internet traffic), followed by the enhanced speed of Wi-Fi access points and the spillover of IoT applications.[91]

According to the contribution to GDP, Wi-Fi will generate approximately 33,000 jobs in Spain in 2021, primarily in the communications sector (19,000), and business services (7,000). In addition, Wi-Fi will generate over 54,000 in 2025.

[91] Detailed analysis is included in the "Theoretical Framework, Methodologies and Detailed Country Assessments for The Economic Value of Wi-Fi: A Global View (2021-2025)" section of this document.

VIII. ECONOMIC VALUE OF WI-FI IN POLAND

Wi-Fi has become a critical component of Poland's telecommunications infrastructure. According to the Cisco Annual Internet Report Highlights Tool 2018-2023 for Europe, there were 3,100,000 public Wi-Fi access points operating in the Polish territory in 2018. In addition, 89 percent of the country's 12.7 million households with broadband rely on Wi-Fi routers to fulfill in-home device connectivity.

Given the Wi-Fi access point density in the country, hotspots have become a very important connectivity feature. This chapter presents the results of the economic assessment.

Before considering the additional effect of Wi-Fi 6 and allocating the 6 GHz spectrum band for unlicensed use as recommended by the European Conference of Postal and Telecommunications Administrations (CEPT)[92], the baseline economic value of Wi-Fi in Poland in 2021 will amount to $15.9 billion. The baseline 2025 forecast of economic value will remain stable at $15.9 billion.

However, the allocation of 500 MHz in the 6 GHz spectrum band for unlicensed use and the deployment of Wi-Fi 6 and Wi-Fi 6E devices will trigger an additional growth of economic value, reaching $5.7 billion in 2025. By combining the baseline and the Wi-Fi 6 and 6 GHz scenarios, the overall economic value of Wi-Fi for Poland is estimated at $16.1 billion, reaching $21.6 billion in 2025 (see Table VIII-1).

Table VIII-1. Poland: Total economic value of Wi-Fi (in $Billions)

	2021	2022	2023	2024	2025
Baseline Scenario	$15.9	$15.7	$16.0	$15.8	$15.9
Wi-Fi 6 / 6 GHz Scenario	$0.2	$1.6	$3.1	$4.6	$5.7
Total	$16.1	$17.3	$19.1	$20.4	$21.6

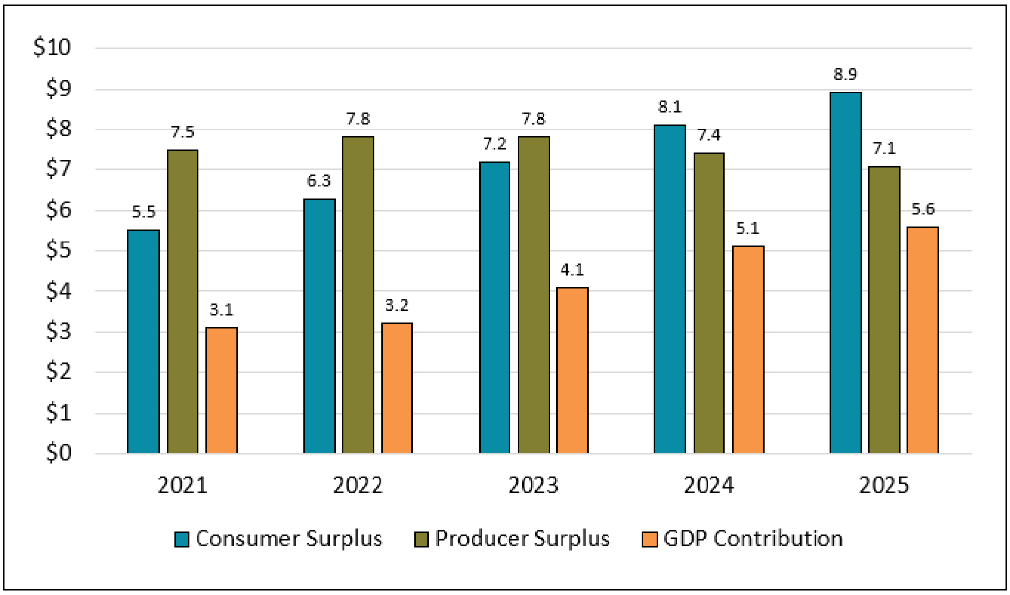
Source: Telecom Advisory Services analysis

As indicated in Table VIII-1, the primary factor driving the increase in economic contribution is the introduction of Wi-Fi 6 combined with the allocation of 6 GHz spectrum. Assuming that by 2025 only 40 percent of Wi-Fi traffic will rely on 6 GHz spectrum, the accelerated effect derived from the new spectrum allocation and latest Wi-Fi technologies will still be far from reaching its maximum potential at this time. Therefore, if the Polish telecommunications regulatory agencies decides to allocate the upper part of the spectrum to unlicensed use, Wi-Fi economic value would increase significantly beyond the values presented in Table VIII-1.

[92] In response to a request from the European Commission to investigate spectrum between 5,925 to 6,425 MHz, the CEPT (European Conference of Postal and Telecommunications Administrations) has issued a technical report to the European Commission on the feasibility of Wi-Fi in the 6 GHz band[92]. The report would apply to Poland's spectrum. The non-binding recommendation for investigating only the 5,925 to 6,425 band (500 MHz) is that European countries have critical services in the upper part of the 6 GHz band (i.e. large amount of point to point fixed services, earth to space communications, road intelligent traffic systems and communication-based train control, and some radio astronomy sites).

The primary source of economic value is producer surplus, although its share declines over time as consumer surplus and GDP become more important (see Graphic VIII-1).

Graphic VIII-1. Poland: Total economic value of Wi-Fi (by source) (in $Billions)



Note: Due to rounding, numbers presented in this graphic may not add up precisely to the totals presented above.
Source: Telecom Advisory Services LLC

Wi-Fi's total value benefits all five economic agents, of which residential Wi-Fi is the most important, followed by enterprises (see Table VIII-2).

Table VIII-2. Poland: Total economic value of Wi-Fi (by agent) (in $Billions)

	2021	2022	2023	2024	2025
Free Wi-Fi	$0.2	$0.2	$0.2	$0.2	$0.2
Residential Wi-Fi	$6.5	$7.1	$8.0	$8.7	$9.6
Enterprise Wi-Fi	$4.5	$4.9	$6.0	$7.3	$8.0
Internet Service Providers	$3.4	$3.2	$2.7	$1.5	$0.4
Wi-Fi ecosystem	$1.5	$1.9	$2.2	$2.7	$3.4
Total	$16.1	$17.3	$19.1	$20.4	$21.6

Source: Telecom Advisory Services analysis

The economic value of free Wi-Fi service is a combination of free Wi-Fi used by households that cannot afford broadband service, and speed of Wi-Fi compared to cellular service. The economic value of residential Wi-Fi is significant in terms of the cost savings gained by avoiding inside wiring and wireless device access at home. The most important factor driving the value of Wi-Fi among enterprises (which currently reaches 58.8 percent of total traffic) is savings in wireless telecommunications, followed by the enhanced speed of Wi-Fi access points and the spillover of IoT applications.[93]

[93] Detailed analysis is included in the "Theoretical Framework, Methodologies and Detailed Country Assessments for The Economic Value of Wi-Fi: A Global View (2021-2025)" section of this document.

According to the contribution to GDP, Wi-Fi will generate approximately 29,500 jobs in Poland in 2021, primarily in the communications sector (15,500), and business services (4,600). Additionally, Wi-Fi is expected to generate 53,000 jobs in 2025.

IX. ECONOMIC VALUE OF WI-FI IN THE EUROPEAN UNION

Having estimated Wi-Fi's economic value for four European Union (EU) countries (Germany, France, Spain, and Poland), we can generate a high-level estimation of the economic value for the other countries in the Union to provide a value for the twenty-seven nations.[94] To do so, we rely on the leading indicators methodology, selecting indicators existing for the four reviewed EU countries and the rest of the block, and relying on these indicators to interpolate the economic value of Wi-Fi for the rest of the EU. The two leading indicators selected are:

- Total GDP: the underlying assumption is that there is a direct link between the level of development of a given country and the economic value of Wi-Fi; and
- Human Development Index (constructed by the United Nations Development Program): this indicator introduces a variable that controls for a country's level of urbanization, literacy, and other social factors.

As the Table IX-1 indicates, the four countries under detailed study represent 55 percent of the EU's GDP.

Table IX-1. EU-27: Distribution of GDP (2019)

Groups	GDP ($Billions)	Percent
Four countries studied (Germany, France, Spain, Poland)	$8,547.4	54.82%
Rest of European Union	$7,045.4	45.18%
Total EU-27	$15,592.8	100 %

Source: World Bank – World Development Indicators

Based on the initial assumption of a correlation between GDP and economic value, we then calculate a first estimate. We then discount these results by the level of development measured by the UN Human Development Index (HDI). The average EU HDI, normalized by population, is 0.895, while the average for the four countries under study is 0.905, and 0.884 for the remaining countries of the EU (see Table IX-2).

Table IX-2. Human Development Index (2018): Four Countries vs. Rest of EU-27

Groups	HDI
Four countries studied (Germany, France, Spain, Poland)	0.905
Rest of the European Union	0.884
Total EU-27	0.895

Sources: United Nations; Telecom Advisory Services analysis

These values are then used to discount the original GDP-based economic value estimates for the "rest of the European Union". The discount factor is calculated by dividing the "rest of European Union" HDI (0.884) by the four countries under study HDI (0.905). This allows a calculation for the economic value of Wi-Fi for the "rest

[94] The remaining European Union countries includes Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Portugal, Romania, Slovakia, Slovenia, Sweden.

of the European Union." Adding this to the four countries under study, we estimate the economic value for the whole of EU under the baseline scenario (see Table IX-3).

Table IX-3. European Union Wi-Fi Economic Value - Baseline scenario (in $Billions)

Countries	2021				2025			
	Consumer surplus	Producer surplus	GDP Contribution	Total	Consumer surplus	Producer surplus	GDP Contribution	Total
Four countries studied (Germany, France, Spain, Poland)	$104.2	$92.8	$52.4	$249.4	$148.4	$107.6	$62.5	$318.5
Rest of European Union estimation	$83.9	$74.7	$42.2	$200.8	$119.5	$86.7	$50.3	$256.5
Total EU-27	$188.1	$167.5	$94.6	$450.2	$267.9	$194.3	$112.8	$575.0

Source: Telecom Advisory Services

By considering specifically the economic value added by Wi-Fi 6 and the allocation of the 6 GHz band, we follow a similar approach to estimate the figures for the rest of European Union and the whole EU-27 (see Table IX-4).

Table IX-4. European Union Wi-Fi Economic Value Wi-Fi 6 and 6 GHz (in $Billions)

Countries	2021				2025			
	Consumer surplus	Producer surplus	GDP Contribution	Total	Consumer surplus	Producer surplus	GDP Contribution	Total
Four countries studied (Germany, France, Spain, Poland)	$0.4	$2.1	$1.5	$4.1	$8.6	$9.6	$16.2	$34.5
Rest of European Union estimation	$0.4	$1.7	$1.2	$3.3	$7.0	$7.7	$13.0	$27.7
Total EU-27	$0.8	$3.9	$2.8	$7.4	$15.6	$17.4	$29.2	$62.2

Source: Telecom Advisory Services

Finally, to calculate the total economic value of Wi-Fi (from current bands and 6 GHz allocation), we follow a similar approach (see Table IX-5).

Table IX-5. European Union Wi-Fi Economic Value – Total (in $Billions)

Countries	2021				2025			
	Consumer surplus	Producer surplus	GDP Contribution	Total	Consumer surplus	Producer surplus	GDP Contribution	Total
Four countries studied (Germany, France, Spain, Poland)	$104.6	$95.0	$53.9	$253.5	$157.0	$117.3	$78.7	$353.0
Rest of European Union estimation	$84.2	$76.5	$43.4	$204.1	$126.4	$94.4	$63.4	$284.2
Total EU-27	$188.8	$171.5	$97.3	$457.6	$283.4	$211.7	$142.1	$637.2

Source: Telecom Advisory Services

As indicated in Table IX-5, Wi-Fi economic value in the European Union amounts to $457.6 billion in 2021, reaching $637.2 in 2025. If the European telecommunications regulatory agencies decide to allocate the upper part of the spectrum to unlicensed use, Wi-Fi economic value would increase significantly beyond the values presented in Table IX-5.

The estimated contribution to GDP for the "rest of European Union" allows us to calculate Wi-Fi's impact on job creation. According to these estimates, the total annual employment generated for the rest of EU has been estimated in Table IX-6.

Table IX-6. Rest of European Union: Wi-Fi generated Annual Employment

Variable	2021			2025		
	Current bands	6 GHz	Total	Current bands	6 GHz	Total
Direct jobs	79,980	2,264	82,245	88,167	32,321	120,488
Indirect jobs	50,940	1,461	52,401	58,187	19,934	78,121
Induced jobs	17,843	505	18,348	19,243	8,045	27,287
Total	148,763	4,230	152,994	165,595	60,299	225,895

Source: Telecom Advisory Services analysis

Adding the four countries studied in detail and the "rest of European Union", Wi-Fi is estimated to contribute 343,000 jobs to the EU market in 2021; by 2025 Wi-Fi will generate 506,000 jobs for the whole economic area (see Table IX-7).

Table IX-7. EU-27: Wi-Fi generated Annual Employment

Variable	2021			2025		
	Four countries studied	Rest of EU	Total EU-27	Four countries studied	Rest of EU	Total EU-27
Direct jobs	102,150	82,245	184,395	149649	120,488	270,137
Indirect jobs	65,083	52,401	117,484	97,028	78,121	175,149
Induced jobs	22,789	18,348	41,137	33,891	27,287	61,178
Total	190,021	152,994	343,016	280,566	225,895	506,465

Source: Telecom Advisory Services analysis

X. ECONOMIC VALUE OF WI-FI IN JAPAN

Wi-Fi has become a significant component of Japan's telecommunications infrastructure. According to the Cisco Annual Internet Report Highlights Tool 2018-2023, there were 400,000 paid Wi-Fi access points operating in the Japanese territory in 2018,[95] while Wiman currently reports the activity of 1,230,000 free Wi-Fi sites in the country.[96] Additionally, 90 percent of Japanese households with broadband are equipped with a Wi-Fi access point.

Given the density of Wi-Fi access points, hotspots have become a very important connectivity feature. According to Opensignal[97], before the outbreak of COVID-19, Japanese smartphone users spent 62.1 percent of their communications time connected to Wi-Fi networks rather than relying on a cellular data connection. That percentage remained fairly stable through March 2020. The increasing importance of Wi-Fi in the digital infrastructure should result in a significant social and economic contribution. This chapter presents the economic assessment results.

In the 2018 study of the economic value of Wi-Fi[98], its economic value in Japan was estimated to reach $213.7 billion in 2021. An update of this study accounting for deployment changes indicates a 14.6 percent increase in value. Before considering the additional effect of the potential allocation of 1,200 MHz in the 6 GHz spectrum band for unlicensed use, the total economic value of Wi-Fi in Japan in 2021 will amount to $245.7 billion. The increase of $32.0 billion in the baseline scenario is due to the development of four new sources of economic value:

- The contribution of Wi-Fi technology to improving broadband speed;
- A substantial boost to deployment of IoT technology; and
- The growing adoption of AR/VR technology use cases.

Even before accounting for the accelerating effect of allocating the 6 GHz band, the 2025 economic value forecast will reach $296.2 billion, comprised of $143.6 billion in consumer surplus, $110.7 billion in producer surplus, and $41.9 billion in GDP contribution. In addition to the value generated from the unlicensed use of the 2.4 GHz and 5 GHz bands (referred to as the baseline scenario), the allocation of the 6 GHz spectrum band for unlicensed use and the deployment of Wi-Fi 6 and Wi-Fi 6E devices will trigger an additional boost in economic value, reaching $28.7 billion in 2025. By combining the baseline and the Wi-Fi 6 and 6 GHz scenarios, the overall economic value of Wi-Fi in Japan will reach $324.9 billion in 2025. Considering that only 40 percent of Wi-Fi traffic is anticipated to rely on the 6 GHz spectrum by 2025, the accelerating effect derived from the new spectrum allocation and latest Wi-Fi

[95] Cisco reports 12.4 million hotspots in 2018, of which 12.0 million are homespots. (Retrieved in: https://www.cisco.com/c/dam/m/en_us/solutions/executive-perspectives/vni-forecast-highlights/total/pdf/Japan_Network_Performance.pdf

[96] Of this installed base of Wi-Fi hotspots in Japan, 485,000 are deployed in Tokyo, 238,000 in Yokohama, and 132,000 in Osaka (Retrieved in: https://www.wiman.me/japan November 17 2020).

[97] Khatri, H. and Fenwick, S. (2020). "Analyzing mobile experience during the coronavirus pandemic: Time on Wi-Fi". *Opensignal* (March 30).

[98] Katz, R. and Callorda, F. (2018). *The Economic value of Wi-Fi: A Global View (2018 and 2023)*. New York: Telecom Advisory Services. October.

technologies will still be far from reaching its maximum potential at this time (see Table X-1).

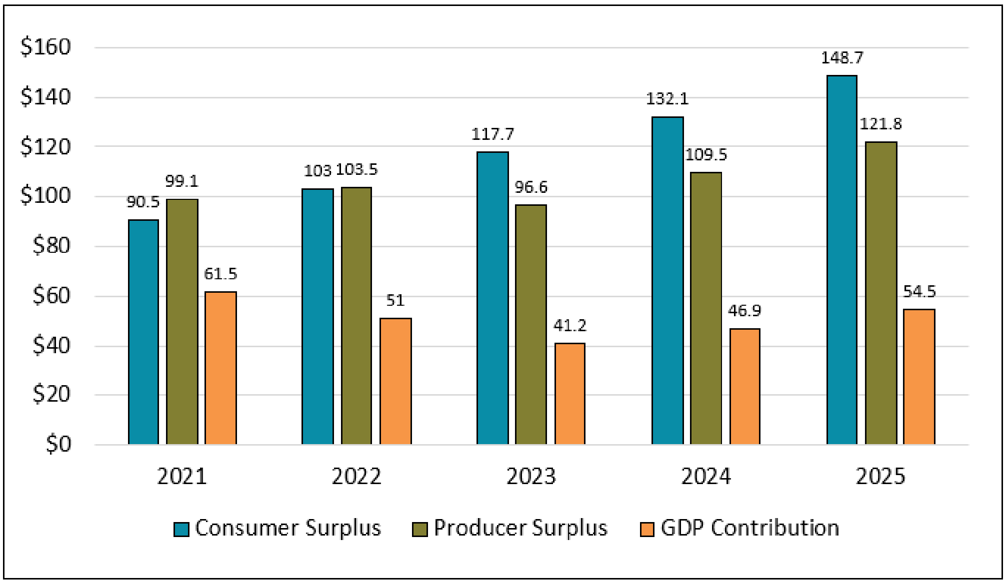
Table X-1. Japan: Total economic value of Wi-Fi (in $Billions)

	2021	2022	2023	2024	2025
Baseline Scenario	$245.7	$246.5	$240.5	$267.5	$296.2
Wi-Fi 6 / 6 GHz Scenario	$5.4	$10.9	$15.0	$21.0	$28.7
Total	$251.1	$257.4	$255.5	$288.5	$324.9

Source: Telecom Advisory Services analysis

After 2022, the primary source of economic value is consumer surplus, followed by producer surplus, and GDP (see Graphic X-1).

Graphic X-1. Japan: Total economic value of Wi-Fi (by source) (in $Billions)



Note: Due to rounding, numbers presented in this graphic may not add up precisely to the totals presented above.
Source: Telecom Advisory Services LLC

This total value benefits five economic agents, of which residential Wi-Fi is the most important, followed by enterprises (see Table X-2).

Table X-2. Japan: Total economic value of Wi-Fi (by agent) (in $Billions)

	2021	2022	2023	2024	2025
Free Wi-Fi	$1.1	$1.2	$1.2	$1.2	$1.2
Residential Wi-Fi	$89.6	$102.0	$116.7	$131.2	$147.7
Enterprise Wi-Fi	$99.2	$91.9	$85.8	$95.7	$108.2
Internet Service Providers	$37.8	$34.5	$18.1	$20.2	$19.4
Wi-Fi ecosystem	$23.4	$27.8	$33.7	$40.2	$48.4
Total	$251.1	$257.4	$255.5	$288.5	$324.9

Source: Telecom Advisory Services analysis

The economic value of residential Wi-Fi is significant in terms of the cost savings gained by avoiding inside wiring and wireless device access at home. The most important factor driving the value of Wi-Fi among enterprises is the spillover of IoT applications, savings in wireless telecommunications, which currently reaches 56 percent of total business traffic, followed by savings in inside wiring, and the enhanced speed of Wi-Fi access points.[99]

According to the contribution to GDP, Wi-Fi will generate approximately 285,000 jobs in Japan in 2021, primarily in the communications sector (192,000), business services (22,000) and manufacturing (15,000).

[99] Detailed analysis is included in the "Theoretical Framework, Methodologies and Detailed Country Assessments for The Economic Value of Wi-Fi: A Global View (2021-2025)" section of this document.

XI. ECONOMIC VALUE OF WI-FI IN SOUTH KOREA

As in all the cases of advanced economies, Wi-Fi has become a pervasive feature in South Korea's telecommunications landscape. According to the Cisco Annual Internet Report Highlights Tool 2018-2023, there were 400,000 paid Wi-Fi access points operating in the South Korean territory in 2018,[100] while Wiman estimates that there are currently 1,037,000 open hotspots in the country.[101] In addition, 90 percent of all South Korean homes with broadband are equipped with Wi-Fi access points.

Given the density of Wi-Fi access points, hotspots have become a very important connectivity feature. According to Opensignal[102], after the outbreak of COVID-19 South Korea wireless users spent 57.9 percent of their communications time connected to Wi-Fi networks, rather than relying on their cellular data connection. This value increased from 54.4 percent before the disruption of the pandemic.

The increasing importance of Wi-Fi technology in the digital ecosystem should have a significant social and economic contribution. This chapter presents the results of the economic assessment.

In the 2018 Economic Value of Wi-Fi[103], the estimated economic value of Wi-Fi in South Korea was $103.52 billion for 2021. MSIT recently decided to approve the use of 1,200 MHz of spectrum in the 6GHz band, which will provide an additional boost to Wi-Fi's economic value.[104] Before considering the additional effect of Wi-Fi 6 and allocating the 6 GHz spectrum band for unlicensed use, the projected total economic value of Wi-Fi in South Korea for 2021 contracted to $87.2 billion. The decline in value between the 2018 study and the current update is mainly due to a faster-than-expected decline in local cellular prices. As a result, the economic benefits consumers experience when using Wi-Fi at home, as well as free Wi-Fi, have reduced considerably with respect to previous estimates. The decline in cellular prices has also reduced the producer surplus derived from business Internet traffic transmitted through Wi-Fi.

In the current update we have not assumed Wi-Fi triggered savings from off-loading cellular traffic, since by 2021 the country is expected to reach 97 percent of 5G coverage. Therefore, those savings will materialize before the time frame of the current study. Before accounting for Wi-Fi 6 and the accelerating effect resulting from the allocation of the entire 6 GHz band, the baseline forecast of economic value is expected to reach $126.1 billion in 2025.

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[100] Cisco reported that in 2018 there were 8.1 million hotspots in South Korea, of which homespots reached 7.7 million (Retrieved in: https://www.cisco.com/c/dam/m/en_us/solutions/executive-perspectives/vni-forecast-highlights/total/pdf/Korea_Network_Performance.pdf

[101] Of this installed base of Wi-Fi hotspots in South Korea, 603,000 are deployed in Seoul, 276,000 in Incheon, and 101,000 in Busan (Retrieved in: https://www.wiman.me/south-korea November 17, 2020).

[102] Khatri, H. and Fenwick, S. (2020). "Analyzing mobile experience during the coronavirus pandemic: Time on Wi-Fi". *Opensignal* (March 30).

[103] Katz, R. and Callorda, F. (2018). *The Economic value of Wi-Fi: A Global View (2018 and 2023)*. New York: Telecom Advisory Services. October.

[104] Cho Mu-Hyun (2020). "South Korea makes 6 GHz band available for Wi-Fi", *ZDNet* (October 16).

That said, Wi-Fi will add value with the addition of the 6 GHz spectrum band for unlicensed use and the deployment of Wi-Fi 6 and Wi-Fi 6E devices. These will trigger an additional boost in economic value, reaching $13.4 billion in 2025. Considering that only 40 percent of Wi-Fi traffic is anticipated to rely on the 6 GHz channels by 2025, the accelerating effect derived from the new spectrum allocation and latest Wi-Fi technologies will still be far from reaching its maximum potential at this time. By combining the baseline and the Wi-Fi 6 and 6 GHz scenarios, the overall economic value of Wi-Fi for South Korea will yield $139.5 billion in 2025 (see Table XI-1).

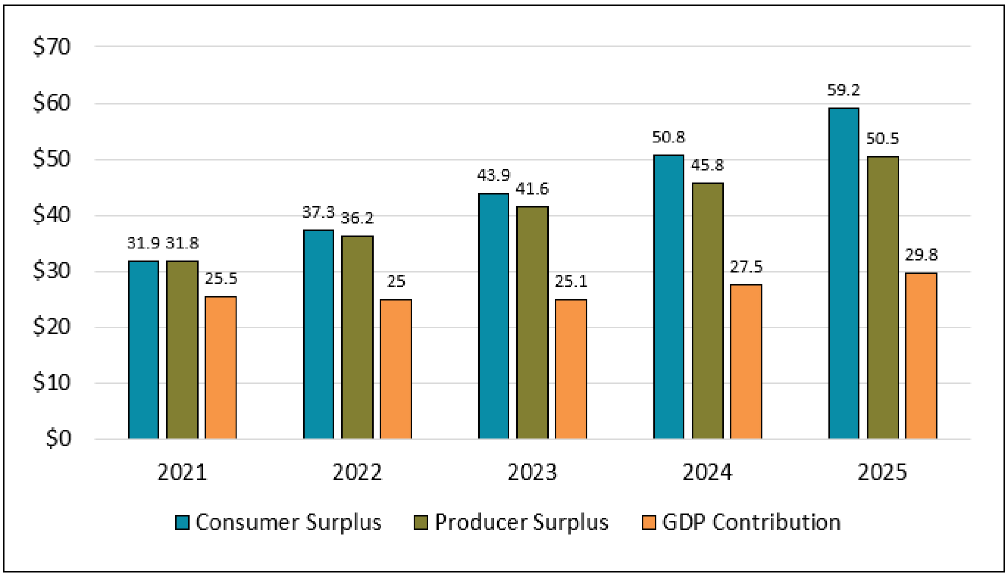
Table XI-1. South Korea: Total economic value of Wi-Fi (in $Billions)

	2021	2022	2023	2024	2025
Baseline Scenario	$87.2	$93.4	$102.6	$113.5	$126.1
Wi-Fi 6 / 6 GHz Scenario	$2.1	$5.1	$7.9	$10.6	$13.4
Total	$89.3	$98.5	$110.5	$124.1	$139.5

Source: Telecom Advisory Services analysis

As indicated in Table XI-1, the Wi-Fi 6 and 6 GHz spectrum allocation will compensate for the decline in value that has occurred in the use of the 2.4 GHz and 5 GHz bands. After 2022, the primary source of economic value will be consumer surplus, followed by producer surplus, and GDP contribution (see Graphic XI-1).

Graphic XI-1. South Korea: Total economic value of Wi-Fi (by Source) (in $Billions)



Note: Due to rounding, numbers presented in this graphic may not add up precisely to the totals presented above.
Source: Telecom Advisory Services LLC

This total value benefits five economic agents, of which residential Wi-Fi is the most important after 2024, followed by enterprises (see Table XI-2).

Table XI-2. South Korea: Total economic value of Wi-Fi (by Agent) (in $Billions)

	2021	2022	2023	2024	2025
Free Wi-Fi	$0.7	$0.7	$0.6	$0.6	$0.6
Residential Wi-Fi	$31.3	$36.8	$43.3	$50.3	$58.7
Enterprise Wi-Fi	$41.6	$43.0	$44.9	$49.3	$54.0
Internet Service Providers	$0.6	$0.6	$0.6	$0.6	$0.6
Wi-Fi ecosystem	$15.1	$17.4	$21.1	$23.3	$25.6
Total	$89.3	$98.5	$110.5	$124.1	$139.5

Source: Telecom Advisory Services analysis

The economic value of residential Wi-Fi is significant in terms of the cost savings gained by avoiding inside wiring and wireless device access at home. The most important factor driving the value of Wi-Fi among enterprises is the spillover of IoT applications, savings in wireless telecommunications (which currently reaches 52 percent of total business traffic), followed by savings in inside wiring, and the enhanced speed of Wi-Fi access points.[105]

According to the contribution to GDP, Wi-Fi will generate approximately 188,000 jobs in South Korea in 2021, primarily in the communications sector (112,000), trade (32,000) and business services (20,000). In 2025, Wi-Fi will contribute to the creation of 220,000 jobs.

[105] Detailed analysis is included in the "Theoretical Framework, Methodologies and Detailed Country Assessments for The Economic Value of Wi-Fi: A Global View (2021-2025)" section of this document.

XII. ECONOMIC VALUE OF WI-FI IN SINGAPORE

Wi-Fi has become a critical component of Singapore's telecommunications infrastructure. According to an interpolation from the Cisco Annual Internet Report Highlights Tool 2018-2023 for the rest of Asia-Pacific, there were 60,000 public Wi-Fi access points operating in the city-state in 2018. Given the density of Wi-Fi access points, hotspots have become a very important connectivity infrastructure. According to Opensignal[106], after the outbreak of COVID-19 Singapore wireless users spent 55.5 percent of their communications time connected to Wi-Fi networks rather than relying on their cellular data connection in the third week of March 2020. This percentage increased from 52.4 percent in January of the same year.

The increasing importance of Wi-Fi technology in the digital ecosystem should have a significant social and economic contribution. This chapter presents the results of the economic assessment.

Before considering the additional effect of Wi-Fi 6 and the potential allocation the 6 GHz spectrum band for unlicensed use, the baseline economic value of Wi-Fi in Singapore in 2021 will amount to $10.4 billion. Likewise, before accounting for the accelerating effect of Wi-Fi 6 and the allocation of the 6 GHz band, the 2025 forecast of economic value will remain stable at $10.4 billion, with a temporary decline in the intervening years.

In addition to the value generated from the baseline scenario (unlicensed use of the 2.4 GHz and 5 GHz bands), the allocation of the 6 GHz spectrum band for unlicensed use and the deployment of Wi-Fi 6 and Wi-Fi 6E devices will trigger a boost in the technology's economic value, reaching $2 billion in 2025. Considering that by 2025 only 40 percent of Wi-Fi traffic will rely on the 6 GHz channels, the accelerating effect of the new spectrum allocation and latest Wi-Fi devices will still be far from reaching its maximum potential at this time. By combining the baseline and the Wi-Fi 6 and 6 GHz scenarios, the overall economic value of Wi-Fi for Singapore will yield $12.4 billion in 2025 (see Table XII-1).

Table XII-1. Singapore: Total economic value of Wi-Fi (in $Billions)

	2021	2022	2023	2024	2025
Baseline Scenario	$10.4	$7.2	$8.3	$9.4	$10.4
Wi-Fi 6 / 6 GHz Scenario	$0.2	$0.5	$0.9	$1.4	$2.0
Total	$10.6	$7.7	$9.2	$10.8	$12.4

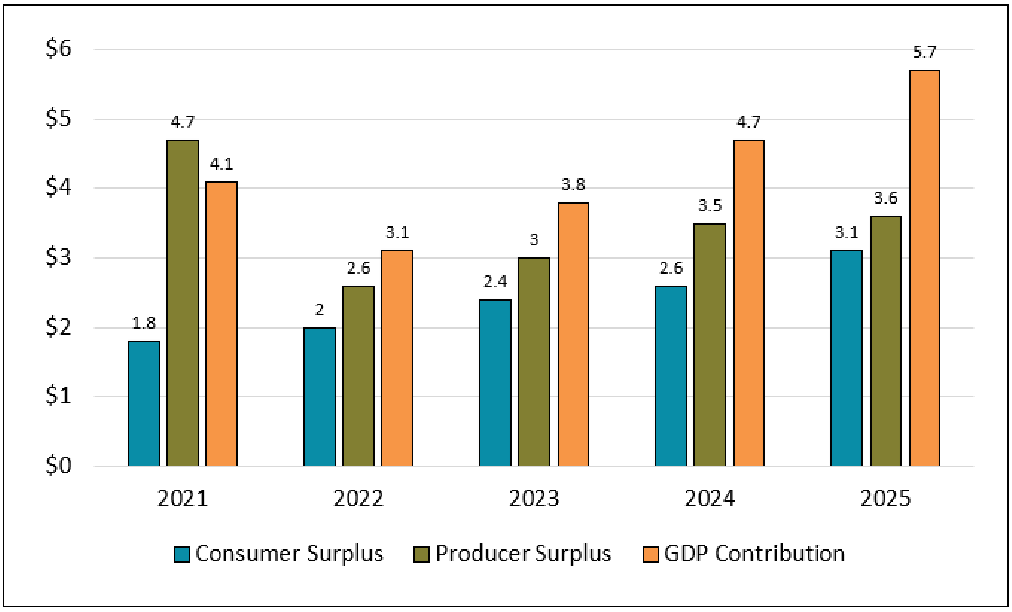
Source: Telecom Advisory Services analysis

While the total value fluctuates in the intervening years, the overall impact when considering the effect of the allocation of the 6 GHz spectrum is positive.

After 2022, the primary source of economic value is GDP, followed by producer surplus and GDP contribution (see Graphic XII-1).

[106] Khatri, H. and Fenwick, S. (2020). "Analyzing mobile experience during the coronavirus pandemic: Time on Wi-Fi". *Opensignal* (March 30).

Graphic XII-1. Singapore: Total economic value of Wi-Fi (by source) (in $Billions)



Note: Due to rounding, numbers presented in this graphic may not add up precisely to the totals presented above. Source: Telecom Advisory Services LLC

This total value benefits five economic agents, of which enterprise Wi-Fi is the most important, followed by residential use (see Table XII-2).

Table XII-2. Singapore: Total economic value of Wi-Fi (by agent) (in $Billions)

	2021	2022	2023	2024	2025
Free Wi-Fi	$0.0	$0.0	$0.0	$0.0	$0.0
Residential Wi-Fi	$1.8	$2.1	$2.4	$2.7	$3.1
Enterprise Wi-Fi	$5.4	$4.4	$5.1	$6.1	$7.1
Internet Service Providers	$2.6	$0.2	$0.5	$0.5	$0.4
Wi-Fi ecosystem	$0.8	$1.0	$1.2	$1.5	$1.8
Total	$10.6	$7.7	$9.2	$10.8	$12.4

Source: Telecom Advisory Services analysis

The most important factor driving the value of Wi-Fi among enterprises is the spillover of IoT applications, savings in wireless telecommunications (which currently reaches 54.6 percent of total business traffic), followed by the enhanced speed of Wi-Fi access points and savings on inside wiring. . The economic value of IoT spillover in the enterprise Wi-Fi segment is a clear demonstration of the technology's contribution to one of Singapore's dominant sources of competitiveness: the logistics industry.[107]

Due to its contribution to GDP, Wi-Fi will generate approximately 13,300 jobs in Singapore in 2021, primarily in the communications sector (9,400), and business services (1,300). In 2025, Wi-Fi technology will contribute to the creation of 18,000 jobs.

[107] Detailed analysis is included in the "Theoretical Framework, Methodologies and Detailed Country Assessments for The Economic Value of Wi-Fi: A Global View (2021-2025)" section of this document.

XIII. ECONOMIC VALUE OF WI-FI IN AUSTRALIA

Wi-Fi technology has become a critical component in Australia's telecommunications infrastructure. According to the Cisco Annual Internet Report Highlights Tool 2018-2023, there were 100,000 public Wi-Fi access points operating in the Australian territory in 2018, while the Wiman site estimates that there are currently 673,000 free hotspots in the country.[108] Additionally, 90 percent of Australian households with broadband have installed a Wi-Fi access point.

Given the density of Wi-Fi access points, hotspots have become a very important connectivity feature. According to Opensignal[109], Australian wireless users currently spend 52.4 percent of their communications time connected to Wi-Fi networks rather than relying on their cellular data connection. This percentage has remained fairly stable during the outbreak of COVID-19.

The increasing importance of Wi-Fi technology in the digital ecosystem should have a significant social and economic contribution. This chapter presents the results of the economic assessment.

Before considering the additional effect of Wi-Fi 6 and the potential 6 GHz spectrum band for unlicensed use, the baseline economic value of Wi-Fi in Australia in 2021 will amount to $34.1 billion. Likewise, the 2025 baseline forecast of economic value will reach $36.3 billion.

In addition to the value generated from the unlicensed use of the 2.4 GHz and 5 GHz bands, the allocation of the 6 GHz spectrum band for Wi-Fi and the deployment of Wi-Fi 6 and Wi-Fi 6E devices will trigger a boost in economic value, reaching $5.4 billion in 2025. Considering that by 2025 only 40 percent of Wi-Fi traffic will rely on the 6 GHz channels, the accelerating effect of the new spectrum allocation and latest Wi-Fi technologies will still be far from reaching its maximum potential at this time. By combining the baseline and the Wi-Fi 6 and 6 GHz scenarios, the overall economic value of Wi-Fi for Australia will yield $41.7 billion in 2025 (see Table XIII-1).

Table XIII-1. Australia: Total economic value of Wi-Fi (in $Billions)

	2021	2022	2023	2024	2025
Baseline Scenario	$34.1	$28.0	$31.1	$33.3	$36.3
Wi-Fi 6 / 6 GHz Scenario	$0.6	$1.6	$2.9	$4.1	$5.4
Total	$34.7	$29.6	$34.0	$37.4	$41.7

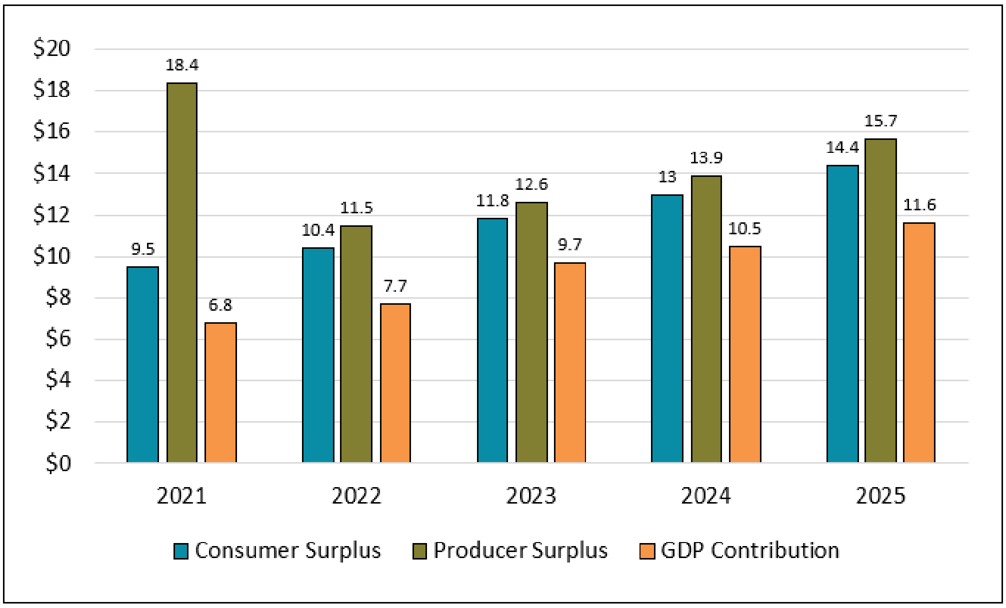
Source: Telecom Advisory Services analysis

The primary source of economic value is producer surplus, although after 2022 the sources of surplus value creation are fairly balanced (see Graphic XIII-1).

[108] Of this installed base of Wi-Fi hotspots in Australia, 36,000 are deployed in Sydney, 50,000 in Melbourne, 17,000 in Adelaide, and 15,000 in Perth (Retrieved in https://www.wiman.me/australia, November 17, 2020).

[109] Khatri, H. and Fenwick, S. (2020). "Analyzing mobile experience during the coronavirus pandemic: Time on Wi-Fi". *Opensignal* (March 30).

Graphic XIII-1. Australia: Total economic value of Wi-Fi (by source) (in $Billions)



Note: Due to rounding, numbers presented in this graphic may not add up precisely to the totals presented above.
Source: Telecom Advisory Services LLC

This total value of Wi-Fi benefits five economic agents, of which consumer use of residential Wi-Fi is the most important, closely followed by enterprise use (see Table XIII-2).

Table XIII-2. Australia: Total Economic Value of Wi-Fi (by agent) (in $Billions)

	2021	2022	2023	2024	2025
Free Wi-Fi	$1.7	$1.9	$2.1	$2.3	$2.4
Residential Wi-Fi	$11.6	$12.6	$14.0	$15.1	$16.6
Enterprise Wi-Fi	$10.3	$11.3	$13.4	$14.4	$15.7
Internet Service Providers	$8.3	$0.4	$0.4	$0.4	$0.4
Wi-Fi ecosystem	$2.8	$3.4	$4.1	$5.2	$6.6
Total	$34.7	$29.6	$34.0	$37.4	$41.7

Source: Telecom Advisory Services analysis

The most important factor driving the value of Wi-Fi among consumer residential use is the cost savings gained by avoiding inside wiring and wireless device access at home. In the case of enterprise Wi-Fi, the highest source of value creation is the reduction of inside wiring costs: nearly half, or $5.5 billion, of the 10.3 billion value in 2021 is brought by reduction in wiring for networks. This is followed by spillover of IoT applications ($2.3 billion in 2021), and savings on wireless telecommunications ($1.9 billion).

According to the contribution to GDP, Wi-Fi will generate approximately 22,000 jobs in Australia in 2021, primarily in the communications sector (8,000), and business services (6,600). In 2025, Wi-Fi will generate 37,800 jobs.

XIV. ECONOMIC VALUE OF WI-FI IN NEW ZEALAND

Wi-Fi has become a pervasive feature in New Zealand's telecommunications landscape. Wiman estimates that there are currently 153,000 open hotspots in the country.[110] In addition, 90 percent of households with broadband are estimated to be equipped with a Wi-Fi access point. The increasing importance of Wi-Fi technology in the digital ecosystem of New Zealand should result in a significant social and economic contribution. This chapter presents the results of the economic assessment.

Before considering the additional effect of Wi-Fi 6 and the potential allocation of the 6 GHz spectrum band for unlicensed use, the total economic value of Wi-Fi in New Zealand in 2021 will amount to $6.6 billion. Similarly, before accounting for Wi-Fi 6 and the 6 GHz band, the 2025 forecast of economic value will reach $8.8 billion.

Adding to the baseline value generated from the unlicensed use of the 2.4 GHz and 5 GHz bands, the allocation of the 6 GHz spectrum band for unlicensed use and the deployment of Wi-Fi 6 and Wi-Fi 6E devices will trigger an additional boost in economic value, reaching $1 billion in 2025. Considering that by 2025 only 40 percent of Wi-Fi traffic will rely on the 6 GHz channels, the accelerating effect of the new spectrum allocation and latest Wi-Fi technologies will still be far from reaching its maximum potential at this time. By combining the baseline and the Wi-Fi 6 and 6 GHz scenarios, the overall economic value of Wi-Fi for New Zealand will yield $9.8 billion in 2025 (see Table XIV-1).

Table XIV-1. New Zealand: Total economic value of Wi-Fi (in $Billions)

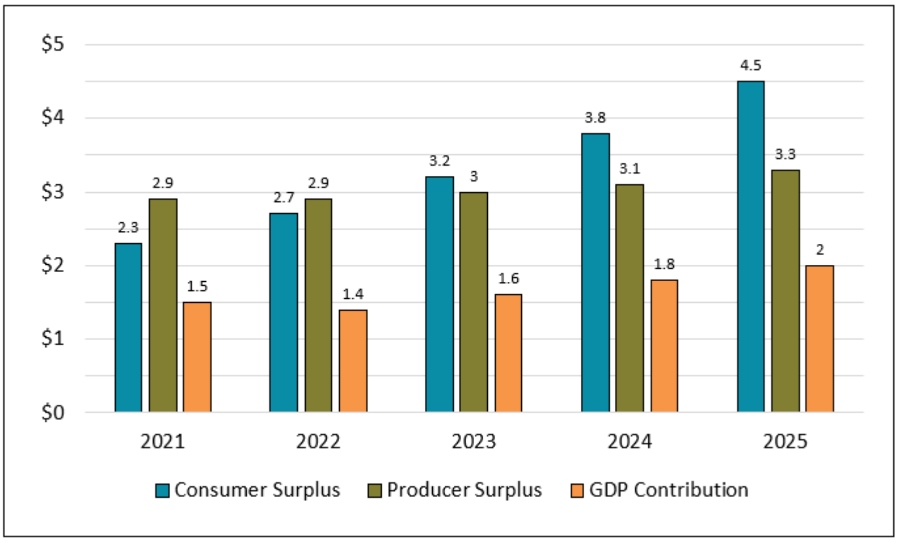
	2021	2022	2023	2024	2025
Baseline Scenario	$6.6	$6.7	$7.3	$8.0	$8.8
Wi-Fi 6 / 6 GHz Scenario	$0.1	$0.3	$0.5	$0.7	$1.0
Total	$6.7	$7.0	$7.8	$8.7	$9.8

Source: Telecom Advisory Services analysis

Beginning in 2023, the primary source of economic value is consumer surplus, followed by producer surplus and GDP contribution (see Graphic XIV-1).

[110] Of this installed base of Wi-Fi hotspots in New Zealand, 37,000 are deployed in Auckland, 22,000 in Wellington, and 26,000 in North Shore (Retrieved in: https://www.wiman.me/new-zealand, November 17, 2020).

Graphic XIV-1. New Zealand: Total economic value of Wi-Fi (by source) (in $Billions)



Note: Due to rounding, numbers presented in this graphic may not add up precisely to the totals presented above.
Source: Telecom Advisory Services LLC

This total value of Wi-Fi in New Zealand benefits five economic agents, of which consumer use of residential Wi-Fi is the most important, closely followed by enterprise use (see Table XIV-2).

Table XIV-2. New Zealand: Total economic value of Wi-Fi (by agent) (in $Billions)

	2021	2022	2023	2024	2025
Free Wi-Fi	$0.3	$0.3	$0.3	$0.3	$0.3
Residential Wi-Fi	$2.7	$3.2	$3.8	$4.4	$5.1
Enterprise Wi-Fi	$2.5	$2.4	$2.6	$2.9	$3.1
Internet Service Providers	$0.8	$0.6	$0.5	$0.3	$0.3
Wi-Fi ecosystem	$0.4	$0.5	$0.6	$0.8	$1.0
Total	$6.7	$7.0	$7.8	$8.7	$9.8

Source: Telecom Advisory Services analysis

The most important factor driving the value of Wi-Fi among consumer residential use is the cost savings gained by avoiding inside wiring and wireless device access at home. In the case of residential use, connectivity and access of wireless devices accounts. In the case of enterprises, the highest source of value creation is the savings on inside wiring costs followed by savings in telecommunications cost since 71 percent of telecommunications traffic is transported through Wi-Fi networks, and spillover of IoT applications.[111]

According to its contribution to GDP, Wi-Fi will generate approximately 3,500 jobs in New Zealand in 2021, primarily in the communications sector (1,300), and business services (1,000). In 2025, Wi-Fi will generate 4,700 jobs.

[111] Detailed analysis is included in the "Theoretical Framework, Methodologies and Detailed Country Assessments for The Economic Value of Wi-Fi: A Global View (2021-2025)" section of this document.

XV. ECONOMIC VALUE OF WI-FI IN INDIA

In recent years, Wi-Fi has become a pervasive feature in the Indian telecommunications landscape. According to data from the Cisco's Annual Internet Report Highlights Tool 2018-2023, there are currently 3.71 million public Wi-Fi access points in India.[112] Similarly, according to Wiman (2021) there are over 541,000 free Wi-Fi sites in the biggest cities of the country (Mumbai, Delhi, Bengaluru, Kolkata, Chennai, Ahmedabad).[113]

The possibility of allowing unlicensed devices to operate in the 6 GHz band spurs the economic value of Wi-Fi, as the capacity available for this technology increases considerably. Before even considering the additional effect of Wi-Fi 6 and allocation of the 6 GHz spectrum band for unlicensed use, the baseline (2.4 and 5 GHz Wi-Fi) economic value of Wi-Fi in India in 2021 is estimated at $130 billion. The 2025 forecast of economic value will reach $177 billion, before considering the multiplier effect of Wi-Fi 6 and 6 GHz band allocation.

Adding to this baseline scenario, the allocation of the 6 GHz spectrum band for unlicensed use and the deployment of Wi-Fi 6 and Wi-Fi 6E devices will trigger additional economic value growth, reaching $63.4 billion in 2025. Considering that we forecast that by 2025 only 40 percent of Wi-Fi traffic will rely on 6 GHz channels, the accelerated effect derived from the new spectrum allocation and latest Wi-Fi technologies will continue to grow and still be far from reaching its maximum potential at this time. By combining the baseline and the Wi-Fi 6 and 6 GHz scenarios, the overall economic value of Wi-Fi for India will yield $240.2 billion in 2025 (see Table XV-1).

Table XV-1. India: Total economic value of Wi-Fi (in $Billions)

	2021	2022	2023	2024	2025
Baseline Scenario	$130.0	$134.3	$145.1	$160.2	$176.8
Wi-Fi 6 / 6 GHz Scenario	$1.2	$13.2	$26.4	$45.2	$63.4
Total	$131.3	$147.5	$171.5	$205.4	$240.2

Source: Telecom Advisory Services analysis

The primary source of Wi-Fi economic value in the country is GDP contribution. This is especially relevant in India due to the capability of free Wi-Fi sites to provide Internet access to millions of unconnected households. By 2025, we forecast GDP contribution to continue being the largest source of economic value (see Graphic XV-1).

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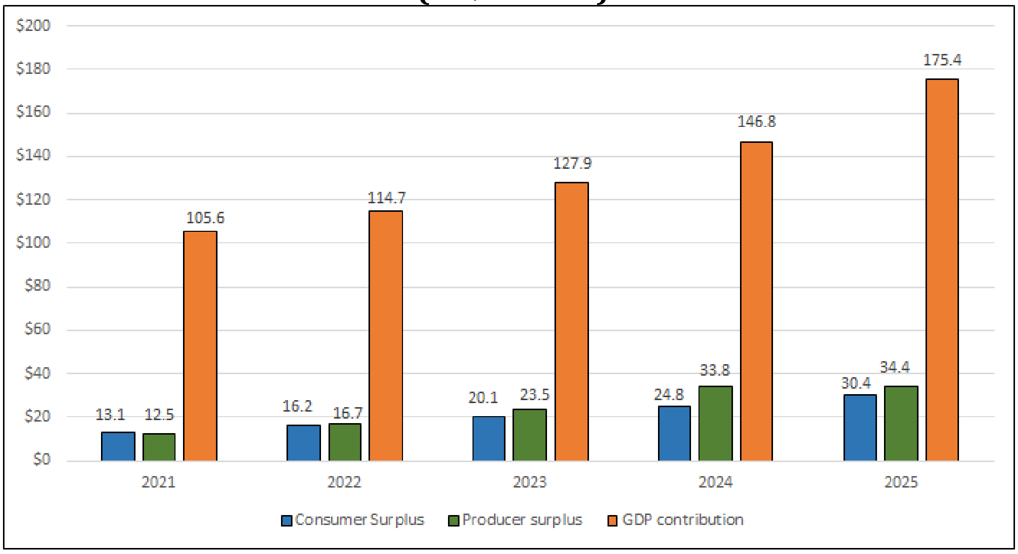
[112] Cisco includes within this category, free hotspots, homespots, and paid hotspots. The report provides a value for 2018 (1.6 million) and 2023 (6.5 million), which allows for interpolating 2021 estimates.

[113] Retrieved in: https://www.wiman.me/india (June 26, 2021).

Graphic XV-1. India: Total economic value of Wi-Fi (by source) (in $Billions)



Note: Due to rounding, numbers presented in this graphic may not add up precisely to the totals above.
Source: Telecom Advisory Services LLC

The total economic value of Wi-Fi benefits five economic agents, of which Free Wi-Fi users is the most important. Beyond free Wi-Fi users, we estimate enterprise Wi-Fi to become the second most important factor driving the value of Wi-Fi. Enterprises will largely benefit from the spillovers from download speed gains resulting from Wi-Fi in comparison with cellular networks (see Table XV-2).

Table XV-2. India: Total Economic Value of Wi-Fi (by agent) (in $Billions)

	2021	2022	2023	2024	2025
Free Wi-Fi	$96.0	$106.5	$116.8	$127.0	$137.0
Residential Wi-Fi	$14.2	$17.9	$22.3	$27.5	$33.6
Enterprise Wi-Fi	$9.4	$7.4	$9.8	$18.2	$36.4
Internet Service Providers	$4.4	$7.4	$12.5	$21.5	$20.6
Wi-Fi ecosystem	$7.2	$8.4	$10.0	$11.3	$12.6
Total	$131.3	$147.5	$171.5	$205.4	$240.2

Source: Telecom Advisory Services analysis

According to its contribution to GDP, Wi-Fi will generate approximately 251,600 jobs in India in 2021, primarily in the communications (161,700), and the trade sector (60,300). In 2025, Wi-Fi will generate 418,000 jobs.

XVI. ECONOMIC VALUE OF WI-FI IN BRAZIL

Wi-Fi has become a critical component of Brazil's telecommunications infrastructure. According to an interpolation of the Cisco Annual Internet Report Highlights Tool 2018-2023, there were approximately 8,800,000 public Wi-Fi access points operating in the country in 2020.[114] Public Wi-Fi sites represent a cost-advantaged approach for consumers with limited affordability to acquire broadband service.

Given the Wi-Fi access point density, hotspots have become a very important connectivity feature. According to Opensignal[115], after the outbreak of COVID-19, Brazilian wireless users spent 70.1 percent of their communications time connected to Wi-Fi networks rather than relying on their cellular data connection. This percent increased from 66.0 percent in January of 2020.

The growing importance of Wi-Fi technology in the digital ecosystem results in a significant social and economic impact. This chapter presents the results of the economic assessment.

The total economic value of Wi-Fi in Brazil in 2021 is estimated at $102.5 billion, before accounting for the accelerating effect resulting from Wi-Fi 6 and the allocation of 1,200 MHz in the 6 GHz band under consideration by the telecommunications regulatory agency. Under the current spectrum allocation (baseline scenario), the 2025 forecast of economic value will reach $109.6 billion.

In addition to the value generated from the baseline scenario involving unlicensed use of the 2.4 GHz and 5 GHz bands, the allocation of 1,200 MHz in the 6 GHz spectrum band for Wi-Fi use and the deployment of Wi-Fi 6 and Wi-Fi 6E devices will trigger an additional boost in economic value, reaching $14.7 billion in 2025. The constant increase in the value of Wi-Fi driven by 6 GHz cancels out the temporary decline in value between 2023 and 2025 that takes place in the baseline scenario. Considering that by 2025, only 37.5 percent of Wi-Fi traffic will rely on the 6 GHz channels, the accelerating effect derived from the new spectrum allocation and latest Wi-Fi technologies will still be far from reaching its maximum potential at this time.

By combining the baseline and the Wi-Fi 6 and 6 GHz scenarios, the overall economic value of Wi-Fi for Brazil will yield $124.3 billion in 2025 (see Table XVI-1).

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[114] The Cisco Annual Internet Report Highlights Tool 2018-2023 states that "Brazil, total public Wi-Fi hotspots (including homespots) will grow 5-fold from 2018 to 2023 from 4.6 million in 2018 to 23.8 million by 2023." https://www.cisco.com/c/dam/m/en_us/solutions/executive-perspectives/vni-forecast-highlights/total/pdf/Brazil_Network_Performance.pdf

[115] Khatri, H. and Fenwick, S. (2020). "Analyzing mobile experience during the coronavirus pandemic: Time on Wi-Fi". *Opensignal* (March 30).

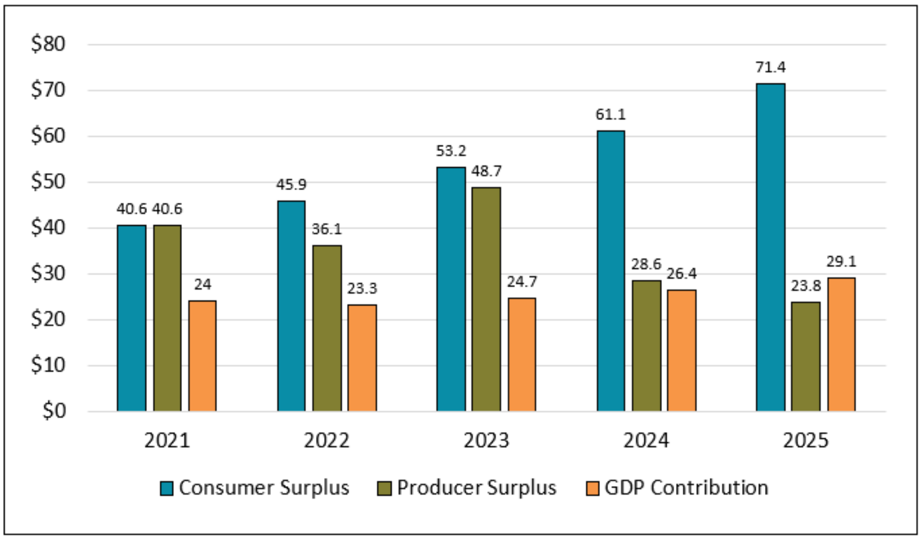
Table XVI-1. Brazil: Total economic value of Wi-Fi (in $Billions)

	2021	2022	2023	2024	2025
Baseline Scenario	$102.5	$100.7	$117.8	$104.6	$109.6
Wi-Fi 6 / 6 GHz Scenario	$2.7	$4.6	$8.8	$11.5	$14.7
Total	$105.2	$105.3	$126.6	$116.1	$124.3

Source: Telecom Advisory Services analysis

After 2022, the primary source of economic value is consumer surplus, followed by producer surplus and GDP contribution (see Graphic XVI-1).

Graphic XVI-1. Brazil: Total economic value of Wi-Fi (by source) (in $Billions)



Note: Due to rounding, numbers presented in this graphic may not add up precisely to the totals presented above.
Source: Telecom Advisory Services LLC

This total value benefits five economic agents, of which residential Wi-Fi is the most important, closely followed by enterprise use (see Table XVI-2).

Table XVI-2. Brazil: Total economic value of Wi-Fi (by agent) (in $Billions)

	2021	2022	2023	2024	2025
Free Wi-Fi	$2.3	$2.4	$2.6	$2.9	$3.2
Residential Wi-Fi	$41.5	$46.9	$54.2	$62.4	$72.7
Enterprise Wi-Fi	$34.2	$33.2	$34.4	$35.7	$38.2
Internet Service Providers	$22.5	$17.4	$28.9	$7.7	$1.8
Wi-Fi ecosystem	$4.7	$5.4	$6.5	$7.4	$8.4
Total	$105.2	$105.3	$126.6	$116.1	$124.3

Source: Telecom Advisory Services analysis

The most important factor driving the value of Wi-Fi among consumer residential use is the cost savings gained by avoiding inside wiring and wireless device access at home. In the case of residential use, the economic value of connectivity and wireless devices access is. In the case of enterprises, the highest source of value creation is the return to speed in wireless telecommunications, followed by savings on inside wiring costs, and savings in telecommunications costs.116

According to the contribution to GDP, Wi-Fi will generate approximately 346,000 jobs in Brazil in 2021, primarily in the communications sector (223,000), and trade (1,000). By 2025, Wi-Fi will generate 421,000 jobs.

116 Detailed analysis is included in the "Theoretical Framework, Methodologies and Detailed Country Assessments for The Economic Value of Wi-Fi: A Global View (2021-2025)" section of this document.

XVII. ECONOMIC VALUE OF WI-FI IN COLOMBIA

Wi-Fi has become a critical component of Colombia's telecommunications infrastructure. According to the Cisco Annual Internet Report Highlights Tool 2018-2023, there are approximately 520,000 public Wi-Fi access points operating in the country[117]. Wiman estimates that there are currently 412,000 free Wi-Fi sites across Colombia. As in the case of Brazil, public Wi-Fi sites represent a cost-advantaged approach for consumers that cannot afford to acquire access to broadband Internet service at home. Additionally, 85 percent of Colombian homes with broadband are equipped with a Wi-Fi router to support device connectivity.

Given the density of Wi-Fi access points, hotspots have become a very important connectivity feature. The increasing importance of Wi-Fi technology in the digital ecosystem results in a significant social and economic impact. This chapter presents the results of the economic assessment.

Before considering the additional effect of Wi-Fi 6 and allocating the 6 GHz spectrum band for unlicensed use, the baseline economic value of Wi-Fi in Colombia in 2021 will amount to $18.7 billion. The 2025 baseline forecast of economic value will reach $36.0 billion.

Adding to the baseline scenario, the potential allocation of the 6 GHz spectrum band for unlicensed use, and the deployment of Wi-Fi 6 and Wi-Fi 6E devices will trigger a growth in economic value, reaching $5.4 billion in 2025. Considering that we forecast that by 2025 only 40 percent of Wi-Fi traffic will be relying on 6 GHz channels, the accelerating effect derived from the new spectrum allocation and latest Wi-Fi technologies will still be far from reaching its maximum potential at this time.

By combining the baseline and the Wi-Fi 6 and 6 GHz scenarios, the overall economic value of Wi-Fi for Colombia will yield $41.4 billion in 2025 (see Table XVII-1).

Table XVII-1. Colombia: Total economic value of Wi-Fi (in $Billions)

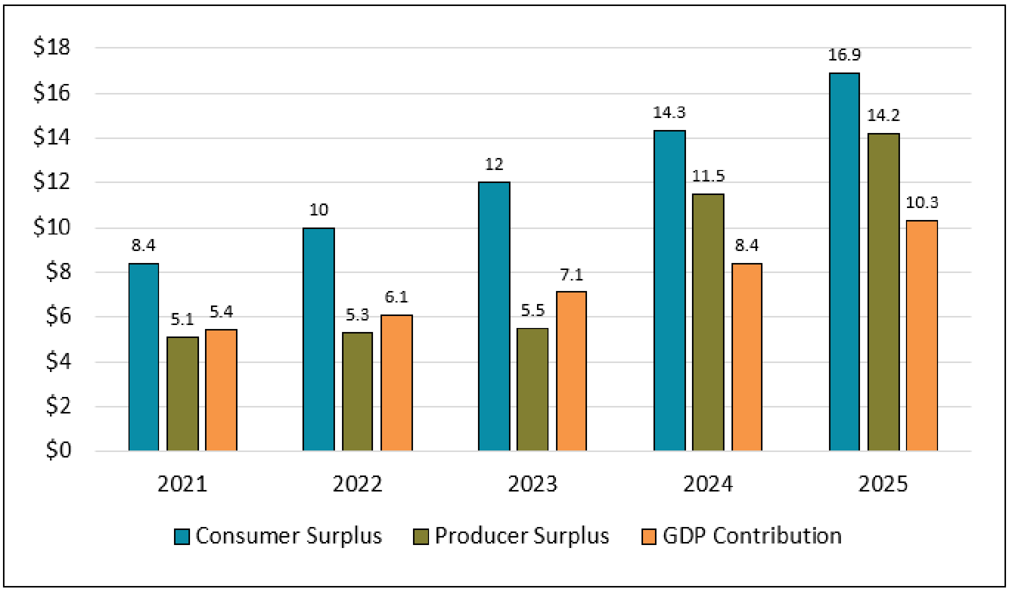
	2021	2022	2023	2024	2025
Baseline Scenario	$18.7	$20.4	$22.6	$30.8	$36.0
Wi-Fi 6 / 6 GHz Scenario	$0.2	$1.0	$2.0	$3.4	$5.4
Total	$18.9	$21.4	$24.6	$34.2	$41.4

Source: Telecom Advisory Services analysis

The primary source of economic value is consumer surplus, followed by producer surplus after 2024 and GDP contribution (see Graphic XVII-1).

[117] Of this installed base, 218,000 are deployed in Bogota, 70,000 in Medellin and 34,000 in Cali (Retrieved in: https://www.wiman.me/colombia, November 17, 2020).

Graphic XVII-1. Colombia: Total economic value of Wi-Fi (by source) (in $Billions)



Note: Due to rounding, numbers presented in this graphic may not add up precisely to the totals presented above.
Source: Telecom Advisory Services LLC

This total value benefits five economic agents, of which residential Wi-Fi is the most important, closely followed by enterprise use (see Table XVII-2).

Table XVII-2. Colombia: Total Economic Value of Wi-Fi (by agent) (in $Billions)

	2021	2022	2023	2024	2025
Free Wi-Fi	$2.6	$2.9	$3.1	$3.4	$3.6
Residential Wi-Fi	$8.6	$10.3	$12.5	$14.9	$17.9
Enterprise Wi-Fi	$7.4	$7.8	$8.5	$9.6	$11.1
Internet Service Providers	$0.1	$0.2	$0.2	$5.9	$8.3
Wi-Fi ecosystem	$0.2	$0.2	$0.3	$0.4	$0.5
Total	$18.9	$21.4	$24.6	$34.2	$41.4

Source: Telecom Advisory Services analysis

The most important factor driving the value of Wi-Fi among consumer residential use is savings in wireless device access at home. In the case of enterprises, the highest source of value creation is savings on telecommunications costs, followed by the return to speed in wireless telecommunications.[118]

Based on the contribution to GDP, Wi-Fi will generate approximately 99,000 jobs in Colombia in 2021, primarily in the communications sector (47,000), and business services (15,000). In 2025, Wi-Fi will generate 187,000 jobs.

[118] Detailed analysis is included in the "Theoretical Framework, Methodologies and Detailed Country Assessments for The Economic Value of Wi-Fi: A Global View (2021-2025)" section of this document.

XVIII. ECONOMIC VALUE OF WI-FI IN MEXICO

Wi-Fi has become a critical component of Mexico's telecommunications infrastructure. According to the Cisco Annual Internet Report Highlights Tool 2018-2023, there are approximately 7,070,000 public Wi-Fi access points operating in the country. Wiman estimates that there are currently 1,787,000 free Wi-Fi sites in Mexico.[119] Additionally, 91 percent of Mexican homes with broadband are estimated to have installed a Wi-Fi router to support device access.

Given the density of Wi-Fi access points, hotspots have become a very important connectivity feature. According to Opensignal[120], Mexican wireless users currently spend 64.0 percent of their communications time connected to Wi-Fi networks rather than relying on their cellular data connection, having increased two percentage points since the start of the COVID-19 pandemic. The increasing importance of Wi-Fi technology in the digital ecosystem results in a significant social and economic impact. This chapter presents the results of the economic assessment.

Before considering the additional effect of Wi-Fi 6 and the potential allocation of the 6 GHz spectrum band for unlicensed use, the baseline economic value of Wi-Fi in Mexico in 2021 will amount to $56.0 billion. The 2025 baseline forecast of economic value will reach $109.0 billion, without considering the accelerating effect from the allocation of Wi-Fi 6 and the 6 GHz band. The 2025 forecast of the baseline scenario will be composed of $67.9 billion in consumer surplus, $33.1 billion in producer surplus, and $8.0 billion in GDP contribution.

Adding to the baseline scenario, the allocation of the 6 GHz spectrum band for unlicensed use and the deployment of Wi-Fi 6 and Wi-Fi 6E devices will trigger a growth in economic value, reaching $8.5 billion in 2025. Considering that we forecast that only 40 percent of Wi-Fi traffic will be relying on 6 GHz channels by 2025, the accelerating effect derived from the new spectrum allocation and latest Wi-Fi technologies will still be far from reaching its maximum potential at this time.

By combining the baseline and the Wi-Fi 6 and 6 GHz scenarios, the overall economic value of Wi-Fi for Mexico will yield $117.5 billion in 2025 (see Table XVIII-1).

Table XVIII-1. Mexico: Total economic value of Wi-Fi (in $Billions)

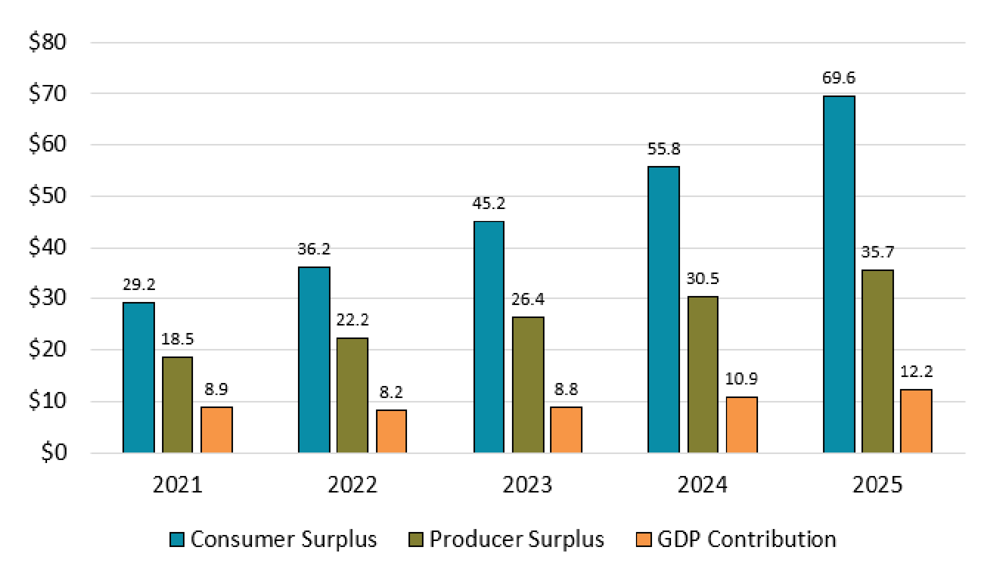
	2021	2022	2023	2024	2025
Baseline Scenario	$56.0	$64.4	$76.4	$90.9	$109.0
Wi-Fi 6 / 6 GHz Scenario	$0.6	$2.2	$3.9	$6.3	$8.5
Total	$56.6	$66.6	$80.3	$97.2	$117.5

Source: Telecom Advisory Services analysis

The primary source of economic value is consumer surplus, followed by producer surplus after 2024, and GDP contribution (see Graphic XVIII-1).

[119] Of this installed base of Wi-Fi hotspots in Mexico, 926,000 are deployed in Mexico City, and 108,000 in Guadalajara (Retrieved in: https://www.wiman.me/mexico.)
[120] Khatri, H. and Fenwick, S. (2020). "Analyzing mobile experience during the coronavirus pandemic: Time on Wi-Fi". *Opensignal* (March 30).

Graphic XVIII-1. Mexico: Total economic value of Wi-Fi (by source) (in $Billions)



Note: Due to rounding, numbers presented in this graphic may not add up precisely to the totals presented above.
Source: Telecom Advisory Services LLC

This total value benefits five economic agents, of which residential Wi-Fi is the most important, closely followed by enterprise use (see Table XVIII-2).

Table XVIII-2. Mexico: Total Economic Value of Wi-Fi (by agent) (in $Billions)

	2021	2022	2023	2024	2025
Free Wi-Fi	$6.4	$6.7	$7.0	$7.1	$7.1
Residential Wi-Fi	$28.9	$35.9	$44.7	$55.5	$69.2
Enterprise Wi-Fi	$16.4	$16.7	$18.3	$21.5	$24.1
Internet Service Providers	$1.3	$3.0	$5.2	$7.5	$10.9
Wi-Fi ecosystem	$3.6	$4.3	$5.1	$5.6	$6.2
Total	$56.6	$66.6	$80.3	$97.2	$117.5

Source: Telecom Advisory Services analysis

The most important factor driving the value of Wi-Fi among consumer residential use is savings in wireless device access at home. In the case of enterprises, the highest source of value creation is savings in telecommunications cost, followed by savings in inside wiring.[121]

Based on the contribution to GDP, Wi-Fi will generate approximately 129,000 jobs in Mexico in 2021, primarily in the communications sector (80,000), and business services (23,000). In 2025, Wi-Fi will generate 177,000 jobs.

[121] Detailed analysis is included in the "Theoretical Framework, Methodologies and Detailed Country Assessments for The Economic Value of Wi-Fi: A Global View (2021-2025)" section of this document.

XIX. ECONOMIC VALUE OF WI-FI IN SOUTH AFRICA

In recent years, Wi-Fi has become a pervasive feature in the South African telecommunications landscape. According to data from the Cisco's Annual Internet Report Highlights Tool 2018-2023, there are currently 640,000 public Wi-Fi access points in South Africa.[122] Wiman (2021) estimates that there are over 309,000 free Wi-Fi sites in the biggest cities of the country (Johannesburg, Cape Town, Soweto, Pretoria, Durban and Port Elizabeth).[123]

Given the density of Wi-Fi access points, hotspots have become a very important connectivity feature. According to Opensignal,[124] since the outbreak of COVID-19, wireless users in South Africa have spent 52.1 percent of their communications time connected to Wi-Fi networks rather than relying on their cellular data connection. This has increased from 48.8 percent at the beginning of February 2020.

The African Telecommunications Union (ATU) Emerging Technologies Task Group has formulated a recommendation to allocate the lower part of the 6 GHz band (5925-6425 MHz) on a license-exempt mode. If African administrations validate the recommendations, then the position of South Africa will be like the one adopted by the European Union.

The possibility of allowing unlicensed devices to operate in the 6 GHz band spurs the economic value of Wi-Fi, as the capacity available for this technology increases considerably. Before even considering the additional effect of Wi-Fi 6 and the allocation of the 6 GHz spectrum band for unlicensed use, the baseline (2.4 and 5 GHz Wi-Fi) economic value of Wi-Fi in South Africa in 2021 is estimated at $30.7 billion. The 2025 forecast of economic value, without considering the accelerating effect of Wi-Fi 6 and 6 GHz band allocation, will reach $41.1 billion.

Adding to this baseline scenario, the allocation of the lower part of the 6 GHz spectrum band for unlicensed use and the deployment of Wi-Fi 6 and Wi-Fi 6E devices will trigger an additional growth of economic value, reaching $3.1 billion in 2025. By combining the baseline and the Wi-Fi 6 and 6 GHz scenarios, the overall economic value of Wi-Fi for South Africa will yield $44.2 billion in 2025 (see Table XIX-1).

Table XIX-1. South Africa: Total economic value of Wi-Fi (in $Billions)

	2021	2022	2023	2024	2025
Baseline Scenario	$30.7	$34.3	$37.5	$42.0	$41.1
Wi-Fi 6 / 6 GHz Scenario	$0.1	$0.8	$1.5	$2.3	$3.1
Total	$30.9	$35.1	$39.0	$44.2	$44.2

Source: Telecom Advisory Services analysis

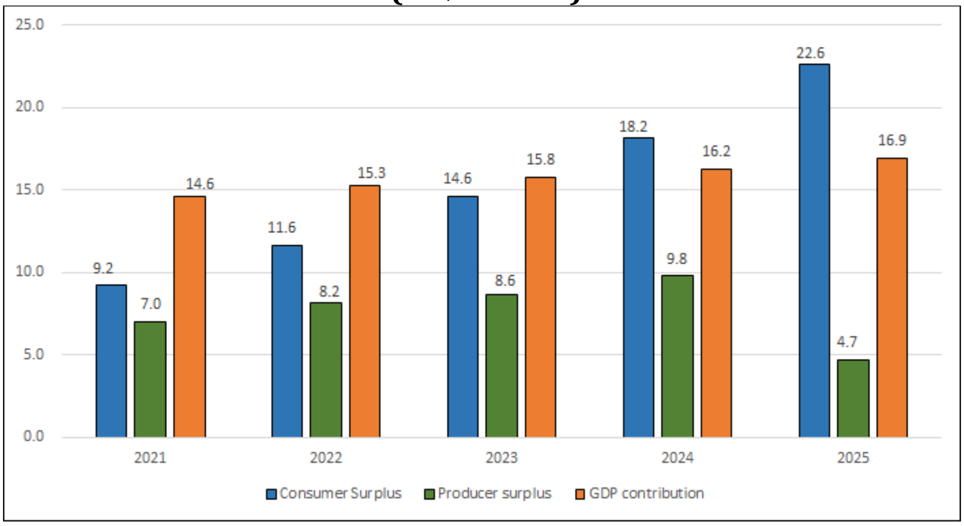
Considering that by 2025 only 40 percent of Wi-Fi traffic will rely on 6 GHz channels, the accelerated effect derived from the new spectrum allocation and the adoption of

[122] Cisco includes within this category, free hotspots, homespots, and paid hotspots. The report provides a value for 2018 and 2023, which allows for interpolating 2021 estimates.
[123] Retrieved in: https://www.wiman.me/South-Africa (June 8, 2021).
[124] Khatri, H. and Fenwick, S. (2020). "Analyzing mobile experience during the coronavirus pandemic: Time on Wi-Fi". *Opensignal* (March 30).

the latest Wi-Fi technologies will continue to grow and still be far from reaching its maximum potential.

Currently, the primary source of economic value is GDP contribution due to the importance of free Wi-Fi to reduce the digital divide in South Africa. A national survey indicates that in South Africa, 13.3% of the population (8,000,000) use public Wi-Fi at least once a day.[125] However, going forward, consumer surplus will become the largest source of economic value due to the expected increase in the economic contribution of residential devices that lack a wired port (see Graphic XIX-1).

Graphic XIX-1. South Africa: Total economic value of Wi-Fi (by source) (in $Billions)



Note: Due to rounding, numbers presented in this graphic may not add up precisely to the totals above.
Source: Telecom Advisory Services LLC

The total economic value of Wi-Fi benefits five economic agents, of which residential and free Wi-Fi users are currently the most important. By 2025, residential Wi-Fi will become the larger economic agent, benefitting mainly from savings in Internet access for home usage of devices that lack a wired port. In addition, the second most important factor driving the value of Wi-Fi is linked to the contribution of free Wi-Fi in public sites to close the digital divide (see Table XIX-2).

Table XIX-2. South Africa: Total Economic Value of Wi-Fi (by agent) (in $Billions)

	2021	2022	2023	2024	2025
Free Wi-Fi	$7.6	$7.7	$7.7	$7.7	$7.7
Residential Wi-Fi	$13.0	$15.7	$18.8	$22.7	$27.3
Enterprise Wi-Fi	$5.0	$5.4	$5.8	$6.1	$6.6
Internet Service Providers	$4.1	$5.0	$5.1	$5.9	$0.2
Wi-Fi ecosystem	$1.1	$1.3	$1.6	$1.9	$2.3
Total	$30.9	$35.1	$39.0	$44.2	$44.2

Source: Telecom Advisory Services analysis

According to its contribution to GDP, Wi-Fi will generate approximately 159,000 jobs in South Africa in 2021, primarily in the communications (102,200) and trade sector (48,800). In 2025, Wi-Fi will generate 184,000 jobs.

[125] RIA After Access survey data, 2017-2018

XX. ECONOMIC VALUE OF WI-FI IN DEMOCRATIC REPUBLIC OF CONGO (DRC)

Wi-Fi technology is entering a period of fast deployment in in the Democratic Republic of Congo (DRC). Our interpolation from Cisco data for the region,[126] projects approximately 52,000 public Wi-Fi hotspots in the country (of which 18% provide free access), although we estimate the installed base will reach 150,000 by 2025. Residential hotspots represent comparable statistics.

Wi-Fi current economic value based on its usage of the 2.4 and 5 GHz bands is estimated at $697 million, of which $154 million represent a contribution to the country's GDP, $423 million is driven by producer surplus, and the remainder ($120 million) accounts for consumer surplus. Most of the producer surplus is based on a benefit resulting from enterprise savings in data communications installations.

The DRC might be following a recommendation of the African Telecommunications Union (ATU) Emerging Technologies Task Group to allow access to the lower part of the 6 GHz band (5925-6425 MHz) on a license-exempt basis. The possibility of allowing unlicensed devices to operate in the 6 GHz band spurs the economic value of Wi-Fi, as the capacity available for this technology increases considerably. Before even considering the additional effect of Wi-Fi 6 and allocation of the 6 GHz spectrum band for unlicensed use, the 2025 forecast of economic value will reach $1.4 billion.

Adding to this baseline scenario, the allocation of the 6 GHz spectrum band for unlicensed use and the deployment of Wi-Fi 6 and Wi-Fi 6E devices will trigger an additional growth of economic value, reaching nearly $ 396 million in 2025. Considering that we forecast that by 2025 only 40 percent of Wi-Fi traffic in the DRC will rely on 6 GHz channels, the accelerated effect derived from the new spectrum allocation and latest Wi-Fi technologies will continue to grow and still be far from reaching its maximum potential at this time. By combining the baseline and the Wi-Fi 6 and 6 GHz scenarios, the overall economic value of Wi-Fi for the country will reach $1.8 billion in 2025 (see Table XX-1).

Table XX-1. DRC: Total economic value of Wi-Fi (in $Billions)

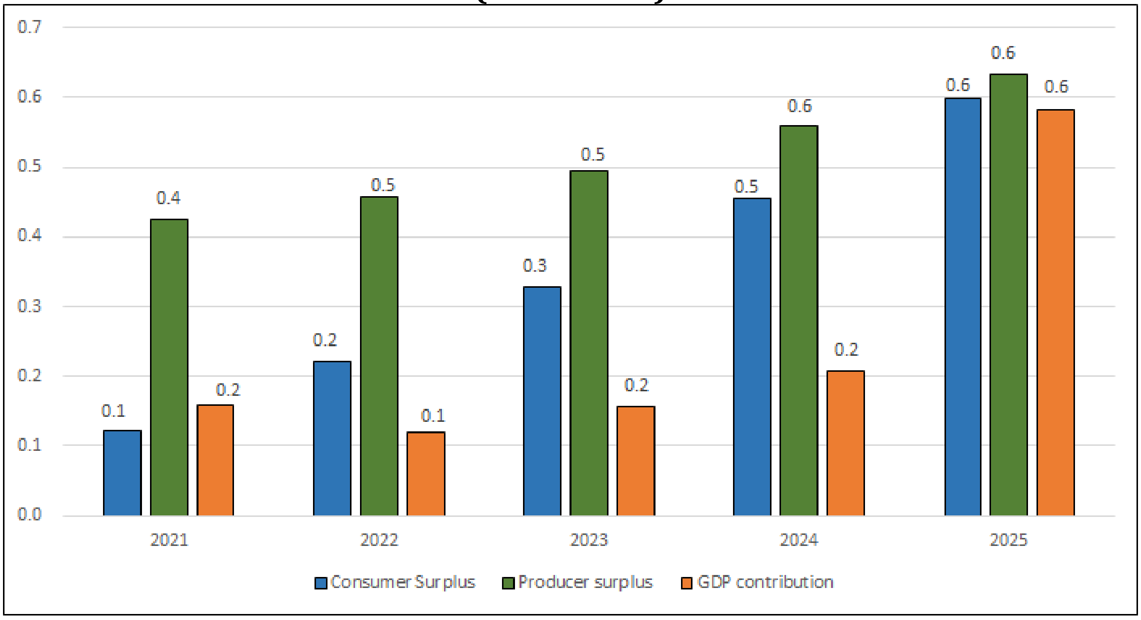
	2021	2022	2023	2024	2025
Baseline Scenario	$0.7	$0.7	$0.8	$0.9	$1.4
Wi-Fi 6 / 6 GHz Scenario	$0.0	$0.1	$0.2	$0.3	$0.4
Total	$0.7	$0.8	$1.0	$1.2	$1.8

Source: Telecom Advisory Services analysis

Currently, the primary source of economic value is producer surplus, although by 2025 we forecast consumer surplus and GDP contribution to catch up. As mentioned above, producer surplus is benefited due to the large savings in data communication installation for DRC enterprises. On the other hand, consumer surplus will grow significantly through the period, mainly driven by the speed increases due to Wi-Fi, which will increase consumer welfare. GDP contribution at the end of the forecast period will be mainly associated to the return to speed effect (see Graphic XX-1).

[126] Cisco. *Annual Internet Report Highlights Tool 2018-2023*

Graphic XX-1. DRC: Total economic value of Wi-Fi (by source) (in $Billions)



Note: Due to rounding, numbers presented in this graphic may not add up precisely to the totals above.
Source: Telecom Advisory Services LLC

The total economic value of Wi-Fi benefits five economic agents, of which enterprise Wi-Fi is the most important. It is expected to remain in that position until 2025 (see Table XX-2).

Table XX-2. DRC: Total Economic Value of Wi-Fi (by agent) (in $Billions)

	2021	2022	2023	2024	2025
Free Wi-Fi	$0.0	$0.1	$0.2	$0.2	$0.3
Residential Wi-Fi	$0.1	$0.1	$0.2	$0.2	$0.3
Enterprise Wi-Fi	$0.5	$0.5	$0.6	$0.7	$1.1
Internet Service Providers	$0.0	$0.0	$0.0	$0.0	$0.0
Wi-Fi ecosystem	$0.0	$0.0	$0.0	$0.1	$0.1
Total	$0.7	$0.8	$1.0	$1.2	$1.8

Source: Telecom Advisory Services analysis

Currently, residential Wi-Fi will follow closely in terms of economic value. By 2025, we expect free Wi-Fi to become the second most important source of economic value. Free Wi-Fi will largely benefit from the speed increases resulting from the deployment of Wi-Fi 6 access points and devices.

According to its contribution to GDP in the Democratic Republic of Congo, Wi-Fi will generate approximately 1,700 jobs in 2021, primarily in the communications sector (1,100), and secondarily in the trade sector (500). In 2025, Wi-Fi driven job creation will rise to 6,300.

XXI. ECONOMIC VALUE OF WI-FI IN THE SOUTHERN AFRICAN DEVELOPMENT COMMUNITY (SADC)

Having estimated Wi-Fi's economic value for two Southern Africa Development Community (SADC) countries (Democratic Republic of Congo and South Africa), we developed a high-level estimation of the economic value for the remaining countries of that economic area.[127] To do so, we rely on the leading indicators methodology, selecting indicators existing for the reviewed countries and the rest of the block, and relying on these indicators to interpolate the economic value of Wi-Fi for the rest of the SADC region. The two leading indicators selected are:

- Total GDP: The underlying assumption is that there is a direct link between the level of development of a given country and the economic value of Wi-Fi; and;
- Human Development Index (constructed by the United Nations Development Program): This indicator introduces a variable that controls for a country's level of urbanization, literacy, and other social factors.

As the table XXI-1 indicates, the countries under study represent 59% percent of SADC's GDP.

Table XXI-1. SADC: Distribution of GDP (2020)

Groups	GDP ($billion)	Percent
Countries studied (DRC and South Africa)	$351.2	58.6%
Rest of SADC	$248.2	41.4%
Total SADC	$599.4	100.0%

Source: World Bank – World Development Indicators

Based on the initial assumption of a correlation between GDP and Wi-Fi economic value, we calculate a first estimate. This value is then discounted by the level of development measured by the UN Human Development Index (HDI). The average SADC HDI, normalized by population, is 0.550, while the average for the two countries under study is 0.571, and 0.535 for the remaining countries of the region (see table XXI-2).

Table XXI-2. Human Development Index (2019): Countries studied vs. Rest of SADC

Groups	HDI
Countries studied (DRC and South Africa)	0.571
Rest of SADC	0.535
Total SADC	0.550

Sources: United Nations; Telecom Advisory Services analysis

As mentioned above, these values are then used to discount the original GDP-based economic value estimates for the "rest of SADC." The discount factor is calculated by dividing the "rest of SADC" HDI (0.535) by the two countries under study HDI

[127] The Rest of the SADC sample is composed of Angola, Botswana, Comoros, Eswatini, Lesotho, Madagascar, Malawi, Mauritius, Mozambique, Namibia, Seychelles, Tanzania, Zambia, and Zimbabwe.

(0.571). This allows the estimation of the economic value of Wi-Fi for the "rest of SADC." Adding this to the countries under study, we estimate the economic value for the whole region under the baseline scenario (see Table XXI-3).

Table XXI-3. SADC Wi-Fi Economic Value - Baseline scenario (in $Billions)

Countries	2021				2025			
	Consumer surplus	Producer surplus	GDP Contribution	Total	Consumer surplus	Producer surplus	GDP Contribution	Total
Countries studied	$9.3	$7.3	$14.8	$31.4	$22.6	$4.4	$15.6	$42.5
Rest of SADC	$6.2	$4.9	$9.8	$20.8	$14.9	$2.9	$10.3	$28.2
Total SADC	$15.5	$12.2	$24.5	$52.2	$37.5	$7.3	$25.9	$70.7

Source: Telecom Advisory Services

By considering the economic value added by Wi-Fi 6 and the allocation of the 6 GHz band, we follow a similar approach to estimate the figures for the rest of SADC and the whole region (see Table XXI-4).

Table XXI-4. SADC Wi-Fi Economic Value – Only 6 GHz (in $Billions)

Countries	2021				2025			
	Consumer surplus	Producer surplus	GDP Contribution	Total	Consumer surplus	Producer surplus	GDP Contribution	Total
Countries studied	$0.0	$0.1	$0.0	$0.1	$0.6	$0.9	$1.9	$3.5
Rest of SADC	$0.0	$0.1	$0.0	$0.1	$0.4	$0.6	$1.3	$2.3
Total SADC	$0.0	$0.2	$0.0	$0.2	$1.1	$1.5	$3.2	$5.8

Source: Telecom Advisory Services

Finally, to calculate the total economic value of Wi-Fi (from current bands and 6 GHz allocation), we follow a similar approach (see Table XXI-5).

Table XXI-5. SADC Wi-Fi Economic Value – Total (in $Billions)

Countries	2021				2025			
	Consumer surplus	Producer surplus	GDP Contribution	Total	Consumer surplus	Producer surplus	GDP Contribution	Total
Countries studied	$9.4	$7.4	$14.8	$31.6	$23.2	$5.3	$17.5	$46.0
Rest of SADC	$6.2	$4.9	$9.8	$20.9	$15.4	$3.5	$11.6	$30.5
Total SADC	$15.6	$12.4	$24.6	$52.5	$38.6	$8.8	$29.1	$76.5

Source: Telecom Advisory Services

Based on the estimates from table XXI-5, the total Wi-Fi economic value for the SADC community amounts to $52.5 billion in 2021, and will reach $ 76.5 billion in 2025.

XXII. ECONOMIC VALUE OF WI-FI IN CAMEROON

In recent years, Wi-Fi has become a pervasive feature in Cameroon's telecommunications landscape. Interpolating the data provided for the Middle East and Africa by Cisco's Annual Internet Report Highlights Tool 2018-2023, we estimate there are currently over 40,500 public Wi-Fi access points in Cameroon,[128] while according to Wiman (2021) there are over 7,500 free Wi-Fi sites, mostly concentrated in the cities of Douala, Yaounde, Garoua, Maroua, Bamenda, and Kousseri.[129] Furthermore, Wi-Fi access points are fairly prevalent among enterprises: approximately 77.7% of medium and large establishments have installed Wi-Fi networks.

Current economic value of Wi-Fi based on the reliance on the 2.4 and 5 GHz frequency bands is estimated at $1 billion, of which $537 million is based on consumer benefits, and of which $248 million is data communications savings for enterprises. The 2025 forecast of economic value will reach $2.3 billion. These values are expected to increase if the Cameroon regulator follows the African Telecommunications Union (ATU) Emerging Technologies Task Group recommendation on license-exempt access to the lower part of the 6 GHz band (5925-6425 MHz).

The possibility of allowing unlicensed devices to operate in the 6 GHz band spurs the economic value of Wi-Fi, as the capacity available for this technology increases considerably. Assuming that the regulator follows the ATU recommendation, the allocation of the 6 GHz spectrum band for unlicensed use and the deployment of Wi-Fi 6 and Wi-Fi 6E devices will trigger an additional growth of economic value, reaching $224 million in 2025. Considering that we forecast that by 2025 only 40 percent of Wi-Fi traffic will rely on 6 GHz channels, the multiplier effect derived from the new spectrum allocation and adoption of the latest Wi-Fi technologies will continue to grow and still be far from reaching its maximum potential at this time. By combining the baseline and the Wi-Fi 6 and 6 GHz scenarios, the overall economic value of Wi-Fi for Cameroon will yield $2.6 billion in 2025 (see Table XXII-1).

Table XXII-1. Cameroon: Total economic value of Wi-Fi (in $Billions)

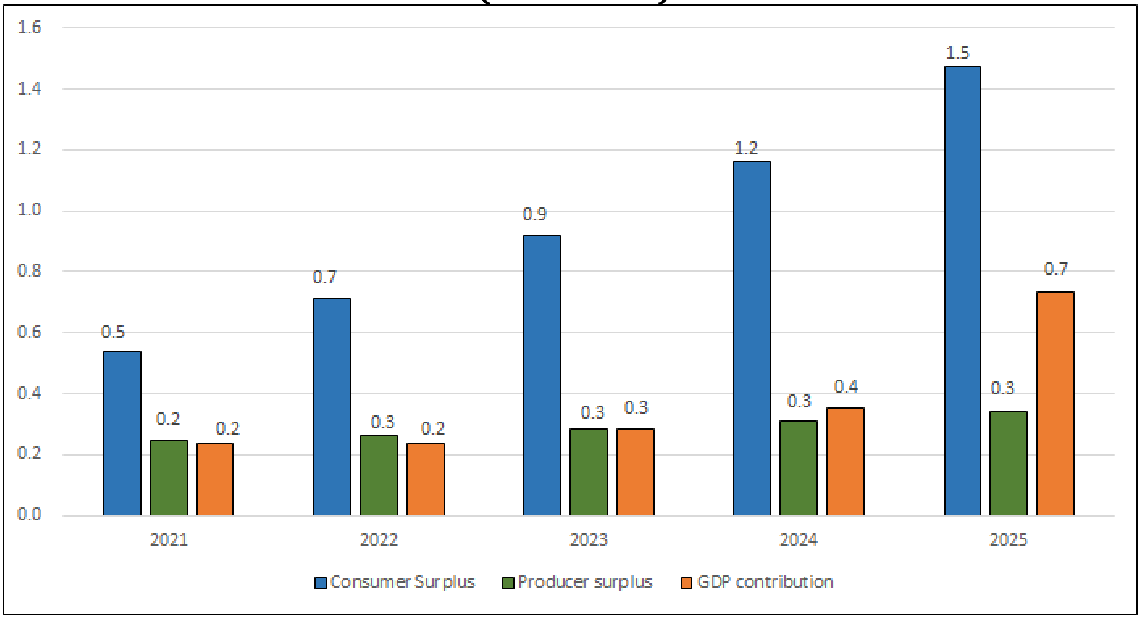
	2021	2022	2023	2024	2025
Baseline Scenario	$1.0	$1.2	$1.4	$1.7	$2.3
Wi-Fi 6 / 6 GHz Scenario	$0.0	$0.0	$0.1	$0.1	$0.2
Total	$1.0	$1.2	$1.5	$1.8	$2.6

Source: Telecom Advisory Services analysis

Currently, the primary source of economic value is consumer surplus. This surplus is mainly driven by avoiding wired Internet access for home usage. However, we forecast an important increase in GDP contribution in 2025, largely associated with the return to speed effect that will benefit local enterprises (see Graphic XXII-1).

[128] Cisco includes within this category, free hotspots, home-spots, and paid hotspots, for the region of Middle East and Africa. Values for Cameroon were estimated by considering the country weight in the region's GDP. The report provides values for 2018 and 2023, which allows for interpolating 2021 estimates.
[129] Retrieved in: https://www.wiman.me/cameroon (June 25, 2021).

Graphic XXII-1. Cameroon: Total economic value of Wi-Fi (by source) (in $Billions)



Note: Due to rounding, numbers presented in this graphic may not add up precisely to the totals above.
Source: Telecom Advisory Services LLC

The aggregate economic value will break down across five economic agents, of which residential Wi-Fi is the most important, followed by enterprise Wi-Fi (see Table XXII-2).

Table XXII-2. Cameroon: Total Economic Value of Wi-Fi (by agent) (in $Billions)

	2021	2022	2023	2024	2025
Free Wi-Fi	$0.0	$0.0	$0.1	$0.1	$0.1
Residential Wi-Fi	$0.5	$0.7	$0.9	$1.1	$1.4
Enterprise Wi-Fi	$0.3	$0.3	$0.4	$0.4	$0.8
Internet Service Providers	$0.1	$0.1	$0.2	$0.2	$0.2
Wi-Fi ecosystem	$0.0	$0.0	$0.0	$0.0	$0.1
Total	$1.0	$1.2	$1.5	$1.8	$2.6

Source: Telecom Advisory Services analysis

In 2025, we forecast that the main sources of economic value will continue to be residential Wi-Fi (due to large savings from home traffic in devices lacking an ethernet port) and enterprise Wi-Fi (as the increases in speed due to the allocation of 6 GHz band are expected to have a strong impact in GDP).

Based on its contribution to GDP, Wi-Fi will generate approximately 2,600 jobs in Cameroon in 2021. Job contribution will be primarily in the communications sector (1,700), and in the trade sector (800). In 2025, Wi-Fi triggered job creation will increase to 8,000 jobs.

XXIII. ECONOMIC VALUE OF WI-FI IN GABON

The use of Wi-Fi technology in Gabon is embryonic. By interpolating the data provided for Middle East and Africa by Cisco's Annual Internet Report Highlights Tool 2018-2023, we estimate there are currently approximately 17,500 public Wi-Fi access points in Gabon.[130] This estimate is validated by the deployment of 3,500 free Wi-Fi sites, mostly concentrated in the cities of Libreville, Port Gentil, Franceville, Mouila, Moanda and Oyem.[131]

Even under this limited deployment, Wi-Fi already generates economic value in the country. Current installations, relying on the 2.4 and 5 GHz frequency bands, represent an aggregate economic value of $ 560 million. Considering that approximately 78% of large and medium industrial establishments have at least one access point, the enterprise segment benefits from savings in data communication installations and cellular costs. The 2025 forecast of economic value will reach $1.1 billion, without considering the accelerating effect of Wi-Fi 6 and 6 GHz band allocation.

In this context, the recommendation of the African Telecommunications Union (ATU) Emerging Technologies Task Group on license-exempt access to the lower part of the 6 GHz band (5925-6425 MHz) will result in an increase in Wi-Fi economic value. The possibility of allowing unlicensed devices to operate in the 6 GHz band spurs the economic value of Wi-Fi, as the capacity available for this technology increases to some degree.

Adding to this baseline scenario, the allocation of the 6 GHz spectrum band for unlicensed use and the deployment of Wi-Fi 6 and Wi-Fi 6E devices will trigger an additional growth of economic value, reaching $66 million in 2025. Considering that we forecast that by 2025 only 40 percent of Wi-Fi traffic will rely on 6 GHz channels, the accelerated effect derived from the new spectrum allocation and latest Wi-Fi technologies will continue to grow and still be far from reaching its maximum potential at this time. By combining the baseline and the Wi-Fi 6 and 6 GHz scenarios, the overall economic value of Wi-Fi for Gabon will yield $1.2 billion in 2025 (see Table XXIII-1).

Table XXIII-1. Gabon: Total economic value of Wi-Fi (in $Billions)

	2021	2022	2023	2024	2025
Baseline Scenario	$0.6	$0.6	$0.7	$0.9	$1.1
Wi-Fi 6 / 6 GHz Scenario	$0.0	$0.0	$0.0	$0.1	$0.1
Total	$0.6	$0.7	$0.8	$0.9	$1.2

Source: Telecom Advisory Services analysis

Currently, the primary source of economic value is producer surplus. This surplus is mainly driven by the savings linked to avoiding the ethernet wiring of business

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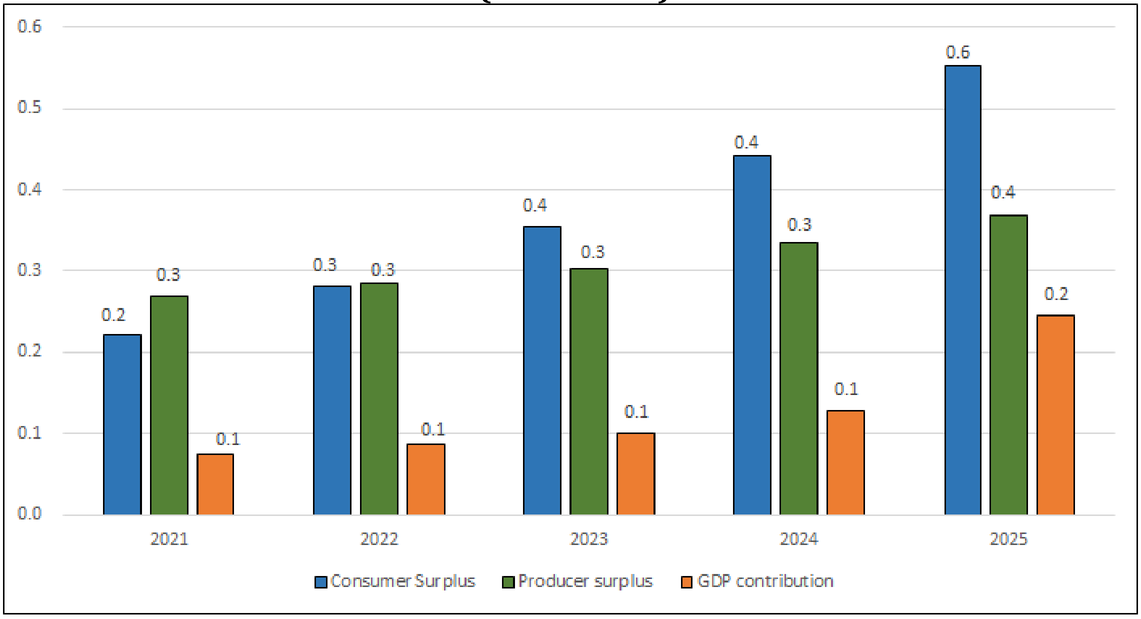
130 Cisco includes within this category, free hotspots, home-spots, and paid hotspots, for the region of Middle East and Africa. Values for Gabon were estimated by considering the country weight in the region's GDP. The report provides values for 2018 and 2023, which allows for interpolating 2021 estimates.

131 Wiman. Retrieved in: https://www.wiman.me/gabon (June 25, 2021).

establishments. However, by the end of the period, we expect consumer surplus to become the main source of economic value (see Graphic XXIII-1).

Graphic XXIII-1. Gabon: Total economic value of Wi-Fi (by source) (in $Billions)



Note: Due to rounding, numbers presented in this graphic may not add up precisely to the totals above.
Source: Telecom Advisory Services LLC

The total economic value of Wi-Fi benefits five economic agents, of which, as mentioned above, enterprise Wi-Fi is the most important (see Table XXIII-2).

Table XXIII-2. Gabon: Total Economic Value of Wi-Fi (by agent) (in $Billions)

	2021	2022	2023	2024	2025
Free Wi-Fi	$0.0	$0.0	$0.0	$0.0	$0.0
Residential Wi-Fi	$0.2	$0.3	$0.3	$0.4	$0.5
Enterprise Wi-Fi	$0.3	$0.4	$0.4	$0.4	$0.6
Internet Service Providers	$0.0	$0.0	$0.0	$0.0	$0.0
Wi-Fi ecosystem	$0.0	$0.0	$0.0	$0.0	$0.0
Total	$0.6	$0.7	$0.8	$0.9	$1.2

Source: Telecom Advisory Services analysis

By 2025, we expect an important increase in the economic value coming from the consumer use of residential Wi-Fi. In that respect, the main gains for consumers will come from the savings incurred due to Internet access for home usage of devices that lack a wired port, followed by the avoidance of investment in in-house wiring.

Based on its contribution to GDP, Wi-Fi should generate approximately 800 jobs in Gabon in 2021, primarily in communications (500), and trade (250). In 2025, job creation caused by Wi-Fi will increase to 2,700 jobs.

XXIV. ECONOMIC VALUE OF WI-FI IN ECONOMIC COMMUNITY OF CENTRAL AFRICAN STATES (ECCAS)

Having estimated Wi-Fi's economic value for three ECCAS countries (DRC, Cameroon, Gabon), we can generate a high-level estimation of the economic value for the remaining countries of that economic area.[132] To do so, we rely on the leading indicators methodology, selecting indicators existing for the reviewed countries and the rest of the block, and relying on these indicators to interpolate the economic value of Wi-Fi for the rest of the ECCAS region. The two leading indicators selected are:

- Total GDP: The underlying assumption is that there is a direct link between the level of development of a given country and the economic value of Wi-Fi; and
- Human Development Index (constructed by the United Nations Development Program): This indicator introduces a variable that controls for a country's level of urbanization, literacy, and other social factors.

As the Table XXIV-1 indicates, the three countries under study represent 49% percent of ECCAS's GDP.

Table XXIV-1. ECCAS: Distribution of GDP (2020)

Groups	GDP ($billion)	Percent
Countries studied (DRC, Cameroon, Gabon)	$103.7	48.7%
Rest of ECCAS	$109.1	51.3%
Total ECCAS	$212.8	100.0%

Source: World Bank – World Development Indicators

Based on the initial assumption of a correlation between GDP and economic value, we then calculate a first estimate. We then discount these results by the level of development measured by the UN Human Development Index (HDI). The average ECCAS HDI, normalized by population, is 0.504, while the average for the countries under study is 0.502, and 0.507 for the remaining countries of the region (see Table XXIV-2).

Table XXIV-2. Human Development Index (2019): Countries studied vs Rest of ECCAS

Groups	HDI
Countries studied (DRC, Cameroon, Gabon)	0.502
Rest of ECCAS	0.507
Total ECCAS	0.504

Sources: United Nations; Telecom Advisory Services analysis

These values are then used to discount the original GDP-based economic value estimates for the "rest of ECCAS." The discount factor is calculated by dividing the "rest of ECCAS" HDI (0.507) by the countries under study HDI (0.502). This allows a

[132] The Rest of ECCAS sample is composed by Angola, Burundi, Central African Republic, Chad, Congo, Equatorial Guinea, Rwanda, Sao Tome and Principe.

calculation for the economic value of Wi-Fi for the "rest of ECCAS." Adding this to the countries under study, we estimate the economic value for the whole region under the baseline scenario (see Table XXIV-3).

Table XXIV-3. ECCAS Wi-Fi Economic Value - Baseline scenario (in $Billions)

Countries	2021				2025			
	Consumer surplus	Producer surplus	GDP Contribution	Total	Consumer surplus	Producer surplus	GDP Contribution	Total
Countries studied	$0.9	$0.9	$0.5	$2.3	$2.1	$1.3	$1.4	$4.8
Rest of ECCAS	$0.9	$1.0	$0.5	$2.4	$2.2	$1.4	$1.5	$5.1
Total ECCAS	$1.8	$1.9	$0.9	$4.7	$4.3	$2.7	$2.9	$10.0

Source: Telecom Advisory Services

By considering specifically the economic value added by Wi-Fi 6 and the allocation of the 6 GHz band, we follow a similar approach to estimate the figures for the rest of ECCAS and the whole region (see Table XXIV-4).

Table XXIV-4. ECCAS Wi-Fi Economic Value – Only 6 GHz (in $Billions)

Countries	2021				2025			
	Consumer surplus	Producer surplus	GDP Contribution	Total	Consumer surplus	Producer surplus	GDP Contribution	Total
Countries studied	$0.0	$0.0	$0.0	$0.0	$0.5	$0.0	$0.1	$0.7
Rest of ECCAS	$0.0	$0.0	$0.0	$0.0	$0.6	$0.0	$0.1	$0.7
Total ECCAS	$0.0	$0.0	$0.0	$0.0	$1.1	$0.0	$0.3	$1.4

Source: Telecom Advisory Services

Finally, to calculate the total economic value of Wi-Fi (from current bands and 6 GHz allocation), we follow a similar approach (see Table XXIV-5).

Table XXIV-5. ECCAS Wi-Fi Economic Value – Total (in $Billions)

Countries	2021				2025			
	Consumer surplus	Producer surplus	GDP Contribution	Total	Consumer surplus	Producer surplus	GDP Contribution	Total
Countries studied	$0.9	$0.9	$0.5	$2.3	$2.6	$1.3	$1.6	$5.5
Rest of ECCAS	$0.9	$1.0	$0.5	$2.4	$2.8	$1.4	$1.7	$5.9
Total ECCAS	$1.8	$1.9	$1.0	$4.7	$5.4	$2.8	$3.2	$11.4

Source: Telecom Advisory Services

XXV. ECONOMIC VALUE OF WI-FI IN NIGERIA

In recent years, Wi-Fi has become a pervasive feature in Nigeria's telecommunications landscape. Interpolating the data provided for Middle East and Africa by Cisco's Annual Internet Report Highlights Tool 2018-2023, we estimate there are currently 352,000 public Wi-Fi access points in Nigeria,[133] while according to Wiman (2021) there are over 39,200 free Wi-Fi sites, mostly concentrated in the cities of Lagos; Abuja; Port Hartcourt; Kano; Ibadan and Benin City.[134]

The baseline (2.4 and 5 GHz Wi-Fi) economic value of Wi-Fi in Nigeria in 2021 is estimated at $15.9 billion. The 2025 forecast of economic value will reach $29.8 billion, without considering the accelerating effect of Wi-Fi 6 and 6 GHz band allocation. These estimates do not consider the additional effect of Wi-Fi 6 and allocation of the 6 GHz spectrum band for unlicensed use.

The African Telecommunications Union (ATU) Emerging Technologies Task Group has formulated its recommendation on license-exempt access to the lower part of the 6 GHz band (5925-6425 MHz). The possibility of allowing unlicensed devices to operate in the 6 GHz band spurs the economic value of Wi-Fi, as the capacity available for this technology increases considerably.

Adding to the baseline scenario, the allocation of the 6 GHz spectrum band for unlicensed use and the deployment of Wi-Fi 6 and Wi-Fi 6E devices will trigger an increase of economic value, reaching $3.3 billion in 2025. Considering that we forecast that by 2025 only 40 percent of Wi-Fi traffic will rely on 6 GHz channels, the accelerated effect derived from the new spectrum allocation and latest Wi-Fi technologies will continue to grow and still be far from reaching its maximum potential at this time. By combining the baseline and the Wi-Fi 6 and 6 GHz scenarios, the overall economic value of Wi-Fi for Nigeria will yield $33.1 billion in 2025 (see Table XXV-1).

Table XXV-1. Nigeria: Total economic value of Wi-Fi (in $Billions)

	2021	2022	2023	2024	2025
Baseline Scenario	$15.9	$17.6	$22.5	$24.3	$29.8
Wi-Fi 6 / 6 GHz Scenario	$0.2	$0.6	$1.3	$2.4	$3.3
Total	$16.1	$18.2	$23.8	$26.7	$33.1

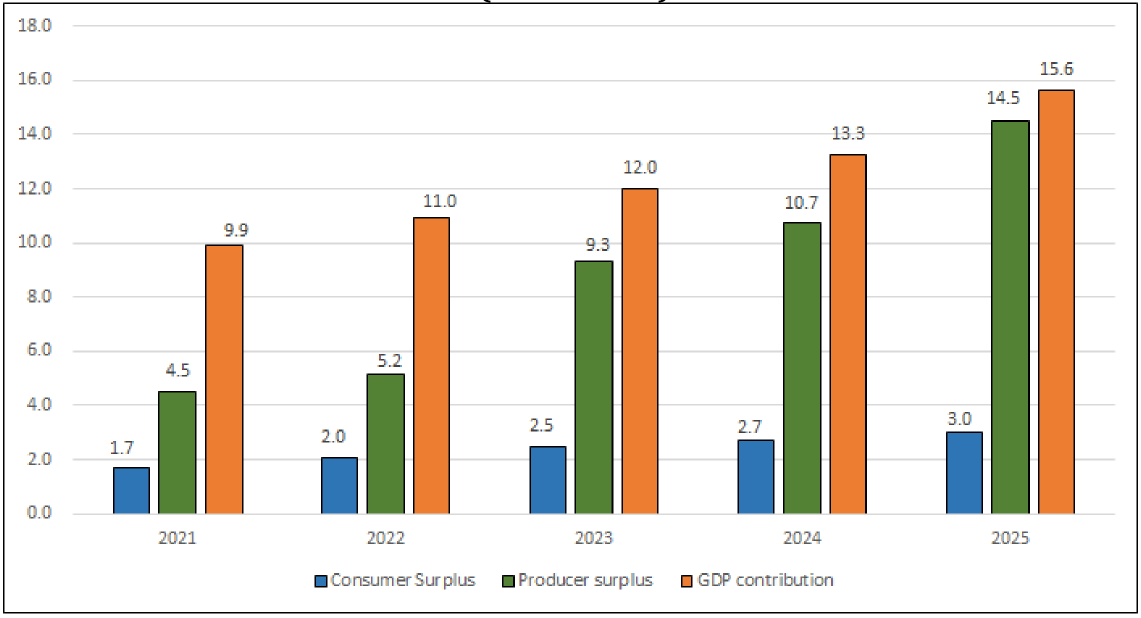
Source: Telecom Advisory Services analysis

The primary source of economic value is GDP contribution due to the relevance of free Wi-Fi to reduce the digital divide in Nigeria. A national survey indicates that in Nigeria, 6.2% of the population (11,500,000) use public Wi-Fi at least once a month.[135] We forecast an additional growth in the economic value to come from producer surplus, as the main savings due to cellular off-loading will be concentrated at the end of the forecast period when 5G deployment will start

[133] Cisco includes within this category, free hotspots, homespots, and paid hotspots, for the region of Middle East and Africa. Values for Nigeria were estimated by considering the country weight in the region's M2M adoption. The report provides values for 2018 and 2023, which allows for interpolating 2021 estimates.
[134] Retrieved in: https://www.wiman.me/nigeria (June 8, 2021).
[135] RIA After Access survey data, 2017-2018

(according to GSMA coverage forecasts). Consumer surplus will also have a small growth through the period, mainly driven by household's savings due to Internet access for home usage of devices that lack a wired port and in the avoidance of investment in in-house wiring (see Graphic XXV-1).

Graphic XXV-1. Nigeria: Total economic value of Wi-Fi (by source) (in $Billions)



Note: Due to rounding, numbers presented in this graphic may not add up precisely to the totals above.
Source: Telecom Advisory Services LLC

The total economic value of Wi-Fi benefits five economic agents, of which enterprise Wi-Fi and free Wi-Fi are the most important (see Table XXV-2).

Table XXV-2. Nigeria: Total Economic Value of Wi-Fi (by agent) (in $Billions)

	2021	2022	2023	2024	2025
Free Wi-Fi	$5.6	$6.5	$7.5	$8.5	$9.6
Residential Wi-Fi	$1.7	$2.1	$2.7	$3.2	$3.7
Enterprise Wi-Fi	$8.2	$8.8	$9.3	$10.2	$12.1
Internet Service Providers	$0.1	$0.1	$3.4	$3.7	$6.4
Wi-Fi ecosystem	$0.5	$0.6	$0.8	$1.1	$1.4
Total	$16.1	$18.2	$23.8	$26.7	$33.1

Source: Telecom Advisory Services analysis

In 2025, we forecast that the main sources of economic value will remain enterprise Wi-Fi (the most important factors driving the value of Wi-Fi among enterprises are the spillover of IoT applications, followed by the savings in wireless telecommunications) and free Wi-Fi (due to the importance of free Wi-Fi in public sites to close the digital divide).

Driven by its contribution to GDP, Wi-Fi will generate approximately 107,800 jobs in Nigeria in 2021, primarily in the communications s (69,300), and trade (33,100) sectors. In 2025, Wi-Fi induced job creation will result in 169,800 new jobs.

XXVI. ECONOMIC VALUE OF WI-FI IN SENEGAL

In recent years, Wi-Fi has become a pervasive feature in Senegal's telecommunications landscape. Interpolating the data provided for Middle East and Africa by Cisco's Annual Internet Report Highlights Tool 2018-2023, we estimate there are currently 25,000 public Wi-Fi access points in Senegal.[136] This is fairly consistent with Wiman's estimate of 28,000 free sites (of which, 23,000 are located in Dakar).

Before even considering the additional effect of Wi-Fi 6 and allocation of the 6 GHz spectrum band for unlicensed use, the baseline (2.4 and 5 GHz Wi-Fi) economic value of Wi-Fi in Senegal in 2021 is estimated at $1.2 billion, while the 2025 forecast will reach $2.8 billion.

The African Telecommunications Union (ATU) Emerging Technologies Task Group has formulated its recommendation on license-exempt access to the lower part of the 6 GHz band (5925-6425 MHz). The possibility of allowing unlicensed devices to operate in the 6 GHz band spurs the economic value of Wi-Fi, as the capacity available for this technology increases considerably.

Adding to the baseline scenario, the allocation of the 6 GHz spectrum band for unlicensed use and the deployment of Wi-Fi 6 and Wi-Fi 6E devices will trigger an additional growth of economic value, reaching $70 million in 2025. Considering that we forecast that by 2025 only 40 percent of Wi-Fi traffic will rely on 6 GHz channels, the accelerated effect derived from the new spectrum allocation and latest Wi-Fi technologies will continue to grow and still be far from reaching its maximum potential at this time. By combining the baseline and the Wi-Fi 6 and 6 GHz scenarios, the overall economic value of Wi-Fi for Senegal will yield $2.8 billion in 2025 (see Table XXVI-1).

Table XXVI-1. Senegal: Total economic value of Wi-Fi (in $Billions)

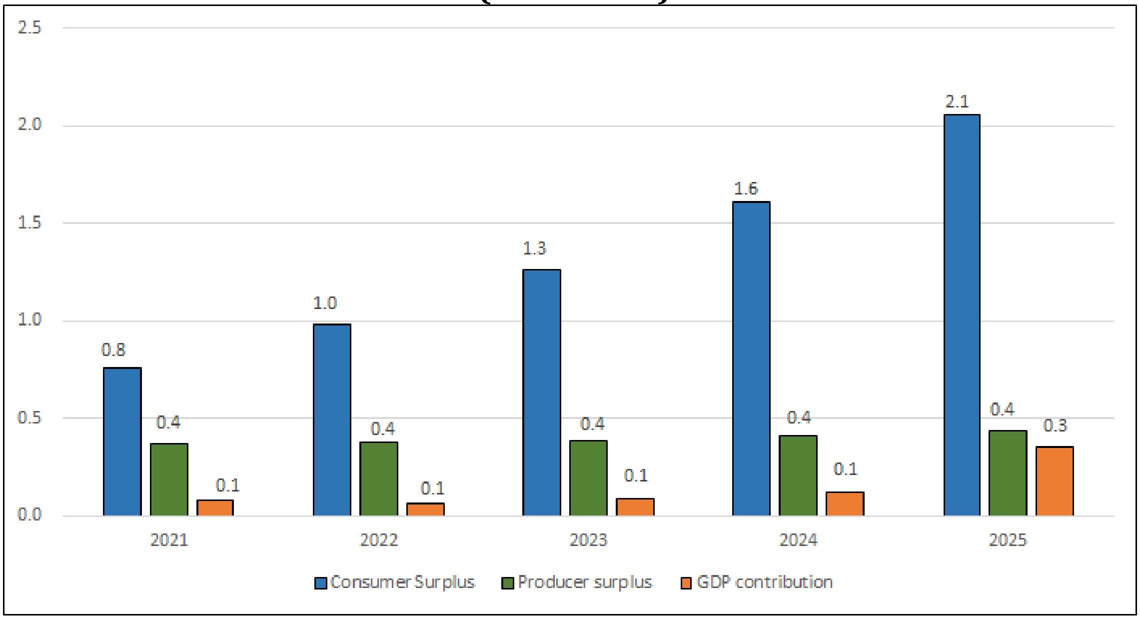
	2021	2022	2023	2024	2025
Baseline Scenario	$1.2	$1.4	$1.7	$2.1	$2.8
Wi-Fi 6 / 6 GHz Scenario	$0.0	$0.0	$0.0	$0.0	$0.1
Total	$1.2	$1.4	$1.7	$2.1	$2.8

Source: Telecom Advisory Services analysis

The primary source of economic value is consumer surplus. This surplus is driven by the savings associated to Internet access for home usage of devices that lack a wired port (see Graphic XXVI-1).

136 Cisco includes within this category, free hotspots, homespots, and paid hotspots, for the region of Middle East and Africa. Values for Senegal were estimated by considering the country weight in the region's GDP. The report provides values for 2018 and 2023, which allows for interpolating 2021 estimates.

Graphic XXVI-1. Senegal: Total economic value of Wi-Fi (by source) (in $Billions)



Note: Due to rounding, numbers presented in this graphic may not add up precisely to the totals above.
Source: Telecom Advisory Services LLC

The total economic value of Wi-Fi benefits five economic agents, of which residential Wi-Fi is currently the most important (see Table XXVI-2).

Table XXVI-2. Senegal: Total Economic Value of Wi-Fi (by agent) (in $Billions)

	2021	2022	2023	2024	2025
Free Wi-Fi	$0.0	$0.0	$0.0	$0.0	$0.1
Residential Wi-Fi	$0.7	$1.0	$1.2	$1.6	$2.0
Enterprise Wi-Fi	$0.4	$0.4	$0.4	$0.5	$0.7
Internet Service Providers	$0.0	$0.0	$0.0	$0.0	$0.0
Wi-Fi ecosystem	$0.0	$0.0	$0.0	$0.0	$0.0
Total	$1.2	$1.4	$1.7	$2.1	$2.8

Source: Telecom Advisory Services analysis

The economic value of consumer use of residential Wi-Fi will continue to be the largest source of economic value by 2025, followed by enterprises. In that respect, the main gains for consumers will come from the savings incurred due to Internet access for home usage of devices that lack a wired port. The most important factor driving the value of Wi-Fi among enterprises is savings in wiring establishments, followed by the spillovers generated by the return to speed effect.

Based on its contribution to GDP, Wi-Fi will generate approximately 900 jobs in Senegal in 2021, primarily in the communications sector (600), and trade sector (300). In 2025, Wi-Fi induced job creation will increase to 3,800 jobs.

XXVII. ECONOMIC VALUE OF WI-FI IN THE ECONOMIC COMMUNITY OF WEST AFRICAN STATES (ECOWAS)

Having estimated Wi-Fi's economic value for two ECOWAS countries (Nigeria and Senegal), we can generate a high-level estimation of the economic value for the remaining countries of that economic area.[137] To do so, we rely on the leading indicators methodology, selecting indicators for the two reviewed countries and the rest of the block, and relying on these indicators to interpolate the economic value of Wi-Fi for the rest of the ECOWAS region. The two leading indicators selected are:

- Total GDP: The underlying assumption is that there is a direct link between the level of development of a given country and the economic value of Wi-Fi; and
- Human Development Index (constructed by the United Nations Development Program): This indicator introduces a variable that controls for a country's level of urbanization, literacy, and other social factors.

As the table XXVII-1 indicates, the five countries under study represent 67% percent of ECOWAS's GDP.

Table XXVII-1. ECOWAS: Distribution of GDP (2020)

Groups	GDP ($billion)	Percent
Countries studied (Nigeria, Senegal)	$453.9	66.5%
Rest of ECOWAS	$228.2	33.5%
Total ECOWAS	$682.0	100.0%

Source: World Bank – World Development Indicators

Based on the initial assumption of a correlation between GDP and economic value, we then calculate a first estimate. This estimate is then discounted by the level of development measured by the UN Human Development Index (HDI). The average ECOWAS HDI, normalized by population, is 0.519 while the average for the two countries under study is 0.537, and 0.497 for the remaining countries of the region (see Table XXVII-2).

Table XXVII-2. Human Development Index (2019): Countries studied vs. Rest of ECOWAS

Groups	HDI
Countries studied (Nigeria, Senegal)	0.537
Rest of ECOWAS	0.497
Total ECOWAS	0.519

Sources: United Nations; Telecom Advisory Services analysis

These values are then used to discount the original GDP-based economic value estimates for the "rest of ECOWAS." The discount factor is calculated by dividing the "rest of ECOWAS" HDI (0.497) by the countries under study HDI (0.537). This yields the estimate of economic value of Wi-Fi for the "rest of ECOWAS." Adding this to the

[137] The Rest of ECOWAS sample is composed by Benin, Burkina Faso, Cabo Verde, Côte d'Ivoire, Gambia, Ghana, Guinea, Guinea-Bissau, Liberia, Mali, Niger, Sierra Leone, and Togo.

countries under study, we estimate the economic value for the whole region under the baseline scenario (see Table XXVII-3).

Table XXVII-3. ECOWAS Wi-Fi Economic Value - Baseline scenario (in $Billions)

Countries	2021				2025			
	Consumer surplus	Producer surplus	GDP Contribution	Total	Consumer surplus	Producer surplus	GDP Contribution	Total
Countries studied	$2.4	$4.7	$10.0	$17.1	$4.5	$14.3	$13.8	$32.6
Rest of ECOWAS	$1.1	$2.2	$4.6	$8.0	$2.1	$6.7	$6.4	$15.2
Total ECOWAS	$3.6	$6.9	$14.6	$25.1	$6.6	$21.0	$20.2	$47.7

Source: Telecom Advisory Services

By considering specifically the economic value added by Wi-Fi 6 and the allocation of the 6 GHz band, we follow a similar approach to estimate the corresponding value for the rest of ECOWAS and the whole region (see Table XXVII-4).

Table XXVII-4. ECOWAS Wi-Fi Economic Value – Only 6 GHz (in $Billions)

Countries	2021				2025			
	Consumer surplus	Producer surplus	GDP Contribution	Total	Consumer surplus	Producer surplus	GDP Contribution	Total
Countries studied	$0.0	$0.1	$0.0	$0.2	$0.6	$0.7	$2.2	$3.4
Rest of ECOWAS	$0.0	$0.1	$0.0	$0.1	$0.3	$0.3	$1.0	$1.6
Total ECOWAS	$0.0	$0.2	$0.0	$0.3	$0.8	$1.0	$3.2	$5.0

Source: Telecom Advisory Services

Finally, to calculate the total economic value of Wi-Fi (from current bands and 6 GHz allocation), we follow a similar approach (see Table XXVII-5).

Table XXVII-5. ECOWAS Wi-Fi Economic Value – Total (in $Billions)

Countries	2021				2025			
	Consumer surplus	Producer surplus	GDP Contribution	Total	Consumer surplus	Producer surplus	GDP Contribution	Total
Countries studied	$2.5	$4.9	$10.0	$17.3	$5.1	$15.0	$16.0	$36.0
Rest of ECOWAS	$1.1	$2.3	$4.7	$8.1	$2.4	$7.0	$7.4	$16.7
Total ECOWAS	$3.6	$7.1	$14.6	$25.4	$7.4	$21.9	$23.4	$52.7

Source: Telecom Advisory Services

XXVIII. ECONOMIC VALUE OF WI-FI IN KENYA

In recent years, Wi-Fi has become a pervasive feature in Kenya's telecommunications landscape. According to Wiman (2021) there are over 39,000 free Wi-Fi sites in the main cities of the country (distributed across Nairobi: 31,000; Mombasa: 3,000; Nakuru: 2,000; Eldoret: 1,000; Kisumu: 1,000, and Thika: 1,000).[138]

Kenya has so far allocated two license-exempt frequency bands for Wi-Fi use. The 2400-2483.5 MHz band has been historically assigned to be used by fixed wireless access systems.[139] In addition, following the decisions of the World Radio Conference-19 in November 2019, the Communications Authority of Kenya voted to enable both indoor and outdoor usage of Wi-Fi in order to meet the growth in demand for wireless access systems, including Radio Local Areas Networks (RLANs) for end-user radio connections, while limiting their interference into existing satellite services. In the band between 5150 and 5250 MHz, Wi-Fi networks were allowed indoor or outdoor usage with a maximum EIRP of 30 dBm (1W), while Wi-Fi devices would be restricted to a maximum transmitter power of 250 mW in the band between 5470 and 5725 MHz.[140]

Before even considering the additional effect of Wi-Fi 6 and allocation of the 6 GHz spectrum band for unlicensed use, the baseline (2.4 and 5 GHz Wi-Fi) economic value of Wi-Fi in Kenya in 2021 is estimated at $12.2 billion. The 2025 forecast of economic value will reach $15.3 billion, without considering the accelerating effect of Wi-Fi 6 and 6 GHz band allocation.

Following the recommendation formulated by the African Telecommunications Union (ATU) Emerging Technologies Task Group, the Communications Authority of Kenya is considering the extension of license-exempt access for Wi-Fi to the lower part of the 6 GHz band (5925-6415 MHz).[141] This potential decision reflects the growing importance that Wi-Fi technology in the fixed wireless eco-system in the country. It raises the need to evaluate the impact of such a move in terms of its contribution to economic growth, enterprise surplus, and consumer welfare. The possibility of allowing unlicensed devices to operate in the 6 GHz band spurs the economic value of Wi-Fi, as the capacity available for this technology increases considerably.

Adding to the baseline scenario, the allocation of the 6 GHz spectrum band for unlicensed use and the deployment of Wi-Fi 6 and Wi-Fi 6E devices will trigger an additional growth of economic value, reaching $967 million in 2025. Considering that we forecast that by 2025 only 40 percent of Wi-Fi traffic will rely on 6 GHz channels, the accelerated effect derived from the new spectrum allocation and latest

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[138] Retrieved in: https://www.wiman.me/kenya (June 8, 2021).

[139] Communications Authority of Kenya (2016). *Kenya table of radiofrequency allocations*.

[140] Communications Authority of Kenya (2020). *Frequency Spectrum Management Report 2nd Quarter 2019/20* (October-December 29019), p. 2.

[141] ATU Work on Spectrum Recommendations to Promote Innovative Wi-Fi/WiGig Connectivity Solutions in Africa, retrieved in: https://www.atuuat.africa/2020/12/29/atu-work-on-spectrum-recommendations-to-promote-innovative-wi-fi-wigig-connectivity-solutions-in-africa/

Wi-Fi technologies will continue to grow and still be far from reaching its maximum potential at this time. By combining the baseline and the Wi-Fi 6 and 6 GHz scenarios, the overall economic value of Wi-Fi for Kenya will yield $16.3 billion in 2025 (see Table XXVIII-1).

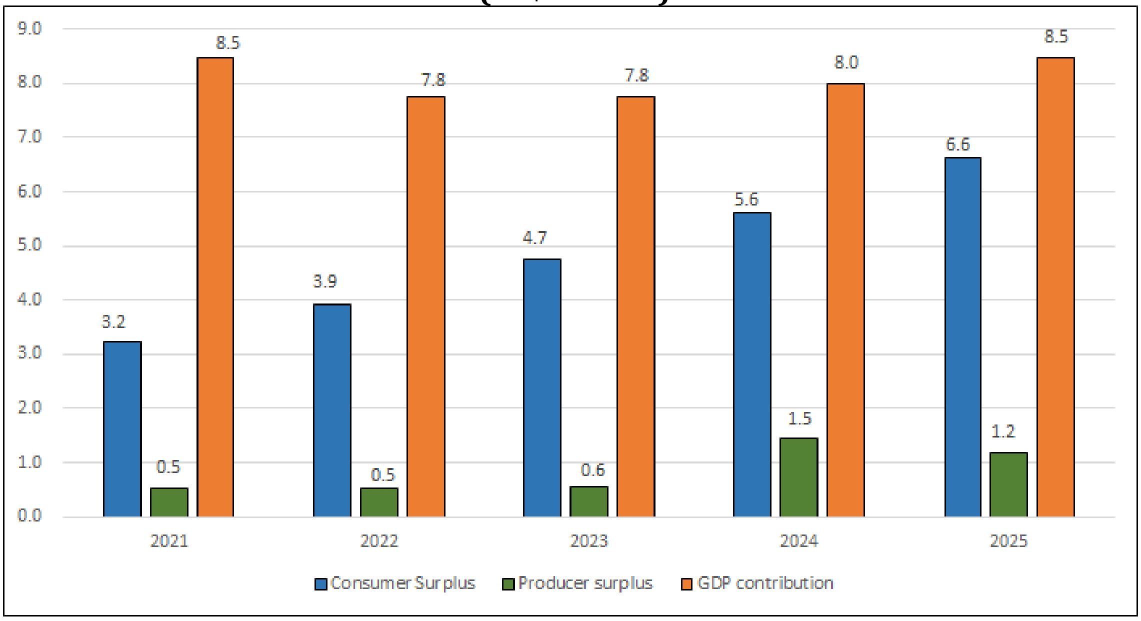
Table XXVIII-1. Kenya: Total economic value of Wi-Fi (in $Billions)

	2021	2022	2023	2024	2025
Baseline Scenario	$12.2	$12.0	$12.6	$14.4	$15.3
Wi-Fi 6 / 6 GHz Scenario	$0.0	$0.2	$0.4	$0.7	$1.0
Total	$12.2	$12.2	$13.0	$15.1	$16.3

Source: Telecom Advisory Services analysis

The primary source of economic value is impact on the GDP contribution due to the relevance of free Wi-Fi to reduce the digital divide in the country. A national survey indicates that in Kenya, 7.6% of the population use public Wi-Fi once an hour or more; 12.9% once a day or more and 5.7% at least once a month.[142]. Consumer surplus will grow through the period, mainly driven by household savings due to Internet access for home usage of devices that lack a wired port and through the avoidance of investment in in-house wiring. We also forecast a growth in the economic value to be derived from producer surplus, since the main savings due to cellular off-loading will be concentrated at the end of the period when 5G deployments will accelerate (according to GSMA coverage forecasts) (see Graphic XXVIII-1).

Graphic XXVIII-1. Kenya: Total economic value of Wi-Fi (by source) (in $Billions)



Note: Due to rounding, numbers presented in this graphic may not add up precisely to the totals above.
Source: Telecom Advisory Services LLC

The total economic value of Wi-Fi benefits five economic agents, of which free Wi-Fi and residential Wi-Fi (due to the importance of WISP to close the digital divide) are the most important (see Table XXVIII-2).

[142] RIA After Access survey data, 2017-2018

Table XXVIII-2. Kenya: Total Economic Value of Wi-Fi (by agent) (in $Billions)

	2021	2022	2023	2024	2025
Free Wi-Fi	$5.9	$5.3	$4.9	$4.8	$4.9
Residential Wi-Fi	$5.2	$6.1	$7.1	$8.3	$9.6
Enterprise Wi-Fi	$1.0	$0.7	$0.8	$0.8	$1.0
Internet Service Providers	$0.1	$0.1	$0.1	$1.0	$0.6
Wi-Fi ecosystem	$0.1	$0.1	$0.1	$0.1	$0.1
Total	$12.2	$12.2	$13.0	$15.1	$16.3

Source: Telecom Advisory Services analysis

Enterprises follow in terms of economic value. The most important factor driving the value of Wi-Fi among enterprises is the economic spillover of IoT applications, followed by the savings in wireless telecommunications.

According to its contribution to GDP, Wi-Fi will generate approximately 92,200 jobs in Kenya in 2021, primarily in the communications (59,300), and trade (28,300) sectors. In 2025, Wi-Fi will generate 92,000 jobs.

XXIX. ECONOMIC VALUE OF WI-FI IN UGANDA

Wi-Fi is increasingly becoming a key technology in the Ugandan telecommunications industry. By interpolating the data provided for Middle East and Africa by Cisco's Annual Internet Report Highlights Tool 2018-2023, we estimate there are currently over 37,000 public Wi-Fi access points in Uganda.[143] According to Wiman (2021) there are 12,000 free Wi-Fi sites, mostly concentrated in Kampala (11,000).[144]

Before even considering the additional effect of Wi-Fi 6 and allocation of the 6 GHz spectrum band for unlicensed use, the baseline (2.4 and 5 GHz Wi-Fi) economic value of Wi-Fi in Uganda in 2021 is estimated at $1.4 billion. The 2025 forecast of economic value will reach $4 billion, without considering the accelerating effect of Wi-Fi 6 and 6 GHz band allocation.

The African Telecommunications Union (ATU) Emerging Technologies Task Group has formulated its recommendation on license-exempt access to the lower part of the 6 GHz band (5925-6425 MHz). Assuming that African administrations validate the recommendations, then the position of Uganda will be like the one adopted by the European Union. The possibility of allowing unlicensed devices to operate in the 6 GHz band will accelerate the economic contribution of Wi-Fi, as the capacity available for this technology increases considerably.

Adding to the baseline scenario, the allocation of the 6 GHz spectrum band for unlicensed use and the deployment of Wi-Fi 6 and Wi-Fi 6E devices will trigger an additional growth of economic value, reaching $250 million in 2025. Considering that we forecast that by 2025 only 40 percent of Wi-Fi traffic will rely on 6 GHz channels, the accelerated effect derived from the new spectrum allocation and latest Wi-Fi technologies will continue to grow and still be far from reaching its maximum potential at this time. By combining the baseline and the Wi-Fi 6 and 6 GHz scenarios, the overall economic value of Wi-Fi for Uganda will yield $4.2 billion in 2025 (see Table XXIX-1).

Table XXIX-1. Uganda: Total economic value of Wi-Fi (in $Billions)

	2021	2022	2023	2024	2025
Baseline Scenario	$1.4	$1.7	$2.0	$3.4	$4.0
Wi-Fi 6 / 6 GHz Scenario	$0.0	$0.1	$0.1	$0.2	$0.2
Total	$1.4	$1.8	$2.1	$3.6	$4.2

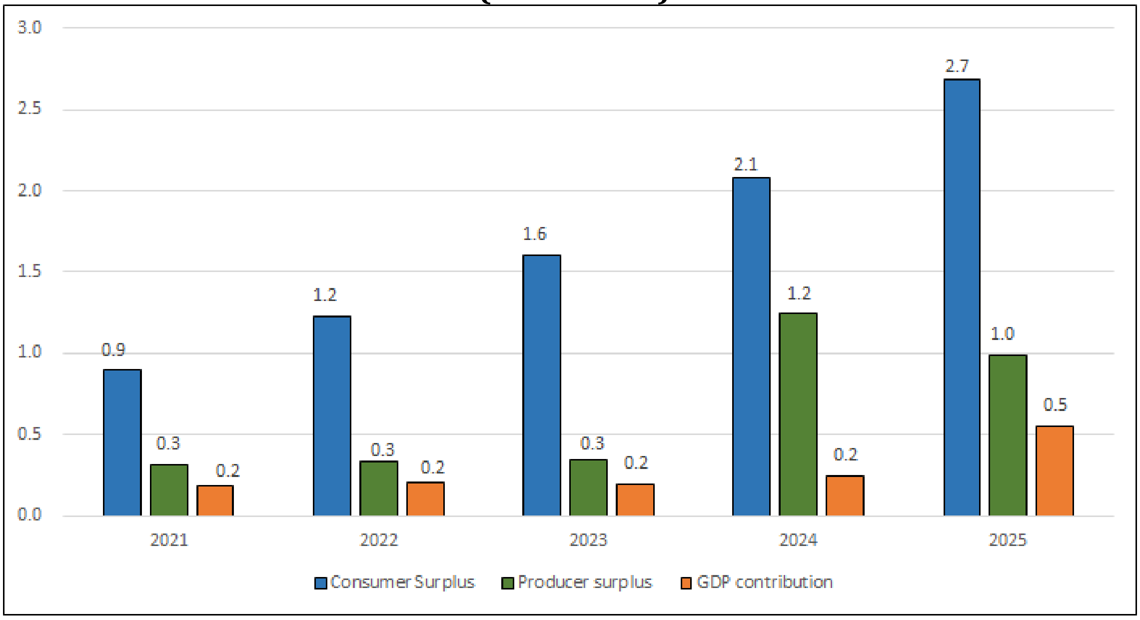
Source: Telecom Advisory Services analysis

The primary source of economic value is currently consumer surplus. This surplus is driven by the savings enjoyed by residential users who avoid the deployment of inside wiring (Graphic XXIX-1).

143 Cisco includes within this category, free hotspots, home-spots, and paid hotspots, for the region of Middle East and Africa. Values for Uganda were estimated by considering the country weight in the region's GDP. The report provides values for 2018 and 2023, which allows for interpolating 2021 estimates.

144 Retrieved in: https://www.wiman.me/uganda (June 25, 2021).

Graphic XXIX-1. Uganda: Total economic value of Wi-Fi (by source) (in $Billions)



Note: Due to rounding, numbers presented in this graphic may not add up precisely to the totals above.
Source: Telecom Advisory Services LLC

The total economic value of Wi-Fi benefits five economic agents, of which residential Wi-Fi is currently the most important (see Table XXIX-2).

Table XXIX-2. Uganda: Total Economic Value of Wi-Fi (by agent) (in $Billions)

	2021	2022	2023	2024	2025
Free Wi-Fi	$0.0	$0.1	$0.1	$0.2	$0.2
Residential Wi-Fi	$0.9	$1.2	$1.5	$1.9	$2.5
Enterprise Wi-Fi	$0.5	$0.5	$0.5	$0.5	$0.9
Internet Service Providers	$0.0	$0.0	$0.0	$0.9	$0.6
Wi-Fi ecosystem	$0.0	$0.0	$0.0	$0.0	$0.0
Total	$1.4	$1.8	$2.1	$3.6	$4.2

Source: Telecom Advisory Services analysis

The economic value of consumer use of residential Wi-Fi will continue to be the largest source of economic value by 2025, followed by enterprises. In that respect, the main gains for consumers will continue to be the savings incurred due to the avoidance of investment in inside wiring. The most important factor driving the value of Wi-Fi among enterprises is the economic efficiencies generated due to faster Internet speeds.

According to its contribution to GDP, Wi-Fi will generate approximately 2,000 jobs in Uganda in 2021, primarily in the communications (1,300), and trade (600) sectors. In 2025, Wi-Fi will generate 6,000 jobs.

XXX. ECONOMIC VALUE OF WI-FI IN EAST AFRICAN COMMUNITY (EAC)

Having estimated Wi-Fi's economic value for two EAC countries (Kenya and Uganda), we can generate a high-level estimation of the economic value for the remaining countries of that economic area.[145] To do so, we relied on the leading variables methodology, selecting indicators the two reviewed countries and the rest of the block, and relying on these indicators to interpolate the economic value of Wi-Fi for the rest of the EAC region. The two leading indicators selected are:

- Total GDP: The underlying assumption is that there is a direct link between the level of development of a given country and the economic value of Wi-Fi; and
- Human Development Index (constructed by the United Nations Development Program): This indicator introduces a variable that controls for a country's level of urbanization, literacy, and other social factors.

As the Table XXX-1 indicates, the countries under study represent 63% percent of EAC's GDP.

Table XXX-1. EAC: Distribution of GDP (2020)

Groups	GDP ($billion)	Percent
Countries studied (Kenya, Uganda)	$136.9	62.9%
Rest of EAC	$80.7	37.1%
Total EAC	$217.6	100.0%

Source: World Bank – World Development Indicators

Based on the initial assumption of a correlation between GDP and economic value, we then calculate a first estimate. We then discount this estimate by the level of development measured by the UN Human Development Index (HDI). The average EAC HDI, normalized by population, is 0.539, while the average for the two countries under study is 0.575, and 0.505 for the remaining countries of the region (see Table XXX-2).

Table XXX-2. Human Development Index (2019): Countries studied vs. Rest of EAC

Groups	HDI
Countries studied (Kenya, Uganda)	0.575
Rest of EAC	0.505
Total EAC	0.539

Sources: United Nations; Telecom Advisory Services analysis

These values are then used to discount the original GDP-based economic value estimates for the "rest of EAC." The discount factor is calculated by dividing the "rest of EAC" HDI (0.505) by the countries under study HDI (0.575). This allowed calculating the economic value of Wi-Fi for the "rest of EAC." By adding this value to

[145] The Rest of EAC sample is composed by Burundi, Rwanda, South Sudan, and Tanzania.

the Wi-Fi economic value of the countries under study, we estimated the economic value for the whole region under the baseline scenario (see Table XXX-3).

Table XXX-3. EAC Wi-Fi Economic Value - Baseline scenario (in $Billions)

Countries	2021				2025			
	Consumer surplus	Producer surplus	GDP Contribution	Total	Consumer surplus	Producer surplus	GDP Contribution	Total
Countries studied	$4.1	$0.8	$8.7	$13.6	$9.0	$2.1	$8.2	$19.3
Rest of EAC	$2.1	$0.4	$4.5	$7.0	$4.6	$1.1	$4.3	$10.0
Total EAC	$6.2	$1.2	$13.1	$20.6	$13.6	$3.2	$12.5	$29.2

Source: Telecom Advisory Services

By considering specifically the economic value added by Wi-Fi 6 and the allocation of the 6 GHz band, we follow a similar approach to estimate the same value for the rest of EAC and the whole region (see Table XXX-4).

Table XXX-4. EAC Wi-Fi Economic Value – Only 6 GHz (in $Billions)

Countries	2021				2025			
	Consumer surplus	Producer surplus	GDP Contribution	Total	Consumer surplus	Producer surplus	GDP Contribution	Total
Countries studied	$0.0	$0.0	$0.0	$0.0	$0.3	$0.1	$0.8	$1.2
Rest of EAC	$0.0	$0.0	$0.0	$0.0	$0.2	$0.0	$0.4	$0.6
Total EAC	$0.0	$0.0	$0.0	$0.1	$0.5	$0.1	$1.2	$1.8

Source: Telecom Advisory Services

Finally, to calculate the total economic value of Wi-Fi (from current bands and 6 GHz allocation), we followed the same approach (see Table XXX-5).

Table XXX-5. EAC Wi-Fi Economic Value – Total (in $Billions)

Countries	2021				2025			
	Consumer surplus	Producer surplus	GDP Contribution	Total	Consumer surplus	Producer surplus	GDP Contribution	Total
Countries studied	$4.1	$0.8	$8.7	$13.6	$9.3	$2.2	$9.0	$20.5
Rest of EAC	$2.1	$0.4	$4.5	$7.1	$4.8	$1.1	$4.7	$10.6
Total EAC	$6.3	$1.3	$13.2	$20.7	$14.1	$3.3	$13.7	$31.1

Source: Telecom Advisory Services

XXXI. ECONOMIC VALUE OF WI-FI IN EGYPT

In recent years, Wi-Fi has become a key technology in Egypt's telecommunications landscape. According to Wiman (2021) there are over 470,000 free Wi-Fi sites in the main cities of the country (Cairo: 207,000; Alexandria: 52,000; Giza: 192,000; Suez : 6,000; and Port Said: 8,000).[146] Given the density of Wi-Fi access points, hotspots have become a very important connectivity feature. According to Opensignal,[147] since the outbreak of COVID-19, wireless users in Egypt have spent 61.2 percent of their communications time connected to Wi-Fi networks rather than relying on their cellular data connection. This has increased from 57.5 percent at the beginning of 2020.

Before even considering the additional effect of Wi-Fi 6 and allocation of the 6 GHz spectrum band for unlicensed use, the baseline (2.4 and 5 GHz Wi-Fi) economic value of Wi-Fi in Egypt in 2021 is estimated at $9 billion. The 2025 forecast of economic value will reach $16.3 billion, without considering the accelerating effect of Wi-Fi 6 and 6 GHz band allocation.

In Egypt, the National Telecom Regulatory Authority (NTRA) is reviewing how to employ the 6 GHz band to meet future demand, and enable new, innovative applications. Through a public consultation, the NTRA is exploring the possibility of allowing RLAN operation in the 5925-6425 MHz band indoors. The possibility of allowing unlicensed devices to operate in the 6 GHz band spurs the economic value of Wi-Fi, as the capacity available for this technology increases considerably.

Adding to the baseline scenario, the allocation of the 6 GHz spectrum band for unlicensed use and the deployment of Wi-Fi 6 and Wi-Fi 6E devices will trigger an additional growth of economic value, reaching $889 million in 2025. Considering that by 2025 only 40 percent of Wi-Fi traffic will rely on 6 GHz channels, the accelerated effect derived from the new spectrum allocation and latest Wi-Fi technologies will continue to grow and still be far from reaching its maximum potential at this time. By combining the baseline and the Wi-Fi 6 and 6 GHz scenarios, the overall economic value of Wi-Fi for Egypt is estimated at $17.2 billion for 2025 (see Table XXXI-1).

Table XXXI-1. Egypt: Total economic value of Wi-Fi (in $Billions)

	2021	2022	2023	2024	2025
Baseline Scenario	$9.0	$9.0	$9.6	$10.4	$16.3
Wi-Fi 6 / 6 GHz Scenario	$0.1	$0.3	$0.5	$0.7	$0.9
Total	$9.1	$9.3	$10.1	$11.1	$17.2

Source: Telecom Advisory Services analysis

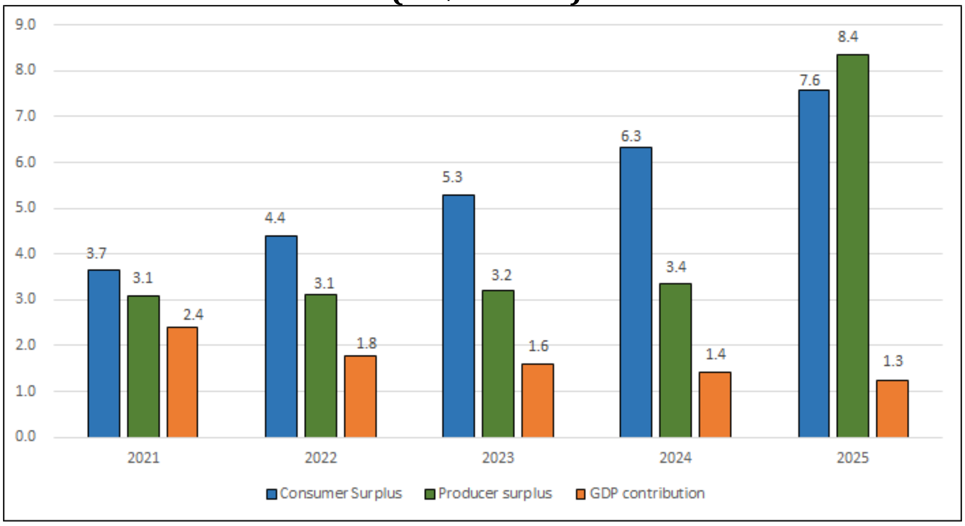
Currently, the primary source of economic value is consumer surplus, although by 2025 we forecast the main economic value to be derived from producer surplus, as

[146] Retrieved in: https://www.wiman.me/egypt (June 4, 2021). Given that Wiman's estimates for Free Wi-Fi are larger than the overall Public Wi-Fi hotspots attributable to Egypt by interpolating the data provided for Middle East and Africa by Cisco, we decided to rely on the former data source as it proved to be more accurate for this country.

[147] Khatri, H. and Fenwick, S. (2020). "Analyzing mobile experience during the coronavirus pandemic: Time on Wi-Fi". *Opensignal* (March 30).

the main savings due to cellular off-loading will be concentrated at the end of the period when 5G deployments will accelerate (according to GSMA coverage forecasts). Consumer surplus will also grow through the period, mainly driven by household savings generated by home usage of devices that lack a wired port, and through the avoidance of investment in in-house wiring. In contrast to other countries in the region, Wi-Fi's GDP contribution is relatively low and declining, given that the economic gains from speed increases will be limited. The country has very few households and enterprises subscribing to fixed broadband lines with speeds above 150 Mbps, which will be those that will benefit the most from the new spectrum allocation (see Graphic XXXI-1).

Graphic XXXI-1. Egypt: Total economic value of Wi-Fi (by source) (in $Billions)



Note: Due to rounding, numbers presented in this graphic may not add up precisely to the totals above.
Source: Telecom Advisory Services LLC

The total economic value of Wi-Fi benefits five economic agents, of which residential Wi-Fi is the most important (see Table XXXI-2).

Table XXXI-2. Egypt: Total Economic Value of Wi-Fi (by agent) (in $Billions)

	2021	2022	2023	2024	2025
Free Wi-Fi	$1.5	$1.3	$1.0	$0.7	$0.3
Residential Wi-Fi	$3.7	$4.4	$5.3	$6.3	$7.6
Enterprise Wi-Fi	$3.1	$2.5	$2.5	$2.6	$2.7
Internet Service Providers	$0.0	$0.1	$0.1	$0.1	$4.8
Wi-Fi ecosystem	$0.8	$1.0	$1.2	$1.4	$1.8
Total	$9.1	$9.3	$10.1	$11.1	$17.2

Source: Telecom Advisory Services analysis

Currently, enterprises follow closely in terms of economic value. The most important factor driving the value of Wi-Fi among enterprises is savings in wireless telecommunications, followed by the spillover of IoT applications.

Driven by its contribution to GDP, Wi-Fi will generate approximately 26,000 jobs in Egypt in 2021. New jobs will be primarily in the communications (16,700), and trade (8,000) sectors. In 2025, Wi-Fi induced job creation will increase to 13,600 jobs.

XXXII. ECONOMIC VALUE OF WI-FI IN JORDAN

In recent years, Wi-Fi has become a key technology in Jordan's telecommunications infrastructure. Interpolating the data provided for Middle East and Africa by Cisco's Annual Internet Report Highlights Tool 2018-2023, we estimate there are currently 46,900 public Wi-Fi access points in Jordan.[148] According to Wiman (2021) there are over 19,700 free Wi-Fi sites, mostly concentrated in the cities of Amman (13,000), Wadi Al Seer (5,000) and Zarqa (1,000).[149]

The baseline economic value of Wi-Fi in Jordan (derived from the use of 2.4 GHz, and 5 GHz Wi-Fi) in 2021 is estimated at $2.2 billion. The 2025 forecast will reach $2.5 billion, without even considering the accelerating effect of Wi-Fi 6 and 6 GHz band allocation.

Jordan intends to make the full 6 GHz band available for Wi-Fi technology (low power indoor devices and very low power devices) as soon as possible to meet the increasing demand for high bandwidth. In a submission to the Arab Spectrum Management Group (ASMG) plenary, Jordan's Telecommunications Regulatory Commission said it will release the technical conditions for such uses in the near future. The decision is based on a survey published by the Commission in December 2020, which showed that the overall opinion in the country was in favor of making the entire 6 GHz band available for Wi-Fi technology. The possibility of allowing unlicensed devices to operate in the 6 GHz band will increase the economic value of Wi-Fi, as the capacity available for this technology increases considerably.

Adding to this baseline scenario, the allocation of the 6 GHz spectrum band for unlicensed use and the deployment of Wi-Fi 6 and Wi-Fi 6E devices will trigger an increase in economic value, reaching $1.5 billion in 2025. Considering that we forecast that by 2025 only 40 percent of Wi-Fi traffic will rely on 6 GHz channels, the accelerated effect derived from the new spectrum allocation and latest Wi-Fi technologies will continue to grow and still be far from reaching its maximum potential at this time. By combining the baseline and the Wi-Fi 6 and 6 GHz scenarios, the overall economic value of Wi-Fi for Jordan will yield $4.1 billion in 2025 (see Table XXXII-1).

Table XXXII-1. Jordan: Total economic value of Wi-Fi (in $Billions)

	2021	2022	2023	2024	2025
Baseline Scenario	$2.2	$2.1	$2.2	$2.2	$2.5
Wi-Fi 6 / 6 GHz Scenario	$0.0	$0.2	$0.4	$0.7	$1.5
Total	$2.2	$2.3	$2.7	$2.8	$4.1

Source: Telecom Advisory Services analysis

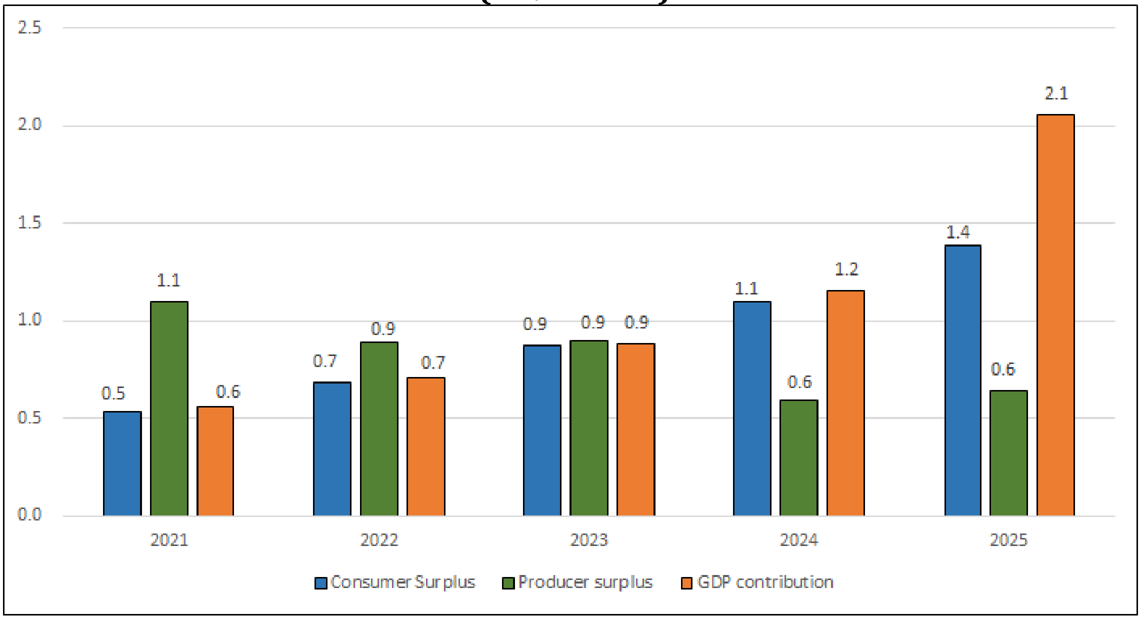
Currently, the primary source of economic value is producer surplus. This surplus is driven by the savings enjoyed by cellular operators who rely on Wi-Fi traffic

[148] Cisco includes within this category, free hotspots, home-spots, and paid hotspots, for the region of Middle East and Africa. Values for Jordan were estimated by considering the country weight in the region's GDP. The report provides values for 2018 and 2023, which allows for interpolating 2021 estimates.

[149] Retrieved in: https://www.wiman.me/jordan (June 4, 2021).

rerouting, and by the savings in enterprise costs. However, we forecast a decreasing trend for producer surplus, as 5G deployment, where CAPEX savings due to offloading will be concentrated, will take place at the beginning of the period. In contrast, we expect an important increase in GDP contribution, mainly driven by the 6 GHz band capability of unlocking massive improvements in Wi-Fi speeds (see Graphic XXXII-1).

Graphic XXXII-1. Jordan: Total economic value of Wi-Fi (by source) (in $Billions)



Note: Due to rounding, numbers presented in this graphic may not add up precisely to the totals above.
Source: Telecom Advisory Services LLC

The total economic value of Wi-Fi benefits five economic agents, of which Internet Service Providers and residential Wi-Fi are currently the most important, followed by enterprises (see Table XXXII-2).

Table XXXII-2. Jordan: Total Economic Value of Wi-Fi (by agent) (in $Billions)

	2021	2022	2023	2024	2025
Free Wi-Fi	$0.2	$0.2	$0.2	$0.1	$0.1
Residential Wi-Fi	$0.7	$0.9	$1.2	$1.6	$2.0
Enterprise Wi-Fi	$0.5	$0.5	$0.6	$0.7	$1.4
Internet Service Providers	$0.7	$0.5	$0.5	$0.3	$0.4
Wi-Fi ecosystem	$0.1	$0.1	$0.2	$0.2	$0.3
Total	$2.2	$2.3	$2.7	$2.8	$4.1

Source: Telecom Advisory Services analysis

In 2025, we forecast that the main sources of economic value will be residential Wi-Fi (due to large savings from home traffic in devices lacking an ethernet port) and enterprises (as the increases in speed due to the allocation of 6 GHz band are expected to have a strong impact in GDP).

Based on its contribution to GDP, Wi-Fi will generate approximately 6,100 jobs in Jordan in 2021, primarily in the communications sector (3,900), and trade sector (1,900). In 2025, Wi-Fi driven job creation will rise to 22,300 jobs.

XXXIII. ECONOMIC VALUE OF WI-FI IN MOROCCO

In recent years, Wi-Fi has become a pervasive feature in Morocco's telecommunications landscape. By interpolating the data provided for Middle East and Africa by Cisco's Annual Internet Report Highlights Tool 2018-2023, we estimate there are currently over 126,000 public Wi-Fi access points in Morocco.[150] According to Wiman (2021) there are over 43,000 free Wi-Fi sites, mostly concentrated in the cities of Rabat (6,000), Casablanca (19,000), Marrakesh (8,000), Fès (2,000), Salé (5,000), and Agadir (3,000).[151]

The possibility of allowing unlicensed devices to operate in the 6 GHz band spurs the economic value of Wi-Fi, as the capacity available for this technology increases considerably. Before even considering the additional effect of Wi-Fi 6 and allocation of the 6 GHz spectrum band for unlicensed use, the baseline economic value of Wi-Fi (which relies only on 2.4 GHz and 5 GHz bands) in 2021 is estimated at $6 billion. The 2025 forecast of economic value will reach $6.2 billion, without considering the accelerating effect of Wi-Fi 6 and 6 GHz band allocation.

In June 2021, The Moroccan National Telecommunications Regulatory Agency (ANRT) announced its decision to amend the current telecommunications framework when it comes to the spectrum in use with low-power short-range devices. Adding to this baseline scenario, the allocation of the 6 GHz spectrum band for unlicensed use and the deployment of Wi-Fi 6 and Wi-Fi 6E devices will trigger an additional growth in economic value, reaching $1.3 billion in 2025. Considering that we forecast that by 2025 only 40 percent of Wi-Fi traffic will rely on 6 GHz channels, the accelerated effect derived from the new spectrum allocation and latest Wi-Fi technologies will continue to grow and still be far from reaching its maximum potential at this time. By combining the baseline and the Wi-Fi 6 and 6 GHz scenarios, the overall economic value of Wi-Fi for Morocco will yield $7.5 billion in 2025 (see Table XXXIII-1).

Table XXXIII-1. Morocco: Total economic value of Wi-Fi (in $Billions)

	2021	2022	2023	2024	2025
Baseline Scenario	$6.0	$6.3	$8.2	$5.6	$6.2
Wi-Fi 6 / 6 GHz Scenario	$0.1	$0.3	$0.6	$0.9	$1.3
Total	$6.1	$6.7	$8.8	$6.5	$7.5

Source: Telecom Advisory Services analysis

Currently, the primary source of economic value is producer surplus. This surplus is mainly driven by the savings enjoyed by cellular operators who rely on Wi-Fi traffic rerouting. The contribution to producer surplus is expected to reach its highest value in 2023, before starting a decreasing trend, as no expansion of 5G coverage is expected between 2023 and 2025. By the end of the period, we expect consumer surplus to become the main source of economic value (see Graphic XXXIII-1).

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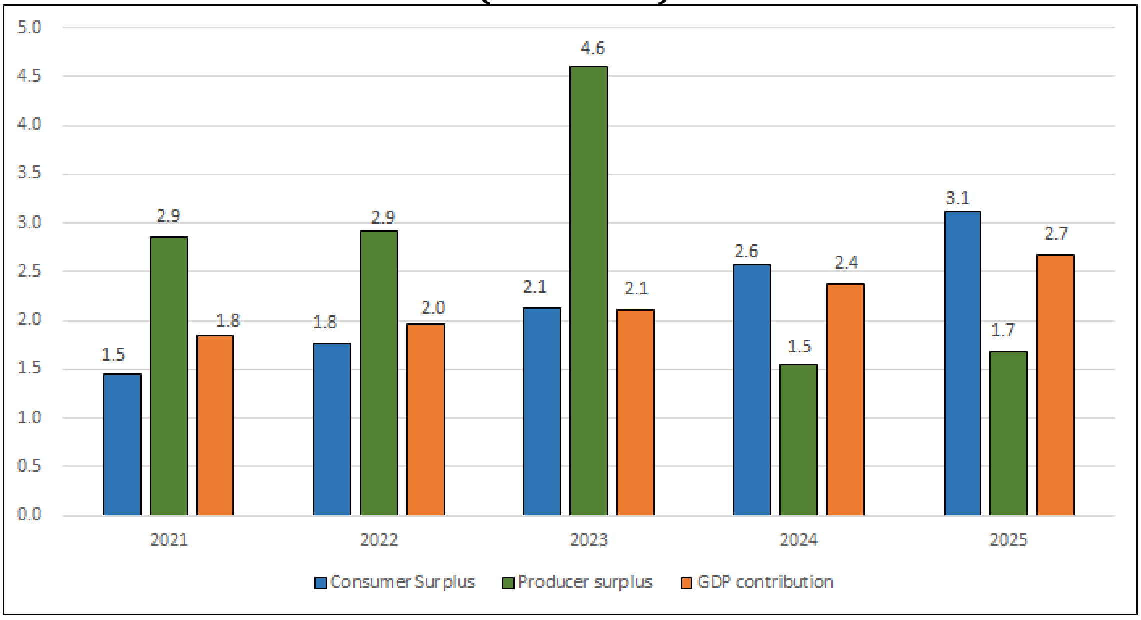
[150] Cisco includes within this category, free hotspots, homespots, and paid hotspots, for the region of Middle East and Africa. Values for Morocco were estimated by considering the country weight in the region's GDP. The report provides values for 2018 and 2023, which allows for interpolating 2021 estimates.

[151] Retrieved in: https://www.wiman.me/morocco (June 4, 2021).

Graphic XXXIII-1. Morocco: Total economic value of Wi-Fi (by source) (in $Billions)



Note: Due to rounding, numbers presented in this graphic may not add up precisely to the totals above.
Source: Telecom Advisory Services LLC

The total economic value of Wi-Fi benefits five economic agents, of which currently ISPs is the most important (see Table XXXIII-2).

Table XXXIII-2. Morocco: Total Economic Value of Wi-Fi (by agent) (in $Billions)

	2021	2022	2023	2024	2025
Free Wi-Fi	$1.6	$1.7	$1.9	$2.1	$2.3
Residential Wi-Fi	$1.4	$1.7	$2.1	$2.5	$3.0
Enterprise Wi-Fi	$1.2	$1.1	$1.1	$1.2	$1.4
Internet Service Providers	$1.7	$1.7	$3.3	$0.1	$0.1
Wi-Fi ecosystem	$0.3	$0.4	$0.5	$0.6	$0.7
Total	$6.1	$6.7	$8.8	$6.5	$7.5

Source: Telecom Advisory Services analysis

By 2025, we expect the biggest economic value to be generated by the consumer use of residential Wi-Fi. In that respect, the main gains for consumers will come from the savings incurred due to Internet access for home usage of devices that lack a wired port, followed by the avoidance of investment in inside wiring. Free Wi-Fi will also constitute an important source of value, given that there is an important part of unconnected households relying in free Wi-Fi hot spots in the country.

According to its contribution to GDP, Wi-Fi will generate approximately 20,000 jobs in Morocco in 2021, primarily in the communications sector (12,800), and trade sector (6,100). In 2025, Wi-Fi will generate 29,100 jobs.

XXXIV. ECONOMIC VALUE OF WI-FI IN OMAN

In recent years, Wi-Fi has become a pervasive feature in Oman's telecommunications landscape. Interpolating the data provided for Middle East and Africa by Cisco's Annual Internet Report Highlights Tool 2018-2023, we estimate there are currently over 65,000 public Wi-Fi access points in Oman.[152] According to Wiman (2021), there are over 52,500 free Wi-Fi sites, mostly concentrated in the cities of Muskat (30,000), Bawshar (19,000), Seeb (6,000), Salalah (8,000), and Sohar (2,000).[153]

Before even considering the additional effect of Wi-Fi 6 and allocation of the 6 GHz spectrum band for unlicensed use, the baseline (2.4 and 5 GHz Wi-Fi) economic value of Wi-Fi in Oman in 2021 is estimated at $2.6 billion. The 2025 forecast of economic value will remain at those levels, without considering the accelerating effect of Wi-Fi 6 and 6 GHz band allocation.

The Telecommunications Regulatory Authority of Oman is running a consultation on making the lower part of the 6 GHz band (5925-6425 MHz) available for Wi-Fi 6E devices on a license-exempt basis, enabling indoor use only. The Authority says the measure "will help to overcome the problems of Internet traffic congestion." The possibility of allowing unlicensed devices to operate in the 6 GHz band will have a positive effect on the economic value of Wi-Fi, as the capacity available for this technology increases considerably.

Adding to this baseline scenario, the allocation of the 6 GHz spectrum band for unlicensed use and the deployment of Wi-Fi 6 and Wi-Fi 6E devices will trigger an additional growth in economic value, reaching $382 million in 2025. Considering that it is estimated that by 2025 only 40 percent of Wi-Fi traffic will rely on 6 GHz channels, the accelerating effect derived from the new spectrum allocation and latest Wi-Fi technologies will continue to grow and still be far from reaching its maximum potential at this time. By combining the baseline and the Wi-Fi 6 and 6 GHz scenarios, the overall economic value of Wi-Fi for Oman will amount to $3 billion in 2025 (see Table XXXIV-1).

Table XXXIV-1. Oman: Total economic value of Wi-Fi (in $Billions)

	2021	2022	2023	2024	2025
Baseline Scenario	$2.6	$2.6	$2.7	$2.6	$2.6
Wi-Fi 6 / 6 GHz Scenario	$0.0	$0.1	$0.2	$0.3	$0.4
Total	$2.6	$2.7	$2.8	$2.9	$3.0

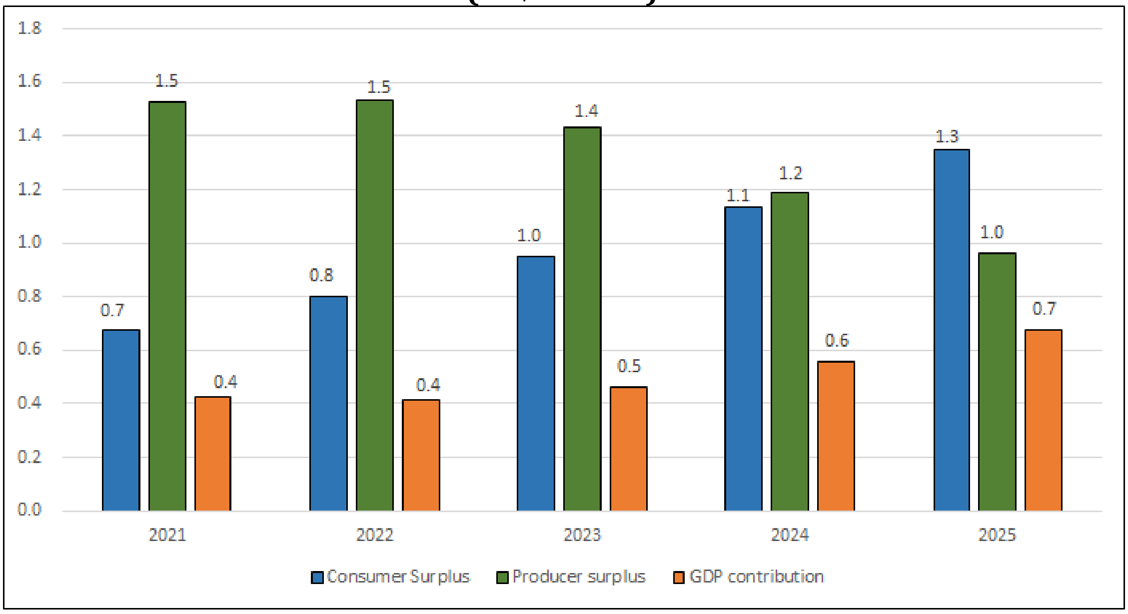
Source: Telecom Advisory Services analysis

The primary source of economic value is currently producer surplus. This surplus is driven by the savings enjoyed by cellular operators who rely on Wi-Fi traffic rerouting. The contribution to producer surplus is expected to gradually decrease,

[152] Cisco includes within this category, free hotspots, homespots, and paid hotspots, for the region of Middle East and Africa. Values for Oman were estimated by considering the country weight in the region's GDP. The report provides values for 2018 and 2023, which allows for interpolating 2021 estimates.
[153] Retrieved in: https://www.wiman.me/oman (June 4, 2021).

given that most 5G deployment will take place at the beginning of the period. By 2025, we expect consumer surplus to become the main source of economic value. The relatively larger contribution from consumer surplus is explained by the fact that wireless operators in Oman have higher mobile prices than in the other countries analyzed in this report. Thus, the costs avoided by using Wi-Fi rather than cellular networks becomes relevant (see Graphic XXXIV-1).[154]

Graphic XXXIV-1. Oman: Total economic value of Wi-Fi (by source) (in $Billions)



Note: Due to rounding, numbers presented in this graphic may not add up precisely to the totals above.
Source: Telecom Advisory Services LLC

The total economic value of Wi-Fi benefits five economic agents, of which ISPs and residential Wi-Fi are currently the most important (see Table XXXIV-2).

Table XXXIV-2. Oman: Total Economic Value of Wi-Fi (by agent) (in $Billions)

	2021	2022	2023	2024	2025
Free Wi-Fi	$0.0	$0.0	$0.0	$0.0	$0.0
Residential Wi-Fi	$0.8	$1.0	$1.1	$1.3	$1.5
Enterprise Wi-Fi	$0.5	$0.5	$0.5	$0.6	$0.7
Internet Service Providers	$1.0	$1.0	$0.9	$0.6	$0.3
Wi-Fi ecosystem	$0.2	$0.2	$0.3	$0.4	$0.4
Total	$2.6	$2.7	$2.8	$2.9	$3.0

Source: Telecom Advisory Services analysis

The economic value of consumer use of residential Wi-Fi will become the largest source of economic value by 2025, followed by enterprises. In that respect, the main gains for consumers will come from the savings incurred due to Internet access for home usage of devices that lack a wired port, followed by the avoidance of

154 There are two main MNO in Oman: Ooredoo and Omantel, with 45% and 55% market share respectively. The weighted average price per GB after the reviewed commercial plans from the operator's website is $1.06, which we project will decrease till $0.70 in 2025.

investment in in-house wiring. The most important factor driving the value of Wi-Fi among enterprises is savings in wireless telecommunications.

According to its contribution to GDP, Wi-Fi will generate approximately 4,600 jobs in Oman in 2021, primarily in the communications sector (3,000), and trade sector (1,400). In 2025, Wi-Fi will generate 7,300 jobs.

XXXV. ECONOMIC VALUE OF WI-FI IN SAUDI ARABIA

In recent years, Wi-Fi has become a pervasive feature in the Saudi Arabia telecommunications landscape. According to data from the Cisco's Annual Internet Report Highlights Tool 2018-2023, we estimate there are currently 391,000 paid and free public Wi-Fi access points in the country.[155] According to Wiman (2021) there are over 190,000 free Wi-Fi sites in the biggest cities of the country (Riyadh: 69,000; Jeddah: 46,000; Mecca: 31,000; Medina: 14,000; Dammam: 15,000; and Sultanah: 14,000).[156]

Given the density of Wi-Fi access points, hotspots have become a very important connectivity feature. According to Opensignal[157], since the outbreak of COVID-19, wireless users in Saudi Arabia have spent 51.9 percent of their communications time connected to Wi-Fi networks rather than relying on their cellular data connection. This has increased from 48.7 percent at the beginning of 2020.

In Saudi Arabia, the regulator Communications and Information Technology Commission (CITC) is expected to release the entire 6 GHz band on a license-exempt basis in 2021. In a new spectrum roadmap, the CITC said it is making the 5925-7125 MHz band license-exempt because of the "importance of WLAN use in the Kingdom and substantial amount of Wi-Fi traffic, which was exemplified during the COVID-19 lockdowns, and the emergence of a promising device ecosystem that can be taken advantage of starting from 2021 to enable a wide range of innovative digital services." It added that a substantial amount of licensed TDD mid-band spectrum is already being made available for IMT and 5G.

Before even considering the additional effect of Wi-Fi 6 and allocation of the 6 GHz spectrum band for unlicensed use, the baseline (2.4 and 5 GHz Wi-Fi) economic value of Wi-Fi in Saudi Arabia in 2021 is estimated at $16.9 billion. The 2025 forecast of economic value will reach $17.9 billion, without considering the accelerating effect of Wi-Fi 6 and 6 GHz band allocation. The possibility of allowing unlicensed devices to operate in the 6 GHz band will increase the economic value of Wi-Fi, as the capacity available for this technology increases considerably.

Adding to this baseline scenario, the allocation of the 6 GHz spectrum band for unlicensed use and the deployment of Wi-Fi 6 and Wi-Fi 6E devices will trigger an additional growth of economic value, reaching $5.8 billion in 2025. Considering that we forecast that by 2025 only 40 percent of Wi-Fi traffic will rely on 6 GHz channels, the accelerated effect derived from the new spectrum allocation and latest Wi-Fi technologies will continue to grow and still be far from reaching its maximum potential at this time. By combining the baseline and the Wi-Fi 6 and 6 GHz scenarios, the overall economic value of Wi-Fi for Saudi Arabia will yield $23.7 billion in 2025 (see Table XXXV-1).

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[155] Cisco includes within this category, free hotspots, homespots, and paid hotspots. The report provides a value for 2018 (29,300) and 2023 (2.2 million), which allows for interpolating 2021 estimates.
[156] Retrieved in: https://www.wiman.me/saudi-arabia (June 4, 2021).
[157] Khatri, H. and Fenwick, S. (2020). "Analyzing mobile experience during the coronavirus pandemic: Time on Wi-Fi". *Opensignal* (March 30).

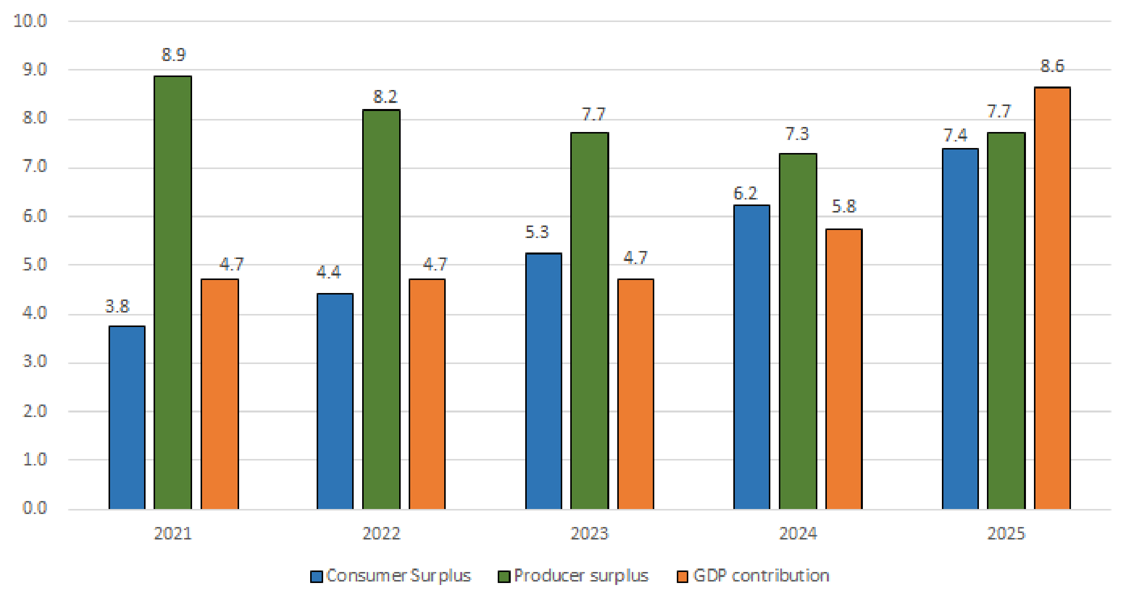
Table XXXV-1. Saudi Arabia: Total economic value of Wi-Fi (in $Billions)

	2021	2022	2023	2024	2025
Baseline Scenario	$16.9	$16.3	$15.9	$16.4	$17.9
Wi-Fi 6 / 6 GHz Scenario	$0.4	$1.1	$1.8	$2.8	$5.8
Total	$17.3	$17.3	$17.7	$19.3	$23.7

Source: Telecom Advisory Services analysis

Currently, the primary source of economic value is producer surplus. This surplus is driven by the savings enjoyed by cellular operators who rely on Wi-Fi traffic rerouting, and the profit margins of an ecosystem of Wi-Fi equipment manufacturers, software developers, and systems integrators. Furthermore, by 2025, we forecast GDP contribution to become the largest source of economic value, due to the large economic returns from the increases in speed resulting from the allocation of 6 GHz (see Graphic XXXV-1).

Graphic XXXV-1. Saudi Arabia: Total economic value of Wi-Fi (by source) (in $Billions)



Note: Due to rounding, numbers presented in this graphic may not add up precisely to the totals above.
Source: Telecom Advisory Services LLC

The total economic value of Wi-Fi benefits five economic agents, of which ISPs and enterprise Wi-Fi are currently the most important. By 2025, however, residential Wi-Fi will benefit the most, mainly due to savings from Internet access for home usage of devices that lack a wired port (see Table XXXV-2).

Table XXXV-2. Saudi Arabia: Total Economic Value of Wi-Fi (by agent) (in $Billions)

	2021	2022	2023	2024	2025
Free Wi-Fi	$2.3	$2.5	$2.8	$3.2	$3.5
Residential Wi-Fi	$3.9	$4.6	$5.5	$6.5	$7.8
Enterprise Wi-Fi	$4.5	$4.2	$4.0	$4.8	$7.4
Internet Service Providers	$4.6	$3.3	$2.2	$1.0	$0.4
Wi-Fi ecosystem	$2.1	$2.5	$3.1	$3.8	$4.7
Total	$17.3	$17.3	$17.7	$19.3	$23.7

Source: Telecom Advisory Services analysis

In turn, the most important factor driving the value of Wi-Fi among enterprises in 2021 is linked to the wide development of IoT, followed by the economic value of business Internet traffic transmitted through Wi-Fi.

Driven by its contribution to GDP, Wi-Fi will generate approximately 51,200 jobs in Saudi Arabia in 2021, primarily in the communications (32,900), and trade (15,700) sectors. In 2025, Wi-Fi induced jobs will increase to 94,000.

XXXVI. ECONOMIC VALUE OF WI-FI IN THE REST OF MIDDLE EAST AND NORTH AFRICA (MENA)

Having estimated Wi-Fi's economic value for five MENA countries (Saudi Arabia, Egypt, Jordan, Morocco, and Oman), we can generate a high-level estimation of the economic value for the remaining countries of that economic area.[158] To do so, we rely on the leading variables methodology, selecting indicators for the five reviewed countries and the rest of the block, and relying on these indicators to interpolate the economic value of Wi-Fi for the rest of the MENA region. The two leading indicators selected are:

- Total GDP: The underlying assumption is that there is a direct link between the level of development of a given country and the economic value of Wi-Fi; and
- Human Development Index (constructed by the United Nations Development Program): This indicator introduces a variable that controls for a country's level of urbanization, literacy, and other social factors.

As the table XXXVI-1 indicates, the five countries under study represent 38% percent of MENA's GDP.

Table XXXVI-1. MENA: Distribution of GDP (2019)

Groups	GDP ($Billions)	Percent
5 countries studied (Saudi Arabia, Egypt, Jordan, Morocco, Oman)	1,336.6	37.7%
Rest of MENA	2,205.8	62.3%
Total MENA	3,542.3	100.0%

Source: World Bank – World Development Indicators

Based on the initial assumption of a correlation between GDP and economic value, we then calculate a first estimate. We then discount this estimate by the level of development measured by the UN Human Development Index (HDI). The average MENA HDI, normalized by population, is 0.731, while the average for the five countries under study is 0.734, and 0.728 for the remaining countries of the region (see Table XXXVI-2).

Table XXXVI-2. Human Development Index (2019): Five Countries vs. Rest of MENA

Groups	HDI
5 countries studied (Saudi Arabia, Egypt, Jordan, Morocco, Oman)	0.734
Rest of MENA	0.728
Total MENA	0.731

Sources: United Nations; Telecom Advisory Services analysis

These values are then used to discount the original GDP-based economic value estimates for the "rest of MENA." The discount factor is calculated by dividing the

[158] The Rest of MENA sample is composed by Algeria, Bahrain, Iran, Iraq, Israel, Kuwait, Lebanon, Libya, Palestine, Qatar, Tunisia, United Arab Emirates, and Yemen.

"rest of MENA" HDI (0.728) by the five countries under study HDI (0.734). This allows a calculation for the economic value of Wi-Fi for the "rest of MENA." Adding this to the five countries under study, we estimate the economic value for the whole region under the baseline scenario (see Table XXXVI-3).

Table XXXVI-3. MENA Wi-Fi Economic Value - Baseline scenario (in $Billions)

Countries	2021				2025			
	Consumer surplus	Producer surplus	GDP Contribution	Total	Consumer surplus	Producer surplus	GDP Contribution	Total
5 countries studied	$10.0	$17.0	$9.7	$36.7	$19.4	$17.9	$8.2	$45.6
Rest of MENA	$16.4	$27.8	$15.9	$60.1	$31.8	$29.4	$13.4	$74.6
Total MENA	$26.4	$44.8	$25.7	$96.9	$51.3	$47.3	$21.6	$120.2

Source: Telecom Advisory Services

By considering the economic value added by Wi-Fi 6 and the allocation of the 6 GHz band, we followed a similar approach to estimate the figures for the rest of MENA and the whole region (see Table XXXVI-4).

Table XXXVI-4. MENA Wi-Fi Economic Value – Only 6 GHz (in $Billions)

Countries	2021				2025			
	Consumer surplus	Producer surplus	GDP Contribution	Total	Consumer surplus	Producer surplus	GDP Contribution	Total
5 countries studied	$0.1	$0.4	$0.2	$0.7	$1.4	$1.4	$7.1	$9.9
Rest of MENA	$0.1	$0.7	$0.3	$1.1	$2.2	$2.3	$11.7	$16.2
Total MENA	$0.2	$1.1	$0.5	$1.8	$3.6	$3.7	$18.8	$26.0

Source: Telecom Advisory Services

Finally, to calculate the total economic value of Wi-Fi (from current bands and 6 GHz allocation), we implemented a similar calculation (see Table XXXVI-5).

Table XXXVI-5. MENA Wi-Fi Economic Value – Total (in $Billions)

Countries	2021				2025			
	Consumer surplus	Producer surplus	GDP Contribution	Total	Consumer surplus	Producer surplus	GDP Contribution	Total
5 countries studied	$10.1	$17.4	$9.9	$37.4	$20.8	$19.3	$15.3	$55.4
Rest of MENA	$16.5	$28.5	$16.2	$61.2	$34.0	$31.7	$25.0	$90.7
Total MENA	$26.5	$46.0	$26.1	$98.6	$54.8	$51.0	$40.3	$146.2

Source: Telecom Advisory Services

The estimated contribution to GDP for the "rest of MENA" allows us to calculate Wi-Fi's contribution to job creation. By adding the five countries studied in detail and the "rest MENA" calculation, Wi-Fi is estimated to create 284,200 jobs in the MENA countries in 2021; by 2025 Wi-Fi will generate 438,700 jobs for the whole economic area (see Table XXXVI -6).

Table XXXVI -6. MENA: Wi-Fi generated Annual Employment

Variable	2021			2025		
	Five countries studied	Rest of MENA	MENA	Five countries studied	Rest of MENA	MENA
Direct jobs	69,247	113,343	182,590	106,909	174,988	281,897
Indirect jobs	20,411	33,408	53,819	31,512	51,578	83,090
Induced jobs	18,120	29,659	47,780	27,976	45,790	73,766
Total	107,776	176,407	284,183	166,393	272,351	438,744

Source: Telecom Advisory Services analysis

XXXVII. GLOBAL ECONOMIC VALUE

Having quantified the economic value for the United States, the United Kingdom, Germany, France, Spain, Poland, Rest of Europe, Japan, South Korea, Australia, New Zealand, Singapore, India, Brazil, Mexico, Colombia, South Africa, DRC, Cameroon, Gabon, Nigeria, Senegal, Kenya, Uganda, Egypt, Jordan, Morocco, Oman, Saudi Arabia and Rest of MENA, we can estimate the economic value for the remaining countries of the world. The extrapolation was based on data from advanced economies.

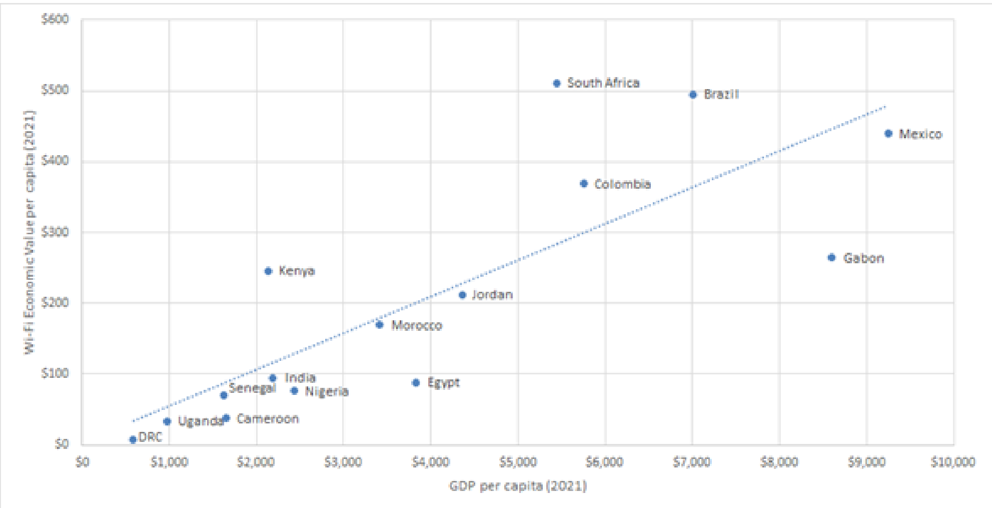
For this purpose, as in the case of Europe and rest of MENA, we use the leading indicators methodology. This methodology consists in selecting indicators for two groups (Group 1: United States, United Kingdom, Japan, South Korea, Australia, New Zealand, Singapore, Brazil, Mexico, Colombia, and the European Union; and for Group 2 the rest of world) and relying on them for the interpolation of values. Once the interpolation is completed, we subtracted the estimates for India, South Africa, DRC, Cameroon, Gabon, Nigeria, Senegal, Kenya, Uganda, Egypt, Jordan, Morocco, Oman, Saudi Arabia, and Rest of MENA.

The two indicators selected for the extrapolation are:

- Total GDP: the underlying assumption is that there is a direct link between the level of development of a given country and the economic value of Wi-Fi
- Human Development Index (constructed by the United Nations Development Program): this indicator introduces a variable that controls for a country's level of urbanization, literacy, and other social factors

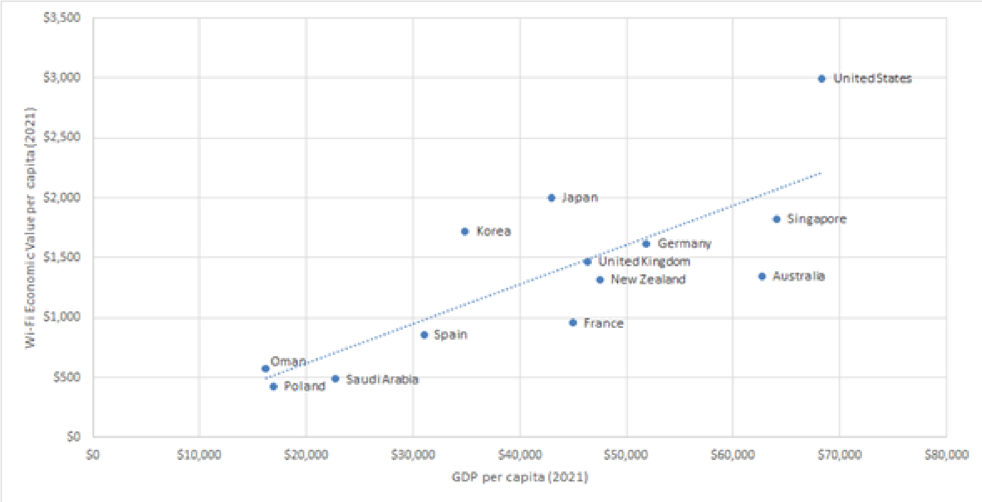
As a starting point, we validated the starting assumption that a country's economy is directly correlated with the economic value of Wi-Fi. Graphics XXXVII-1 and XXXVII-2 indicate that the higher the GDP per capita, the more important is the economic value of Wi-Fi per capita.

Graphic XXXVII-1. Economic Development and **Wi-Fi Value, Countries with GDP per capita lower than US$ 10,000 (*)**



(*) Including the baseline and Wi-Fi 6/6GHz scenarios)
Sources: International Monetary Fund; Telecom Advisory Services analysis

Graphic XXXVII-2. Economic Development and **Wi-Fi Value, Countries with GDP per capita higher than US$ 10,000 (*)**



(*) Including the baseline and Wi-Fi 6/6GHz scenarios)
Sources: International Monetary Fund; Telecom Advisory Services analysis

This correlation supports the use of GDP as lead indicator. As the Table XXXVII-1 indicates, the ten countries and the European Union represent 59.2% of the world GDP.

Table XXXVII -1. World distribution of GDP

Groups	GDP ($Billion)	Percent
10 countries and the European Union [159]	51,912	59.2%
Rest of the World	35,786	40.8%
Total	87,698	100.0%

Source: IMF

With the initial assumption of a correlation between GDP and economic value, we then calculate a first estimate of Wi-Fi economic value. We then discount these results by the level of development measured by the UN Human Development Index (HDI). The average world HDI, normalized by population, is 0.731, while the average for the ten countries and the European Union is 0.870, and 0.699 for the remaining countries of the world (see Table XXXVII-2).

Table XXXVII-2. Human Development Index: Fifteen countries vs. Rest of world

Groups	HDI
10 countries and the European Union	0.870
Rest of the World estimation	0.699
Total	0.731

Source: United Nations

[159] The United States, the United Kingdom, the European Union, Japan, South Korea, Australia, New Zealand, Singapore, Brazil, Mexico, and Colombia.

These values are then used to discount the original GDP-based economic value estimates for the "rest of the world." The discount factor is calculated by dividing the "rest of the world" HDI (0.699) by the 10 countries and the European Union HDI (0.870). This allows refining the Wi-Fi economic value for the "rest of the world," and adding it to the twenty-eight countries and two regions under study, estimating the economic value for the whole world for the baseline scenario (see Table XXXVII-3).

Table XXXVII-3. Global Wi-Fi economic value - Baseline scenario ($Billion)

Countries	2021				2025			
	Consumer surplus	Producer surplus	GDP Contribution	Total	Consumer surplus	Producer surplus	GDP Contribution	Total
28 Countries and Rest of Europe and Rest of MENA	$887.93	$922.73	$567.48	$2,378.15	$1,434.97	$1,229.89	$527.93	$3,192.80
Rest of the World	$404.94	$402.25	$58.80	$865.98	$615.78	$526.05	$13.69	$1,155.52
Total	$1,292.87	$1,324.98	$626.28	$3,244.13	$2,050.75	$1,755.94	$541.62	$4,348.32

Source: Telecom Advisory Services analysis

As presented in Table XXXVII-3, the global Wi-Fi economic value under the baseline scenario in 2021 amounts to $3,244 billion, reaching $4,348 billion in 2025. In 2023, the baseline scenario will reach $3,574 billion. For reference, the projection in the 2018 study was $3,472 billion (3% lower).

The extrapolation for the 6 GHz scenario projects an additional economic value of $58 billion in 2021, reaching $528 billion in 2025 (see Table XXXVII-4).

Table XXXVII-4. Global Wi-Fi economic value – Only 6 GHz ($Billion)

Countries	2021				2025			
	Consumer surplus	Producer surplus	GDP Contribution	Total	Consumer surplus	Producer surplus	GDP Contribution	Total
28 Countries and Rest of Europe and Rest of MENA	$3.09	$21.38	$16.22	$40.68	$66.64	$120.66	$250.08	$437.38
Rest of the World	$1.10	$8.75	$7.46	$17.31	$22.11	$53.59	$14.56	$90.25
Total	$4.19	$30.12	$23.68	$57.99	$88.75	$174.25	$264.64	$527.63

Source: Telecom Advisory Services analysis

Table XVIII-5 presents the sum of both scenarios: $3,302 in 2021 and $4,876 in 2025 (see Table XXXVII-5).

Table XXXVII-5. Global Wi-Fi economic value – Total ($Billion)

Countries	2021				2025			
	Consumer surplus	Producer surplus	GDP Contribution	Total	Consumer surplus	Producer surplus	GDP Contribution	Total
28 Countries and Rest of Europe and Rest of MENA	$891.02	$944.11	$583.70	$2,418.83	$1,501.61	$1,350.55	$778.02	$3,630.18
Rest of the World	$406.03	$411.00	$66.26	$883.29	$637.89	$579.64	$28.25	$1,245.77
Total	$1,297.05	$1,355.11	$649.96	$3,302.12	$2,139.50	$1,930.19	$806.26	$4,875.95

Source: Telecom Advisory Services analysis

In sum, the "rest of the world" estimation represents an amount of Wi-Fi economic value that is fairly close to one third of the value for the twenty-eight economies and two regions under study.

The GDP contribution of the "rest of the world" estimation also enables the quantification of job creation resulting from Wi-Fi. Total, global job contribution of Wi-Fi in 2021 amounts to 3.2 million jobs; by 2025 Wi-Fi will contribute to the creation of 4.0 million jobs worldwide (see table XXXVII -6).

Table XXXVII-6. Global: Wi-Fi generated annual employment

	2021			2025		
	28 Countries and rest of Europe and MENA	Rest of the World	Global	28 Countries and rest of Europe and MENA	Rest of the World	Global
Direct jobs	1,688,896	137,617	1,826,513	2,194,112	59,472	2,253,584
Indirect jobs	889,903	72,513	962,415	1,202,826	32,603	1,235,429
Induced jobs	390,430	31,814	422,243	523,758	14,197	537,955
Total	2,969,228	241,944	3,211,172	3,920,696	106,272	4,026,968

Source: Telecom Advisory Services analysis

It should be noted that, since the estimates for the rest of the world were based on a prorating methodology reflecting a large proportion of advanced country effects, the result might underestimate total employment effects in the developing world.

XXXIX. CONCLUSIONS

In summary, assuming a worldwide availability of Wi-Fi 6 devices operating in the 6 GHz spectrum, the total value in 2021 would increase to $3,302 billion, or $3.3 trillion, reaching $4,876 billion, or $4.9 trillion, by 2025 (see Table XXXIX-1).

Table XXXIX-1. Global Wi-Fi Economic Value ($Billion)

	2021	2025
2018 Study	$2,840.7	$4,361.5
2021 Study: Baseline Scenario	$3,244.1	$4,348.3
2021 Study: Wi-Fi 6 / 6 GHz	$58.0	$527.6
Total 2021 Study	$3,302.1	$4,875.9

Source: Telecom Advisory Services analysis

The countries with the highest Wi-Fi economic value creation (including the baseline and Wi-Fi 6/6 GHz scenarios) in 2021 are the United States ($995.0 billion), followed by Japan ($251.1 billion), Germany ($134.5 billion), India ($131.3), Brazil ($105.2 billion), United Kingdom ($98.8 billion), South Korea ($89.3 billion), and France ($62.5 billion) (see Table XXXIX-2).

Table XXXIX-2. Wi-Fi Total Economic Value (Baseline and Wi-Fi 6 Scenarios)

Continent	Country	2021	2025
North America	United States	$995.0	$1,580.2
Europe	European Union*	$457.6	$637.2
	United Kingdom	$98.8	$108.5
Asia	Australia	$34.7	$41.7
	India	$131.3	$240.2
	Japan	$251.1	$325.0
	New Zealand	$6.7	$9.8
	Singapore	$10.6	$12.4
	South Korea	$89.3	$139.5
Latin America	Brazil	$105.2	$124.4
	Colombia	$18.9	$41.4
	Mexico	$56.7	$117.5
Middle East and North Africa	Egypt	$9.1	$17.2
	Jordan	$2.2	$4.1
	Morocco	$6.1	$7.5
	Oman	$2.6	$3.0
	Saudi Arabia	$17.3	$23.7
Sub-Saharan Africa	Cameroon	$1.0	$2.6
	Democratic Republic of Congo	$0.7	$1.8
	Gabon	$0.6	$1.2
	Kenya	$12.2	$16.3
	Nigeria	$16.1	$33.1
	Senegal	$1.2	$2.8
	South Africa	$30.9	$44.2
	Uganda	$1.4	$4.2
Rest of World		$944.5	$1,336.5
	Total World (*)	$3,302.1	$4,875.9

(*) The estimates for the European Union include detailed analyses for France ($62.5 billion), Germany (134.5 billion), Poland ($16.1 billion), and Spain ($40.4 billion).
(**) Including "Rest of the World" nations not estimated above
Source: Telecom Advisory Services analysis

The main drivers of economic value include:

- Free Wi-Fi: benefit to consumers accessing Wi-Fi hotspots in public sites;
- Residential Wi-Fi: provision of Internet access and connectivity of devices at home;
- Enterprise Wi-Fi: use of Wi-Fi to support a significant portion of enterprise broadband traffic and productivity gains from Wi-Fi enabled IoT and AR/VR;
- Internet Service Providers (ISPs): savings for cellular providers who rely on Wi-Fi re-routing and revenues of Wi-Fi commercial providers; and
- Margins of manufacturing and Wi-Fi ecosystem companies, including manufacturers of Wi-Fi devices and equipment, IoT networks and AR/VR solutions.

The most important sources of economic value in 2025 are residential Wi-Fi and enterprise Wi-Fi. That said, the Wi-Fi ecosystem also benefits from Wi-Fi in terms of the profits received by manufacturers of equipment (access points, controllers, routers, gateways, sensors, AR/VR devices, smart speakers, home security systems, and the like), while ISPs generate savings by relying on the technology to offload traffic from their networks. Finally, Wi-Fi also generates economic value through social contributions: the technology represents a useful application to bridge the digital divide in rural and isolated geographies, while also providing an important platform for free Internet access.

The study also provided an estimate of Wi-Fi contribution to job creation by relying on Input / Output analysis. Global employment benefitting from Wi-Fi in 2021 amounts to 3.2 million jobs and is expected to reach 4.0 million jobs by 2025.

The addition of countries to the original list of nations studied in detail in the 2018 study is useful to draw some cross-national comparisons, and insights:

- **A country's economic development is directly linked to the value of Wi-Fi**. The higher the GDP per capita, the more important is the economic value of Wi-Fi per capita.

- **While GDP per capita is associated with higher Wi-Fi economic value per capita, some developing countries display higher total Wi-Fi economic value than the size of their economy might predict**. Brazil and India exhibit a higher total Wi-Fi economic value than some advanced economies such as the United Kingdom, France, and Germany. In both cases the Wi-Fi value in developing nations exceeds that of some advanced economies. This is due to four factors:

    - Emerging countries typically do not have fully developed cellular infrastructure (i.e., lower density of base stations), with average cellular speeds lagging significantly behind those of Wi-Fi. As a result, **the percentage gain in speed from routing traffic through Wi-Fi is greater in developing countries than in many advanced economies, and so is the implied economic impact**.

- Emerging nations have a larger digital divide (unserved and underserved[160] population) than advanced economies. As a result, **a higher number of households and economic units benefit from free Wi-Fi and Wireless ISPs in developing countries than in industrialized ones.**

- Cellular prices in developing countries are much higher in relative terms than in developed nations. The simple average of the most economic cellular data plan for the three Latin American countries included in this study (Brazil, Mexico, and Colombia) is $2.30 per gigabyte (GB) in 2020 and in Africa it is $1.69, while in Europe it is $0.76, in Asia-Pacific $0.94 and in MENA $0.48. This considerably increases the economic value of routing residential and business traffic through Wi-Fi.

- To calculate the advantage Wi-Fi 6 and 6 GHz bring, we made assumptions based on spectrum allocation levels being considered in those markets. For instance, some country estimates are based on 1,200 MHz (United States, South Korea, Mexico, Colombia, Australia, New Zealand, Japan, Singapore, Brazil, India, Jordan, and Saudi Arabia), while others are based on 500 MHz (Germany, France, United Kingdom, Spain, Poland, Egypt, Morocco, Oman, Cameroon, Democratic Republic of Congo, Gabon, Kenya, Nigeria, Senegal, South Africa, and Uganda).

- A country's level of digitization is exponentially related to the economic value of Wi-Fi. In other words, **the digital transformation of the economy increases the value of Wi-Fi in a non-linear fashion**

Based on this evidence, **Wi-Fi technology should be recognized as one of the dominant economic engines of the digital economy**. Governments around the world should develop incentives to stimulate the social and economic benefits of Wi-Fi. This includes assigning enough spectrum to avoid congestion, encouraging the private sector to create new applications using Wi-Fi, and relying on the technology to address the digital divide barrier.

[160] Broadband underserved is defined as the population that has access to broadband service but at a significantly low level of service quality (i.e. slow download speeds, very high latency).

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Theoretical Framework, Methodologies and Comparison with prior study results for

The Economic Value of Wi-Fi: a global view (2021-2025)

Developed for Wi-Fi Alliance® by

TELECOM ADVISORY SERVICES

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This document is an appendix to the "Economic Value of Wi-Fi: A Global View (2021 – 2025)". It lays out in detail the theoretical framework, methodology, and comparison with prior study results.

This study was commissioned by Wi-Fi Alliance® and conducted by Telecom Advisory Services between August and December of 2020; an addendum was completed also by Telecom Advisory Services between May and July of 2021, covering selected countries in Sub-Saharan Africa, Asia, Middle East and North Africa. The authors of both studies are solely responsible for their content

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APPENDIX A. THEORETICAL FRAMEWORK FOR ESTIMATING THE ECONOMIC VALUE OF Wi-Fi

Wi-Fi is what economists call a factor of production (or enabling resource) that yields economic value by complementing wireline and cellular technologies, enabling the development of alternative technologies that expand consumer choice, supporting the creation of innovative business models, and expanding access to communications services. This chapter defines the intrinsic value of Wi-Fi as a complementary technology that is part of the telecommunications ecosystem, enhancing the performance of networks and providing a platform for developing innovative applications. Next, we present the concept of economic value, calculated as gains to consumer and producer surplus, a contribution to GDP, and a creation of employment. Having formalized these sources of value, we then move to categorize the five economic agents that benefit from them:

- Individual consumers benefitting from accessing free Wi-Fi service;
- consumer residences;
- enterprises;
- Internet Service Providers; and
- manufacturers of communications equipment and consumer electronics.

A.1. The intrinsic value of Wi-Fi

Considered as a factor of production, a complementary technology is a resource that, due to its intrinsic strengths, compensates for the limitations of another one. In this regard, Wi-Fi can enhance the effectiveness of devices, such as smartphones, which use licensed spectrum. Wi-Fi access points can enhance the value of cellular networks by allowing wireless devices to switch to Wi-Fi hotspots, thereby reducing the cost of broadband access and increasing the access speed rate. Along these lines, consumers accessing the Internet within the reach of a Wi-Fi access point can reduce their costs of access by turning off their cellular service. They can also gain additional access speed because the transfer rate of Wi-Fi sites is generally faster than that offered by cellular technology, even 4G LTE at current loads.[161] Likewise, many wireless operators reduce their capital spending by complementing their cellular networks with carrier-grade Wi-Fi access points, which are considerably less expensive than cellular network equipment with similar capacity. In addition to reducing capital expenditures, wireless carriers can offer fast access service without a base station congestion challenge.

In addition to complementing cellular networks, Wi-Fi can provide the environment needed for operating technologies that can substitute for those operating under licensed uses, thereby providing consumers with a larger set of choices. By limiting transmission power and relying on spectrum with low propagation, Wi-Fi avoids

[161] For example, in 2020 the average mobile connection speed in the United States was estimated at 25.51 Mbps while the average Wi-Fi speed from a mobile device is 69.6 Mbps (Source: data interpolated from Cisco Annual Internet Report Highlights Tool 2018-2023). Naturally, we can expect that speed gap to diminish with the progress of 5G deployments.

interference. This ensures the need for licensed spectrum property rights is not a barrier to innovation. In fact, some of the most important technological innovations in communications are intimately linked to Wi-Fi. Numerous products and services, such as the multi-AP/mesh networking systems and smart speakers, launched in the past ten years were developed leveraging Wi-Fi.

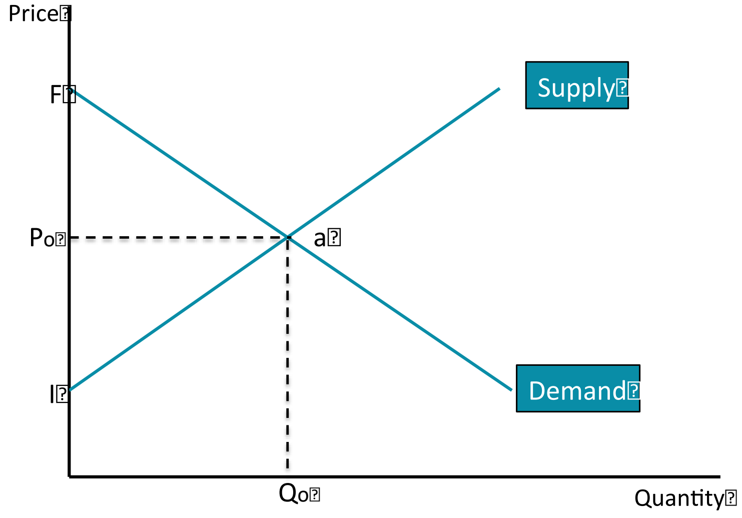
By providing consumers with service choices in addition to those offered through cellular services, Wi-Fi also supports the development of innovative business models. Firms developing new applications that rely on Wi-Fi do not need approval from cellular operators, do not incur time-to-market penalties, and do not face financial disincentives derived from costly revenue splits.

In addition to innovative applications, technologies that rely on Wi-Fi spectrum can help address the digital gap in broadband coverage. A large portion of the population that has not adopted the Internet around the world is in rural and isolated areas. Many of them can gain access to broadband services provided by Wireless Internet Service Providers (WISPs), which typically operate through Wi-Fi. In addition, further developments in the areas of spectrum sensing, dynamic spectrum access, and geo-location techniques can improve the quality of Wi-Fi.

A.2. The derived value of Wi-Fi

Wi-Fi yields economic gains at several levels, both to consumers and producers, as well as a direct net contribution to output (GDP) and employment. Prior research agrees that, contrary to licensed bands where economic value could equate to whatever is paid at auction, the economic value of unlicensed spectrum, such as Wi-Fi, needs to be measured based on the concept of economic surplus.[162] The methodology implicit in relying on the economic surplus approach is captured in Figure A-1.

Figure A-1. Measurement of Economic Surplus



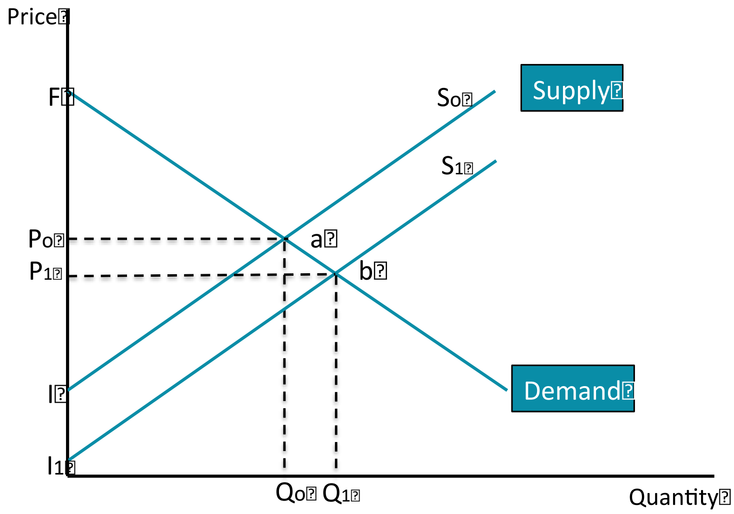
Source: Telecom Advisory Services

[162] Thanki, R. (2009). *The economic value generated by current and future allocations of unlicensed spectrum*. London: Perspective Associates; Thanki, R. (2012). *The Economic Significance of License-Exempt Spectrum to the Future of the Internet.* London; Perspective Associates; Milgrom, P., Levin, J., and Eilat, A. (2011). *The case for unlicensed spectrum*. Stanford Institute for Economic Policy Research Discussion Paper No. 10-036; Katz, R. ibid.

The concept of economic surplus is based on the difference between the value of units consumed and produced up to the equilibrium price and quantity, allowing for the estimation of consumer surplus (area of F, Po, a) and producer surplus (area of Po, I, a).[163] Consumer surplus measures the total amount consumers would be willing to pay to have the service, compared to what they actually pay, while producer surplus measures the analogous quantity for producers, which is essentially the economic profit they earn from providing the service. Thus, in Figure 1 the total surplus is contained in the area F, I, a.

Consistent with the concept presented above, the approach relied upon in this study to measure the economic value of Wi-Fi focuses first on the surplus generated after its adoption.[164] The underlying assumption is that Wi-Fi as a resource generates a shift both in the demand and supply curves resulting from changes in the production function of services, as well as the corresponding willingness-to-pay for its acquisition. On the supply side, the approach measures changes in the value of inputs in the production of wireless communications. The most obvious example is, as mentioned above, whether Wi-Fi represents a positive contribution to wireless carriers' capital expenditures (CAPEX) and operating expenses (OPEX) insofar as they can control their spending while meeting demand for increased wireless traffic. From an economic theory standpoint, the telecommunications industry can then increase its output, yielding a marginal benefit exceeding the marginal cost. This results in a shift in the supply curve by a modification in the production costs (see Figure A-2).

Figure A-2. Measurement of economic surplus resulting from a supply shift



Source: Telecom Advisory Services

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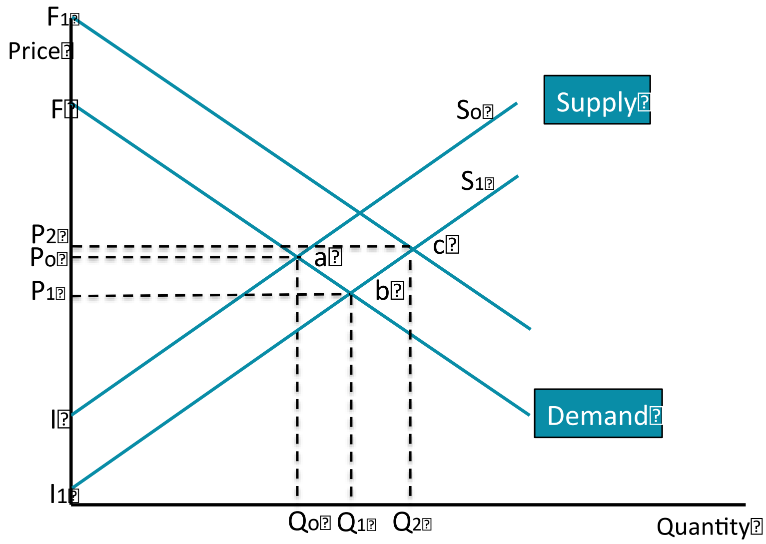
163 Following Alston (1990), we acknowledge that this approach ignores effects of changes in other product and factor markets; for example, Wi-Fi also increases the economic value of technologies operating in licensed bands (Alston, J.M. and Wohlgenant, M.K. (1990). "Measuring Research Benefits Using Linear Elasticity Equilibrium Displacement Models". John D. Mullen and Julian M. Alston, *The Returns to Australian Wool Industry from Investment in R&D*, Sydney, Australia: New South Wales Department of Agriculture and Fisheries, Division of Rural and Resource Economics).

164 See a similar approach used by Mensah and Wohlgenant (2010) to estimate the economic surplus of adoption of soybean technology (Mensah, E., and Wohlgenant, M. (2010). "A market impact analysis of Soybean Technology Adoption", *Research in Business and Economics Journal*).

The development and adoption of carrier-grade Wi-Fi technology causes a shift in the supply curve, yielding a new equilibrium price and quantity. Under this condition, consumer surplus is represented by the triangle F, b, P_1, and producer surplus by the area within P_1, b, I_1. Additionally, since the demand curve is derived from the utility function[165], higher benefit to the consumer derived from the reliance on Wi-Fi at a stable price will yield an increase in the willingness-to-pay, and consequently a shift in the demand curve (see Figure A-3).

Figure A-3. Measurement of Economic Surplus resulting from a supply and demand shift



Source: Telecom Advisory Services

Under these conditions, total economic value is now represented by the area I_1, c, F_1, in Figure A-3, representing both changes in consumer and producer surplus.

To quantify the incremental surplus derived from the adoption of Wi-Fi, we need to itemize all the effects linked to this standard. We complement the concept of economic surplus with an assessment of the direct contribution of the technologies and applications that rely on Wi-Fi, such as Wi-Fi service providers, to the nation's GDP. By including the GDP contribution measurement, we follow Greenstein et al. (2010) and prior literature measuring the economic gains of new goods.[166] We focus on consumer and producer surplus, but we also consider the new economic growth enabled by Wi-Fi. In measuring the direct contribution to GDP, we strictly consider the revenues added "above and beyond" what would have occurred had the Wi-Fi spectrum been licensed. After quantifying the contribution of Wi-Fi to GDP, the impact on job creation can also be ascertained not only on the telecommunications industry itself, but, more importantly, in terms of the spillovers through the rest of the economy.

[165] A utility function measures the consumer preference for a service beyond the explicit monetary value paid for it.

[166] Greenstein, S. and McDevitt, R. (2009). *The broadband bonus: accounting for broadband Internet's impact on U.S. GDP.* National Bureau of Economic Research Working Paper 14758. Cambridge, MA.

APPENDIX B. METHODOLOGIES FOR ESTIMATING THE ECONOMIC VALUE OF Wi-Fi

Measuring Wi-Fi's economic value requires a formalized approach that can integrate the various economic gains, be it consumer or producer benefits, as well as their net direct contributions to the GDP[167]. The methodology used in this study is structured around the benefits captured by each of the five economic agents reviewed in Chapter A:

- Free Wi-Fi service;
- Residential Wi-Fi;
- Enterprise Wi-Fi;
- Internet Service Providers; and
- Wi-Fi ecosystem companies.

The economic value for each economic agent is measured based on three potential options: consumer surplus, producer surplus, and GDP growth. The contribution to GDP growth is also used to estimate the impact on job creation. Table B-1 presents the formalization of each value.

Table B-1. Sources of economic value of Wi-Fi by economic agent

Agents	Sources	Type of Economic Value	Scenarios	
			Baseline	Wi-Fi 6 & 6 GHz
1. Free Wi-Fi	1.4. Savings generated by free Wi-Fi traffic offered in public sites	Consumer Surplus	X	X
	1.5. Deployment of free Wi-Fi in public sites	GDP contribution	X	X
	1.6. Benefit of faster free Wi-Fi with Wi-Fi 6E devices	Consumer Surplus		X
2. Residential Wi-Fi	2.1. Home Internet access for devices that lack a wired port	Consumer Surplus	X	
	2.2. Avoidance of investment in in-house wiring	Consumer Surplus	X	
	2.3. Benefit to consumers from speed increases	Consumer Surplus	X	X
	2.4. Residential Wi-Fi devices and equipment deployed	Consumer Surplus	X	X
	2.6. Closing digital divide: use of Wi-Fi to increase coverage in rural and isolated areas	GDP contribution	X	X

[167] See the prior research in Thanki, R. (Sept. 8, 2009). *The economic value generated by current and future allocations of unlicensed spectrum*. Perspective Associates; Milgrom, P., Levin, J., & Eilat, A. (2011). *The case for unlicensed spectrum*. Stanford Institute for Economic Policy Research Discussion Paper No. 10-036; Cooper, M. (2011). *The consumer benefits of expanding shared use of unlicensed radio spectrum: Liberating Long-Term Spectrum Policy from Short-Term Thinking*. Washington D.C.: Consumer Federation of America, Katz, R. (2014a). *Assessment of the economic value of unlicensed spectrum in the United States.* New York: Telecom Advisory Services. Katz, R. (2014b). *Assessment of the future economic value of unlicensed spectrum in the United States.* New York: Telecom Advisory Services. Katz, R. (2018). *A 2017 assessment of the current and future economic value of unlicensed spectrum*. Washington, DC: Wi-Fi Forward. Katz, R. (2018). *The global economic value of Wi-Fi 2018-2023*. New York: Telecom Advisory Services.

Agents	Sources	Type of Economic Value	Scenarios	
			Baseline	Wi-Fi 6 & 6 GHz
3. Enterprise Wi-Fi	3.1. Business Internet traffic transmitted through Wi-Fi	Producer surplus	X	X
	3.2. Avoidance of enterprise inside wiring costs	Producer surplus	X	
	3.3. Return to speed: contribution to GDP derived from an increase in average mobile speed	GDP contribution	X	X
	3.4. Wide deployment of IoT	GDP contribution	X	X
	3.5. Deployment of AR/VR solutions	GDP contribution	X	X
4. ISPs	2.2 CAPEX and OPEX savings due to cellular off-loading	Producer surplus	X	X
	2.4. Revenues of service providers offering paid Wi-Fi access in public places	GDP contribution	X	X
	2.5. Aggregated revenues of WISPs	GDP contribution	X	X
5. Wi-Fi ecosystem	5.1. Locally manufactured residential Wi-Fi devices and equipment	Producer surplus	X	X
	5.2. Locally manufactured Wi-Fi enterprise equipment	Producer surplus	X	X
	5.3. Locally produced IoT products and services	Producer surplus	X	X
	5.4. Locally produced of AR/VR solutions	Producer surplus	X	X

Source: Telecom Advisory Services

Having presented the different sources of the economic value of Wi-Fi to be estimated for each economic agent, we detail the methodologies used to measure them.

B.2.1. Individuals benefitting from free Wi-Fi service

As indicated in Table B-1, the sources of economic value benefiting individuals relying on free Wi-Fi service comprise the following three economic effects, which contribute to consumer surplus:

- Public Wi-Fi traffic savings incurred by accessing free Wi-Fi at public sites;
- Bridging the digital divide: Reliance on Wi-Fi to provide broadband to unserved populations; and
- Faster speeds: Benefit to consumers who enjoy higher speed with Wi-Fi 6E devices.

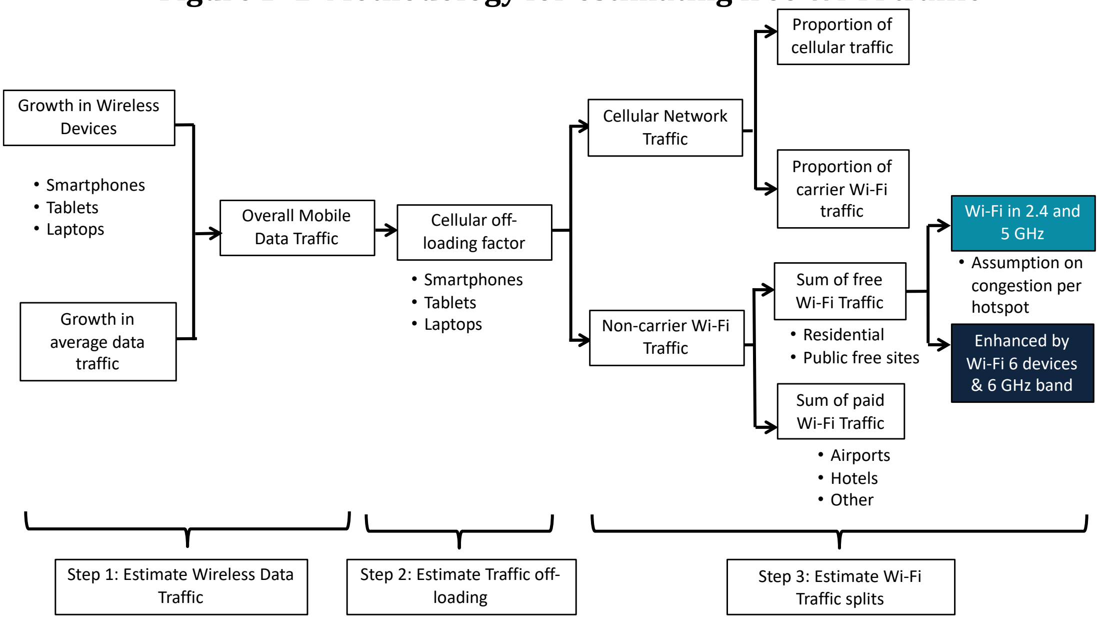
B.2.1.1. Savings incurred by accessing free Wi-Fi in public sites

A consumer that is already accessing the Internet through a wireless broadband plan can save money by switching to a free Wi-Fi access point. While this is less relevant for consumers who purchase unlimited plans, it is significant in the case of pre-paid and capped plans. The economic value should be calculated by multiplying the traffic generated at free sites by the difference between what the consumer would have to pay if he/she were to utilize a wireless broadband plan, and the cost of offering free Wi-Fi incurred by the free site operator.

Free Wi-Fi in the 2.4 GHz and 5 GHz bands

The estimation of the economic value of free Wi-Fi traffic first requires an estimate of the portion of mobile data traffic that is channeled through free Wi-Fi access points. We start by calculating current and future wireless data traffic. Estimates are estimated "bottom-up" from the installed base of devices and traffic by device. They are calibrated with existing measurements, such as Cisco's Annual Internet Report Highlights Tool 2018-2023. After quantifying wireless data traffic, we calculate the portion of traffic off-loaded to Wi-Fi access points. However, since off-loading patterns vary by device, off-loading traffic is calculated by type of terminal (tablet, laptop, smartphone) and then aggregated. In addition, since the economic value differs by the type of Wi-Fi site (for example, revenues from a commercial site represent a direct contribution to GDP, which is addressed below, while the benefit of accessing the Internet via a free public site has to be measured in terms of consumer surplus), Wi-Fi traffic needs to be split between free and paid sites. Finally, we calculate the portion of free Wi-Fi traffic attributed to current spectrum bands to isolate its effect from the increased capacity derived from 6 GHz allocation. Figure B-1 presents a flowchart of this analysis.

Figure B-1. Methodology for estimating free Wi-Fi traffic

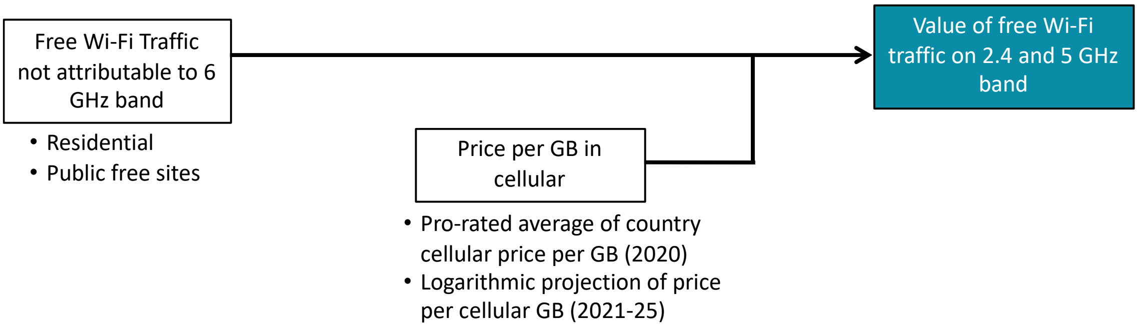


Source: Telecom Advisory Services

To isolate the traffic projection through current unlicensed spectrum bands, we assume that current traffic levels are already resulting in the congestion of most free Wi-Fi hotspots at the time of peak demand. The fact that we assume current hotspots are facing congestion does not necessarily mean a uniform congestion threshold considered for traffic per hotspot across all countries. Several factors can explain why traffic per hotspot may reach different levels across countries: different usage patterns and diverse urban/rural breakdown can have an impact on usage intensity across days and hours. However, as we assume some degree of congestion under current standards for every country, the estimate of traffic per hotspot from 2021 onwards can be expected to remain at 2020 levels, although overall free traffic will continue growing as new hotspots continue to be deployed.

Once the total free Wi-Fi traffic supported by hotspots operating in 2.4 GHz and 5 GHz bands is estimated, we calculate the consumer surplus by multiplying the total free traffic by the difference between what the consumer would have to pay if he/she were to utilize a wireless broadband plan and the cost of offering free Wi-Fi (incurred in this case by the public site operator). To do so, we need an estimate of the average price per GB of wireless data transmitted by wideband networks, which we calculate by prorating the market share of the most economic "dollar per GB" (generally the unlimited) plan of major wireless carriers of the country under analysis. Figure B-2 describes this approach.

Figure B-2. Methodology for estimating consumer surplus of free Wi-Fi traffic in 2.4 and 5 GHz bands



Source: Telecom Advisory Services

Free Wi-Fi in the 6 GHz band

Wi-Fi 6 is the latest among Wi-Fi standards. If supported by the allocation of the 6 GHz spectrum band,[168] it yields an important performance improvement in comparison with previous generations. For example, Wi-Fi 6E provides better efficiency due to its orthogonal frequency-division multiple access (OFDMA), allowing to simultaneously connect more client devices without affecting quality. When the entire 6 GHz band is opened and added to the existing unlicensed bands in 2.4 GHz and 5 GHz, the combined spectrum will be able to support eight 160 MHz channels, or three 320 MHz channels. These channels will be a source of economic value, as their use will allow the support of a high number of devices on a single access point.[169]

In terms of free Wi-Fi service, the allocation of the 6 GHz band will remove the above-mentioned congestion, allowing the traffic per access point to continue to grow at the rate extrapolated from past experience. Once computed, the additional traffic "above and beyond" the forecast under the 2.4 GHz and 5 GHz spectrum bands, we follow a similar approach to calculate the consumer surplus, by multiplying it by the difference between what the consumer would have to pay if

[168] This is because the above-mentioned advances attributed to Wi-Fi 6 only apply when the devices connect using the 160 MHz channel. Although Wi-Fi 6 is available in the traditional 2.4 GHz and 5 GHz bands, that spectrum runs out of space fast if configured under the extra-wide 160MHz channels. Therefore, this shortage needs to be addressed by the allocation of 6 GHz frequency band for unlicensed use to enjoy the developments provided by the latest technological standard.
[169] Some Wi-Fi 6 solutions can handle up to 1,500 devices.

he/she were to utilize a wireless carrier, and the cost of gaining Internet access through free Wi-Fi.

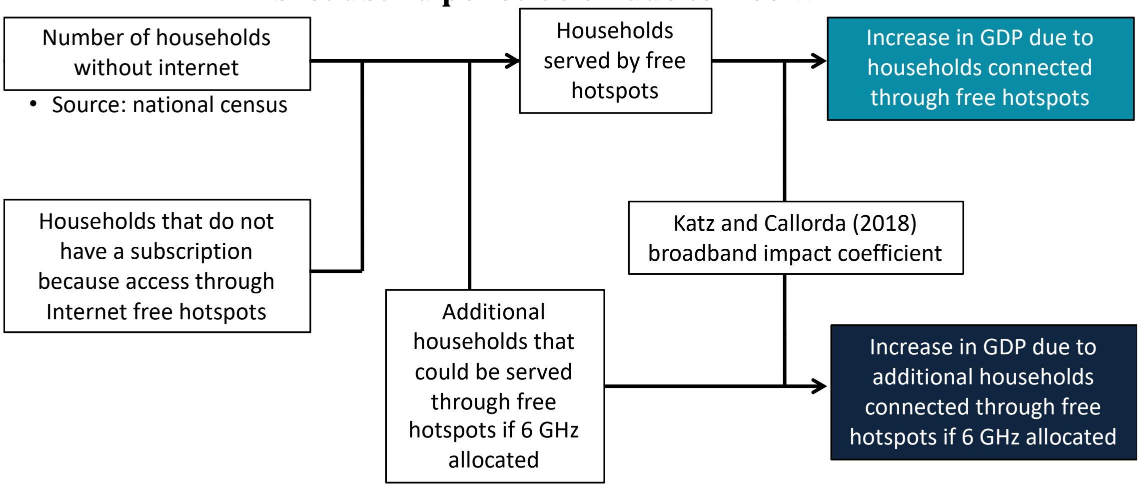
B.2.1.2. Free Wi-Fi provides broadband to the unserved population

In addition to the economic value generated by savings in wireless broadband, free Wi-Fi provides Internet access to the unserved population–consumers that do not have broadband service because of an affordability barrier can rely on free Wi-Fi to gain Internet access.

Free Wi-Fi in the 2.4 GHz and 5 GHz bands

Through free Wi-Fi offered in public venues, more people can be connected, enhancing the economic contribution of broadband. More people connected implies that people can be more productive in their own activities and enjoy more leisure time. In this case, we assess the GDP contribution of free Wi-Fi by providing the economically disadvantaged population access to the Internet, as described in Figure B-3.

Figure B-3. Methodology for estimating the GDP contribution of increased broadband penetration due to free Wi-Fi



Source: Telecom Advisory Services

We start by calculating the unserved population and estimating which portion of those are already accessing to Internet through free hotspots. As an example, a survey carried out by Connect Home in the United States stipulates that 10% of unconnected households state that they access Internet outside of the home.[170] We follow a conservative approach and assume that 5% of unconnected households rely on free hotspots for accessing the Internet. Once the additional broadband penetration due to free Wi-Fi hotspots is calculated, we apply the broadband impact

[170] Connect Home. Baseline Internet access among ConnectHome Communities: Results from the National Evaluation of ConnectHome. Retrieved in: https://www.huduser.gov/portal/sites/default/files/pdf/ConnectHome-Brief.pdf

coefficient from Katz and Callorda (2018b), that stipulates a 0.19% increase in GDP for every 1% increase in penetration.[171]

Enhanced GDP contribution due to 6 GHz allocation

As stated above, the developments provided by Wi-Fi 6E equipment allows Wi-Fi to support a higher number of devices on a single access point. Thus, the improved throughput of free Wi-Fi hotspots utilizing the 6 GHz allocation will allow the possibility of serving additional unconnected households. We assume that a further 5% of unconnected consumers will be served through free hotspots in this situation and calculate the GDP contribution following the same criteria as described for the current spectrum bands.[172]

B.2.1.3. Benefit to consumers enjoying higher speeds from free Wi-Fi if the 6 GHz band is allocated

When the 6 GHz band is added to the existing unlicensed bands, an additional effect will result from enabling users to access the Internet through faster than current levels of broadband speed. Wi-Fi 6 has a base speed of 1.2 Gbps per stream, therefore, a dual-stream connection has a ceiling speed of 2.4 Gbps, and a quad-stream connection can reach 4.8 Gbps.[173] Under these circumstances, free Wi-Fi customers are expected to benefit from faster services. Consumer surplus is defined as the value that consumers receive from purchasing a product for a price that is less than what they would be willing to pay. Early on, Rosston et al. (2010) noted that, in addition to the benefits consumers receive from broadband adoption (quick access to large amounts of information for learning and health services, access to the world's largest portal for social and entertainment services, and the potential for savings from online shopping), one must also consider consumer preferences and benefits received from the nature of the service, which include speed of access and reliability.

Most studies of consumer surplus derived from faster broadband speed are based on primary research, where users stipulate the amount they would be willing to pay for broadband service (Savage et al., 2004; Greenstein and McDewitt, 2011; Liu et al., 2017). Other studies of broadband speed consumer surplus focus on how consumers react to variations in price according to their data usage. For example, Nevo et al. (2016) studied hour-by-hour Internet usage for 55,000 U.S. subscribers facing different price schedules. They concluded that consumer surplus for speed is heterogeneous. Consumers will pay between $0 to $5 per month for a 1 Mbps increase in connection speed, with an average of $2.[174] In addition, they stipulated that with the availability of more content and applications, consumers will likely increase their usage, implying greater time savings and a greater willingness-to-pay

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[171] Katz, R. and Callorda, F. (2018b). *The Economic Contribution of Broadband, Digitization, and ICT Regulation*. Geneva: International Telecommunications Union. Retrieved from: www.itu.int › D-PREF-EF.BDT_AM-2019-PDF-E.pdf

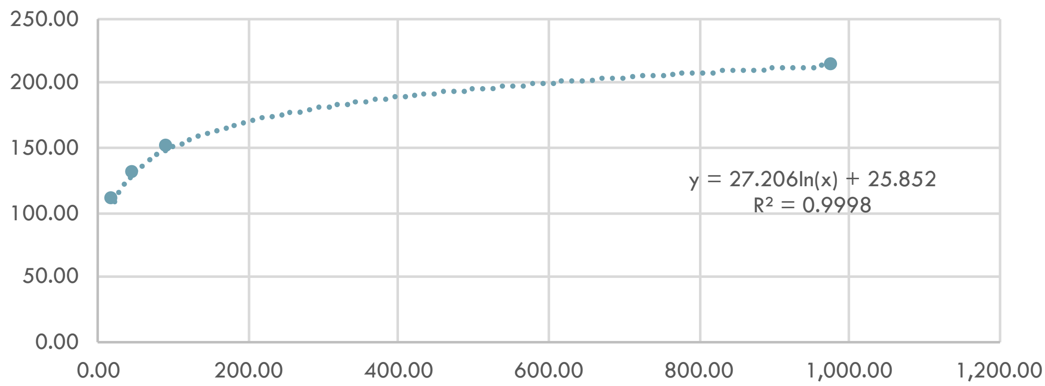
[172] It should be noted, however, that this benefit will flow to users operating Wi-Fi 6E devices.

[173] Ngo, D. (2020). "Wi-Fi 6 in Layman's Terms: Speed, Range, and More". *Dong Knows Tech* (April 29th). This performance assumes MCS coding scheme 11, OFDM, 2 streams, 1024 QAM (quadrature amplitude modulation), 160 MHz channels, and 0.8us guard interval (GI).

[174] Heterogeneity in willingness-to-pay for broadband was also highlighted by Rosston et al. (2010).

for speed. At the time of the research, the increase in willingness-to-pay for high speeds dropped by approximately $0.11 per Mbps.[175] The authors found that the valuation of bandwidth is highly concave, with lesser added value beyond 100 Mbps (see Graphic B-1).

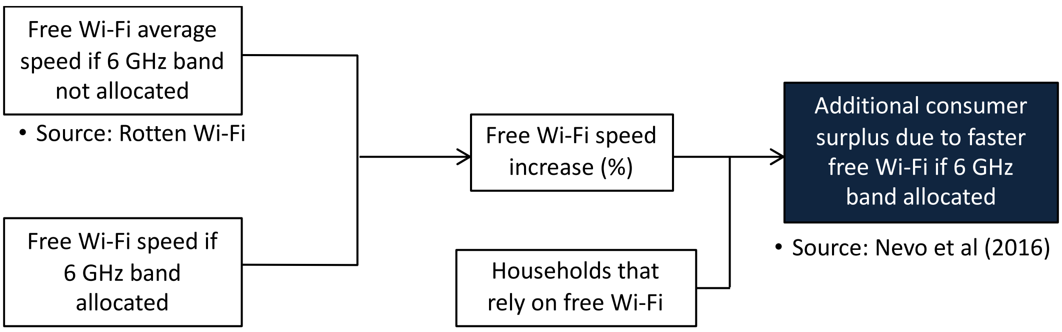
Graphic B-1. Log Curve of relationship between broadband speed and consumer surplus (based on Nevo et al., 2016)



Sources: Nevo et al. (2016); Telecom Advisory Services analysis

As reported in this study, U.S. households are willing to pay about $2.34 per Mbps ($14 total) monthly to increase bandwidth from 4 Mbps to 10 Mbps, $1.57 per Mbps ($24) to increase from 10 to 25 Mbps, and U.S. $0.02 per Mbps ($19) for an increase from 100 Mbps to 1000 Mbps. These figures will be adapted to each specific country, relying on the Purchasing Power Parity (PPP) differences with respect to the United States. Figure B-4 describes the process for estimating consumer surplus under these conditions.

Figure B-4. Methodology for estimating consumer surplus contribution of faster free Wi-Fi if 6 GHz allocated



Source: Telecom Advisory Services

First, we calculate the percentage of speed increase over current free Wi-Fi. For that purpose, we assume that under the 6 GHz allocation, speed from free hotspots will be similar to the Wi-Fi speeds from mobile devices reported by the Cisco Annual Internet Report Highlights Tool 2018-2023. In addition, we weight that increase by the quantity of households relying on free Wi-Fi, and the estimated percentage of

[175] This is confirmed by a more recent study. Liu et al. (2017) administered two national, discrete choice surveys of U.S. consumers to measure households' willingness-to-pay for changes in price, data caps, and speed.

traffic being carried through the 6 GHz channels, which we expect to gradually increase, reaching 40% in 2025. By applying to those figures the willingness-to-pay derived from Nevo et al. (2016), we calculate the resulting consumer surplus.

III.2.2. Residential Wi-Fi

As detailed in Table B-1, the economic value of residential Wi-Fi is driven by the following five sources:

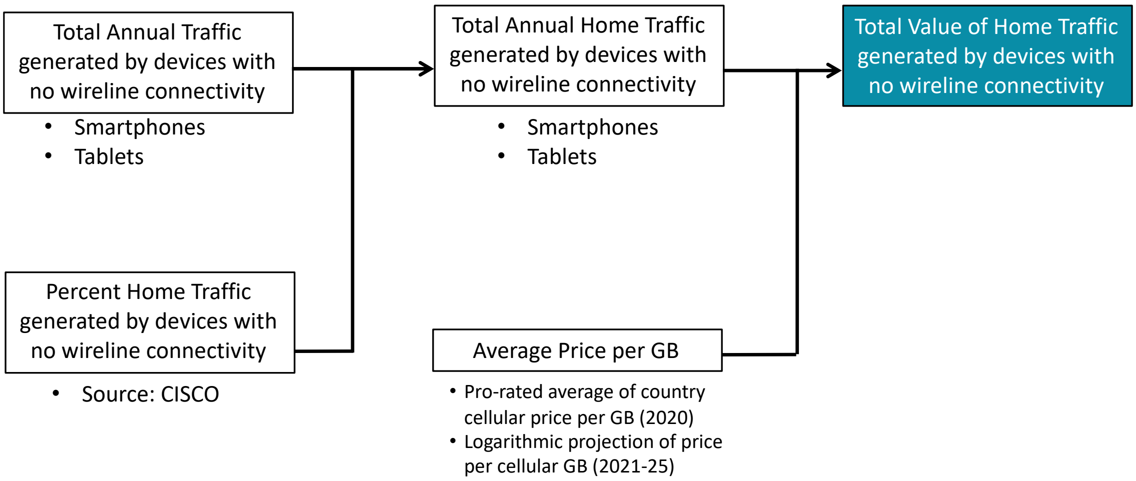
- Wi-Fi only devices (no Ethernet port): home traffic generated by devices that have no inside wiring and access the fixed network through Wi-Fi rather than relying on cellular networks;
- Home networking savings: avoidance of costs required to deploy inside Ethernet wiring to connect home devices and peripherals;
- Faster home Wi-Fi: benefit to consumers for faster broadband speed at home;
- Consumer Wi-Fi equipment: consumer surplus derived from the acquisition of Wi-Fi devices and equipment at prices below their willingness-to-pay; and
- Bridging the digital divide: GDP contribution from additional homes connected through WISPs in rural or isolated areas.

B.2.2.1. Internet access for home usage of Wi-Fi only devices

The underlying premise of this analysis is that, in the absence of Wi-Fi, users would have to depend on the cellular network to gain Internet access. For this reason, to estimate the economic value of Wi-Fi at home, we would first measure the traffic generated by these devices at home, and then multiply it by the consumer's willingness-to-pay.

To estimate this value, we selected a subset of available data on device traffic: smartphones and tablets. We add the total wireless traffic generated by devices with no wireline connectivity and multiply it by the percent that is generated at home. This estimate is used to calculate the consumer surplus in an approach like the one used for calculating the value of free Wi-Fi traffic (see Figure B-5).

Figure B-5. Methodology for estimating consumer surplus of residential Wi-Fi traffic



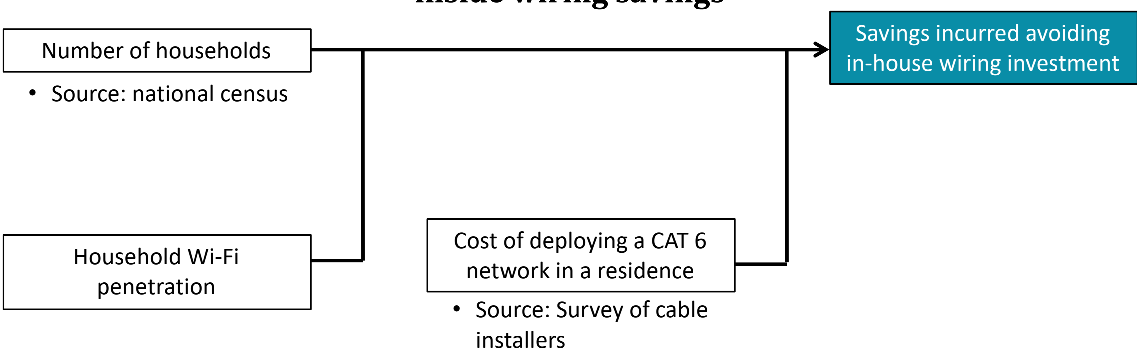
Source: Telecom Advisory Services

Note: future research can explore other home device traffic, such as that of smart TVs and laptops, once reliable sources are available. This study opted for a conservative approach to avoid over-estimation. It is likely that the values in home Internet access are even higher.[176]

B.2.2.2. Avoidance of inside wiring costs

Residential Wi-Fi access points allow consumers to avoid paying for wiring to connect all home devices (printers, laptops, storage units, etc.), which represents a saving to consumers. To calculate this consumer surplus, we estimate the number of households equipped with a Wi-Fi access point and multiply this value by the standard cost of deploying a CAT 6-based network with multiple connections (see Figure B-6).

Figure B-6. Methodology for estimating Consumer Surplus derived from inside wiring savings



Source: Telecom Advisory Services

[176] In particular, the development of Wi-Fi 6E will allow for more devices connected at home, although we prefer to be cautious and not quantify this additional economic effect.

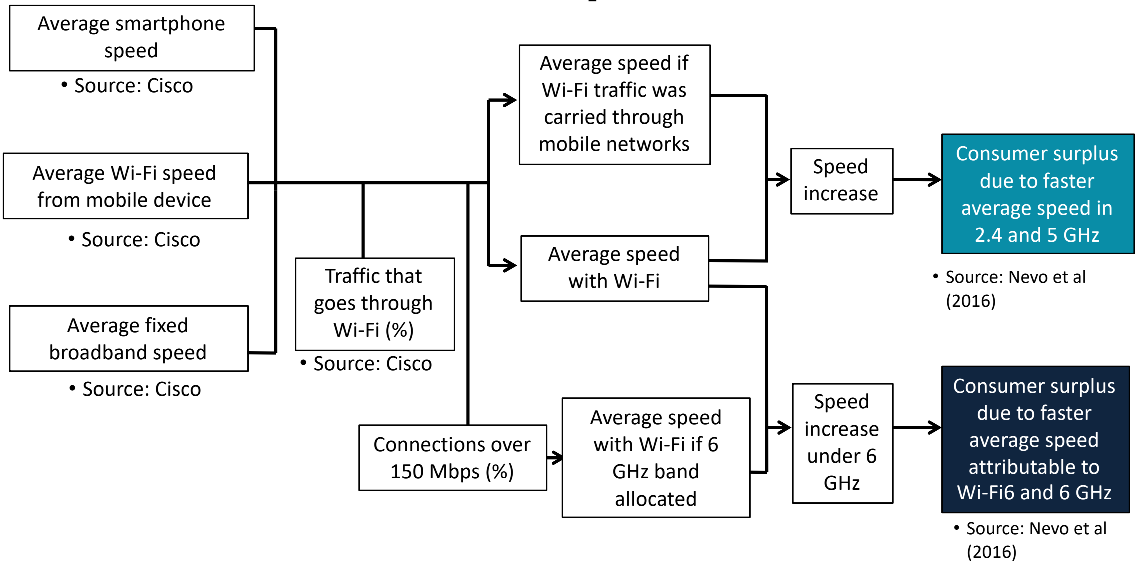
B.2.2.3. Benefit derived from a speed increase

The welfare of residential Wi-Fi customers is expected to benefit from faster broadband speeds than those provided by cellular networks.

Faster broadband speed in the 2.4 GHz and 5 GHz bands

Figure B-7 describes the methodology followed to calculate the consumer surplus generated from faster residential Wi-Fi speeds.

Figure B-7. Methodology for estimating consumer surplus derived from faster speed



Source: Telecom Advisory Services

First, we will calculate the average household speed if the Wi-Fi traffic were carried through cellular networks and compare it with the weighted average by using Wi-Fi.[177] Once the percentage of speed increase is computed, we follow the same procedure as described above, relying on Nevo et al (2016) estimates for the United States (adjusted to each country by PPP differential) to calculate the additional consumer surplus.

Additional benefit to consumers from speed increases due to 6 GHz spectrum allocation

The welfare of residential Wi-Fi customers is expected to benefit from the 6 GHz allocation and the consequent increase in access point performance, which will yield faster service. This will materialize in terms of an additional increase in speed.

When a consumer accesses the Internet, the access speed at the device level is a function of the performance of the fixed and/or wireless network and the router's throughput. The net result differs from the speed of the broadband connection. For

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[177] In any case, it must be said that the progressive launch of 5G services will decrease the speed-advantage in favor of Wi-Fi. Hence, we will have to consider the progressive expansion of 5G in the cellular speed projections towards 2025.

example, if a user purchases a 20 Mbps fixed broadband line, it is highly unlikely that the Wi-Fi router will become a performance bottleneck. A dual band router can deliver peak speeds of 1.2 Gbps on 2.4 GHz radio, 4.8 Gbps on one 5 GHz radio, and 4.8 Gbps on the other 5 GHz radio. Based on the current 2.4 GHz and 5 GHz allocation, dual router performance is estimated to be 266.50 Mbps (which results from assuming an even split of traffic between the 2.4 GHz band (at 173 Mbps) and the 5 GHz band (at 360 Mbps)). This does not mean, however, that each user is receiving the total speed. Under this circumstance, if the user acquires a 150 Mbps fixed broadband line, the router operating on the 2.4 GHz and 5 GHz bands becomes a choke point, and the speed experienced by the consumer will not be equivalent to that delivered by the fixed network.

Through the use of multiple bands and spatial streams, Wi-Fi 6 routers have total throughput capabilities well in excess of the speeds they can enable for individual devices. For example, a Wi-Fi 6E device can, in theory, handle total throughput of 4.8 Gbps.[178] In this context, relying on the 6 GHz band allows users who acquire broadband lines in excess of 150 Mbps to get the full benefit of enhanced speed. The speed increase over the previous Wi-Fi baseline scenario, where routers only rely on the 2.4 GHz and 5 GHz bands, will be calculated in terms of additional consumer surplus.

B.2.2.4. Residential Wi-Fi devices and equipment

Consumers receive an economic surplus from acquiring Wi-Fi devices at a lower price than their willingness-to-pay for them. Value is calculated based on devices that can be acquired either under the baseline scenario of 2.4 GHz and 5 GHz bands, or the 6 GHz band.

Residential Wi-Fi devices and equipment in the 2.4 GHz and 5 GHz bands

Products in this ecosystem include a full range of consumer electronics (see Table B-2):

Table B-2. Wi-Fi enabled residential equipment

Market segment	Equipment
Consumer	• Wireless speakers • Home security systems • Home networking devices • Tablets • Access points • External adapters • Routers • Gateways

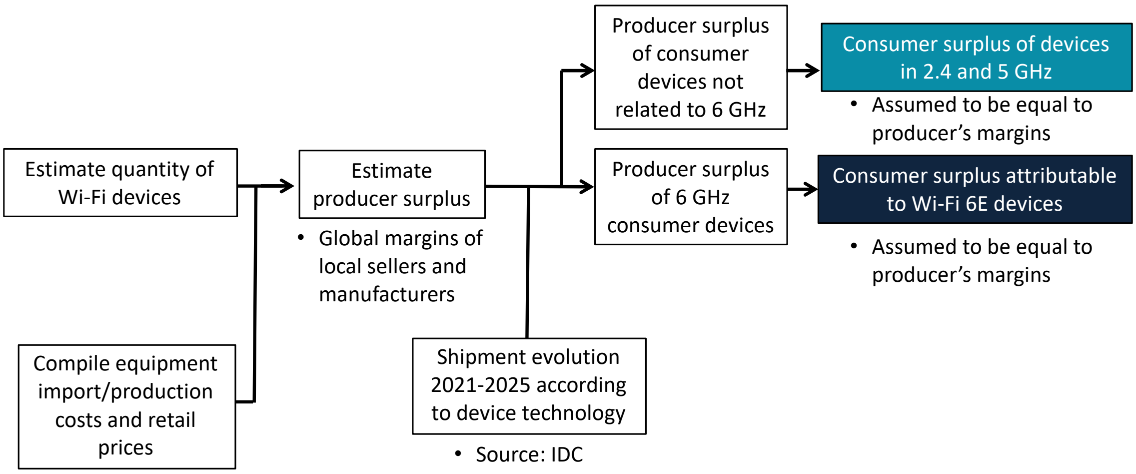
Source: Telecom Advisory Services

The absence of data on the willingness-to-pay for each piece of equipment makes it very difficult to reliably estimate consumer surplus. To overcome that limitation, a possible approximation is to assume that consumer surplus would equal the producer surplus (see Milgrom et al., 2011). Therefore, we calculate the producer's

[178] Estimate provided by Broadcom. This refers to the throughput received by each user device (PC, tablet, etc.) within the user premise.

margin based on the total sales of Wi-Fi enabled residential equipment in a given country, and attribute that value to the consumer surplus.

Figure B-8. Methodology for estimating consumer surplus derived from residential Wi-Fi devices



Source: Telecom Advisory Services

We also calculate the consumer surplus derived from the adoption of tablets (a product that is enabled mostly by Wi-Fi access), by considering the difference between the users' willingness-to-pay and the current market prices. In this case, sales by country and data on the willingness-to-pay is available from research in the United States.

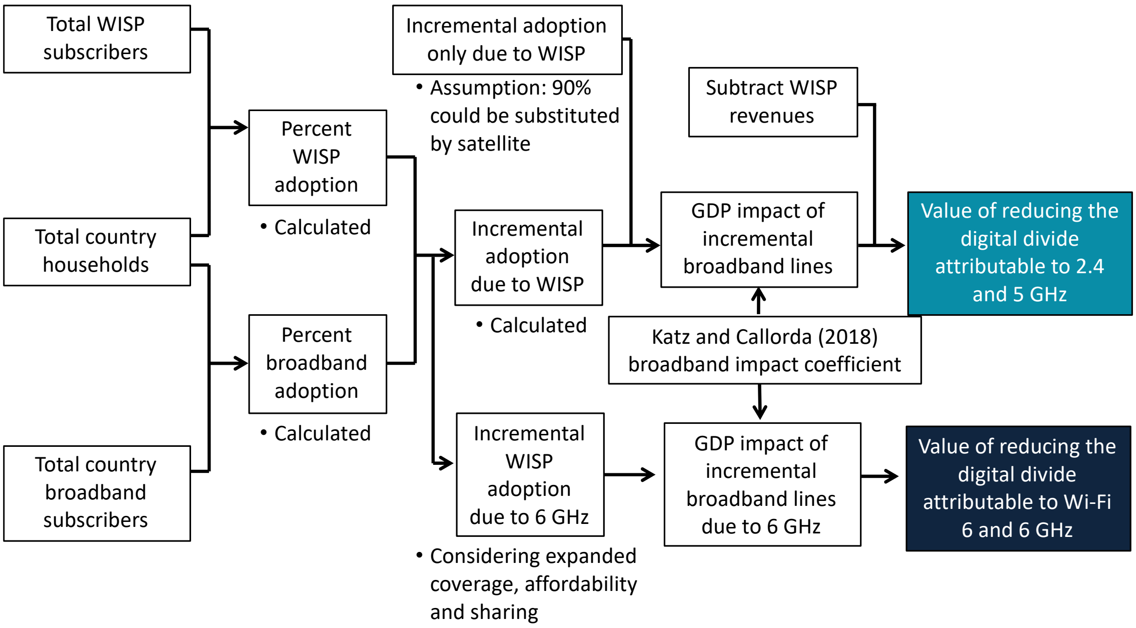
Residential Wi-Fi 6 devices and equipment

As we have seen before, the acquisition of Wi-Fi residential devices yields consumer surplus as long as the price paid is below the amount consumers are willing to pay for them. In this section, we follow the same approach as in the baseline scenario but consider only Wi-Fi 6 devices and equipment. For that purpose, we will follow the forecasts provided by IDC regarding the evolution of shipments for consumer 802.11ax devices for the 6 GHz band.

B.2.2.5. Bridging the digital divide: use of Wi-Fi to increase coverage in rural and isolated areas

Wi-Fi is an appropriate technology to offer Internet access in rural and isolated areas. Given that Wireless Internet service Providers (WISPs) tend to be prevalent in rural areas, to calculate the value of Wi-Fi in reducing the digital divide, we must subtract the impact of Wi-Fi 6 on WISP revenues to avoid double counting. The analysis then proceeds to subtract WISP broadband lines from the incremental growth in rural areas that results from extending broadband service via Wi-Fi. Once this is done, we calculate the impact on GDP by relying on the coefficient estimated by Katz and Callorda (2018b; 2019) through regression models that link the increase in broadband lines to economic growth. The contribution to GDP materializes through multiple effects: creation of new businesses, increasing productivity of existing enterprises (in particular, agriculture), and growth of average income per household (see Figure B-9).

Figure B-9. Methodology for estimating GDP Contribution derived from bridging the digital divide



Source: Telecom Advisory Services

Economic impact of enhanced coverage and affordability due to 6 GHz

As stated above, the WISP industry is a critical contributor to tackling the digital divide. In that respect, WISPs tend to have a primary focus on the vulnerable population and part of their deployment is in rural areas. In that sense, it is critical to understand how these players could benefit from the allocation of 6 GHz.[179]

The allocation of the 6 GHz band to unlicensed use would allow WISPs to potentially increase their subscriber base within their same coverage footprint. Since WISPs rely on the 2.4 and 5 GHz bands for unlicensed Wi-Fi use, these bands support between 50 and 100 client devices per access point at a theoretical maximum aggregate data rate of 6.9 Gbps. The allocation of the 6 GHz band would allow WISPs to sign up new devices and increase download speed, which would trigger several simultaneous positive effects. As an example, the temporary assignment of spectrum by the FCC to deal with the COVID-19 pandemic allowed WISPs in the United States to immediately increase their subscriber base between 20% and 30%. We will follow a cautious approach and consider that the expanded coverage will yield gradual increases in WISP subscribers, from 2% in 2022 to 5% in 2025 over the figures projected without assuming the additional spectrum allocation.

[179] As background, the WISP association in the United States were a key stakeholder supporting the FCC decision to allocate the 6 GHz spectrum (see WISPA, 2020: *Letter to the FCC Commissioners*, March 5).

Recognizing the economies of scale in telecommunications services, an increase of the user base would allow service providers to lower their operating costs. Under a conservative scenario, prices will remain stable within the context of increasing GDP per capita. In consequence, affordability would increase for those potential subscribers that indicate that they do not purchase broadband service because of its cost. With an increase in affordability, the penetration of broadband will further grow. An additional effect on broadband adoption relates to an increase in the household sharing ratio as a result of increased access point performance. This is a particularity especially common in developing countries. The increase in affordability, combined with an improved capability to share lines, will result in the growth of broadband connections and hence, a contribution to GDP.

B.2.3. Enterprise Wi-Fi

The economic value of enterprise Wi-Fi is generated from five sources:

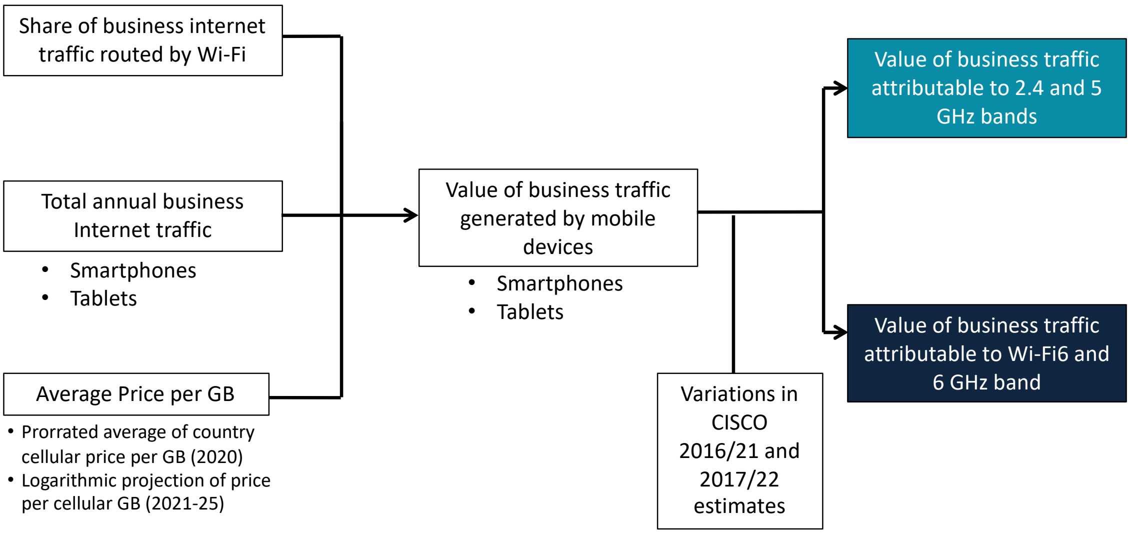
- Business Wi-Fi use: mobile business traffic routed through Wi-Fi access points rather than cellular networks;
- Networking savings: avoidance of capital investment to deploy Ethernet wiring inside enterprise buildings and campuses to connect devices and peripherals;
- Increased speed: enhanced productivity due to faster connectivity via Wi-Fi;
- IoT: economic spillovers generated through the deployment of IoT; and
- AR/VR: economic spillovers generated by the diffusion of AR/VR solutions in the production sector of the economy.

B.2.3.1. Business Internet traffic transmitted through Wi-Fi

Wi-Fi enterprise savings results from wireless traffic that is routed through Wi-Fi access points. The cost of Wi-Fi traffic is calculated by multiplying it by the average price per gigabyte of wireless data transmitted by wideband networks, which we calculate by averaging the most economic dollar per GB plan of major wireless carriers[180] in each country (see Figure B-10).[181]

[180] We acknowledge that enterprises are likely to negotiate wireless rates lower than those offered in the consumer market; however, data in this area is not available.
[181] This economic value is computed as producer surplus, although a different interpretation could justify its consideration as consumer surplus, if assuming that the enterprises are effectively consumers of Internet services in this context.

Figure B-10. Methodology for estimating economic surplus of Enterprise Wi-Fi traffic



Source: Telecom Advisory Services

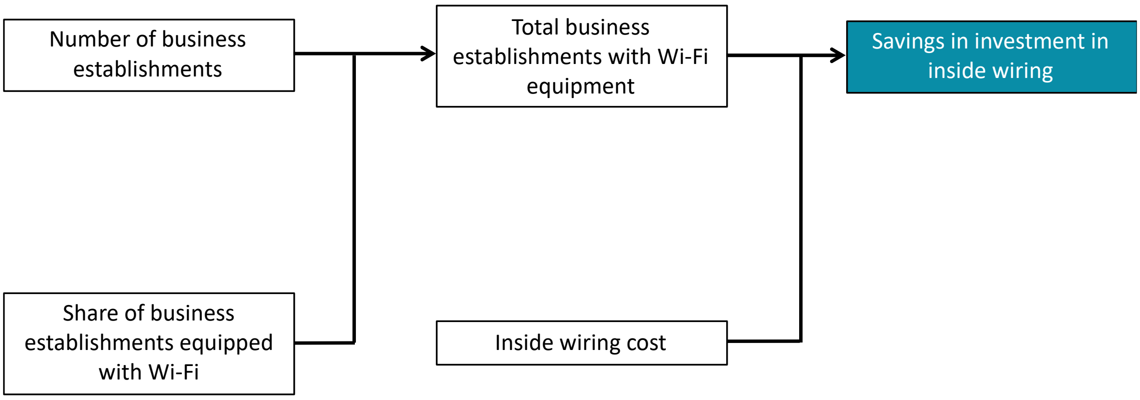
Business traffic if 6 GHz allocated

The increase in unlicensed channel capacity enables more extensive delivery of ubiquitous, high throughput wireless connectivity across multiple access points in business facilities, such as industrial plants, enterprise campuses, and the like. This will allow firms to leverage Wi-Fi infrastructure and generate further savings in the use of wideband wireless communications. As reported above, Wi-Fi 6E will be able to handle up to 1,500 devices, which makes them ideal for enterprise applications. This will help increase the producer surplus of enterprises. To estimate the specific effect attributed to 6 GHz, we begin by analyzing the variations in Cisco's Annual Internet Report Highlights Tool 2018-2023 enterprise Internet traffic forecasts for 2016-21 and 2017/22. We assume that part of the growth in forecasted traffic between both projections was driven by "natural" growth (that is to say, the extrapolation of historical growth), and another portion was triggered by Wi-Fi traffic stimulated by the 6 GHz spectrum allocation.

B.2.3.2. Savings in enterprise building inside wiring

Similar to residential Wi-Fi savings due to capital investment avoidance in inside wiring, we assume the total number of business establishments that are equipped with Wi-Fi access points and multiply this value by a standard cost of deploying a CAT 6-based network (although in this case, the cost is obviously higher than for a residence) (see Figure B-11).

Figure B-11. Methodology for estimating economic surplus derived from inside wiring savings



Source: Telecom Advisory Services

B.2.3.3. Return to speed: contribution to GDP derived from an increase in average mobile speed

The off-loading of cellular traffic to Wi-Fi generates a "return to speed" economic value.[182] As such, the speed of access could be significantly higher via a Wi-Fi access point than on cellular networks, although 5G developments are expected to decrease that speed differential. Literature on econometric research has attempted to measure the impact on GDP of higher broadband speed (see for instance Rohman and Bohlin 2012; Bohlin et al., 2013; Kongaut and Bohlin 2014). More recently, Katz and Callorda (2019) analyzed the impact of fixed broadband speed in GDP for a sample of 159 countries during the period 2008-2019, providing further evidence of the positive economic effect of broadband quality (Table B-3).

Table B-3. Impact of downloading speed of fixed broadband on GDP

Impact on GDP	Speed < 10 Mbps	Speed 10 Mbps - 40 Mbps	Speed > 40 Mbps
Ln Download speed$_{t-4}$	-0.00206 (0.00136)	0.00264 (0.00138) ***	0.00730 (0.00211) ***
Ln Employment t$_{t}$	0.00664 (0.00189) ***	0.00525 (0.00168) ***	0.00458 (0.00165) ***
Ln Investment t$_{t-4}$	0.01459 (0.00216) ***	-0.00616 (0.00382)	-0.00085 (0.00481)
Countries included	116	105	49
Observations	2.113	1.792	575
R-Squared	0.9516	0.9262	0.9438

*Note: all estimates include country and quarterly fixed-effects, and controls for GDP growth in the previous period and for broadband penetration. Robust standard errors in brackets. *p<10%, **p<5%, ***p<1%*

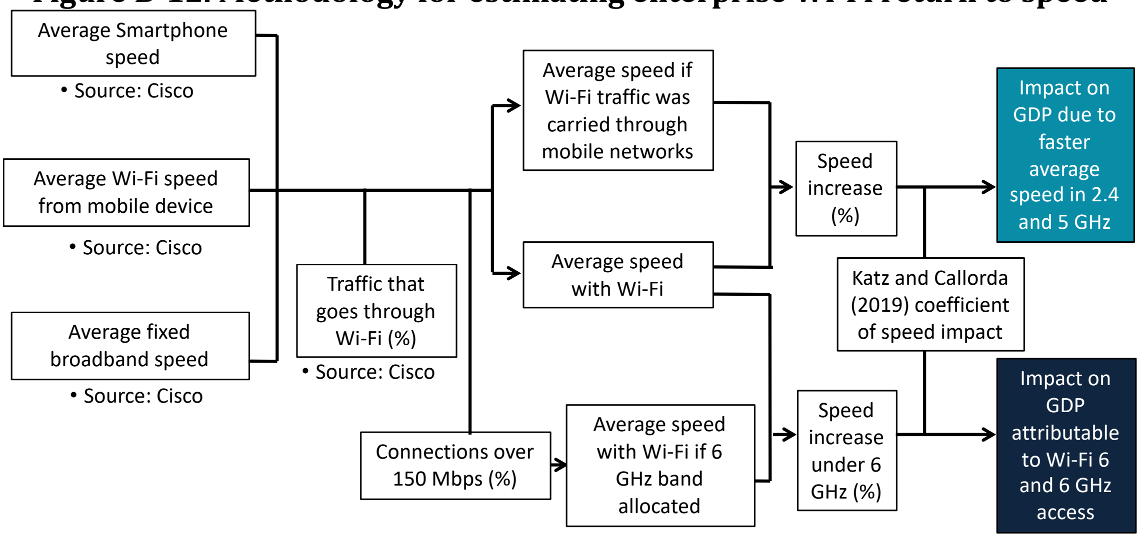
Source: Katz and Callorda (2020)

182 This effect was allocated as part of the economic value related to enterprises as the productivity gains derived from more speed are expected to be especially prominent in the productive sector. However, gains are expected for each economic agent. For instance, individuals enjoying faster speeds will be quicker in performing their online tasks, hence having more spare time for leisure.

The results in Table B-3 suggest that the coefficient that measures the impact of speed on GDP increases with the speed: from non-significant for lower than 10 Mbps speeds to 0.73025 if speeds are doubled for countries above 40 Mbps speed.

To estimate the "return to speed" in enterprise traffic, we first calculate the average speed if the business Wi-Fi traffic were carried through cellular networks and compare it with the average when using Wi-Fi. After finding out the percentage of speed increase by relying on Wi-Fi, we apply the coefficient of GDP impact from Katz and Callorda (2019) to assess the economic contribution (see Figure B-12).

Figure B-12. Methodology for estimating enterprise Wi-Fi return to speed



Source: Telecom Advisory Services

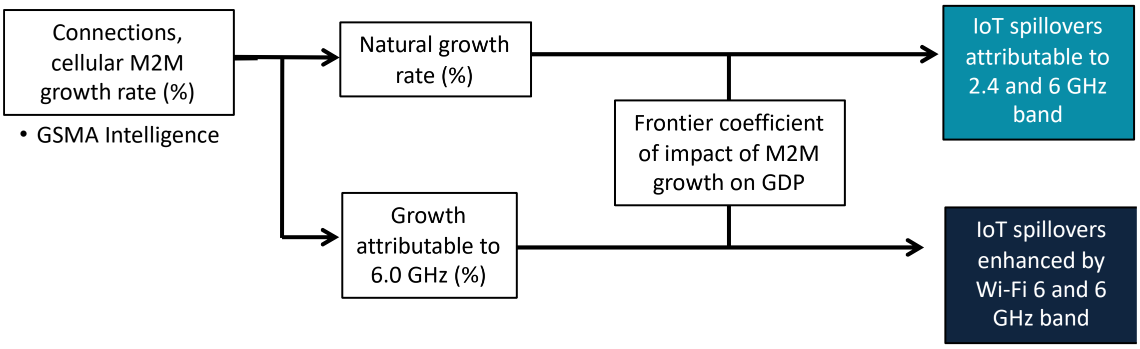
Effects of a return to accelerate speed accelerated due to 6 GHz

The economic value of allocating the 6 GHz band to unlicensed use reduces router congestion, increases Wi-Fi throughput, and has a net effect of accelerating broadband speed. This result does not affect all fixed broadband connections, although its impact among high speed broadband users has a net effect on increasing average broadband speed. As previously described for the case individuals, under current spectrum allocations, the router becomes a choke point in the network for 150 Mbps fixed broadband lines, and the speed experienced will not be equivalent to that delivered by the fixed network. Wi-Fi 6E contributes to overcome this setback, yielding faster speeds, which, in turn, drive a contribution to GDP. Therefore, we calculate the average speed if 6 GHz were allocated, and after assessing the increase with respect to Wi-Fi under the current spectrum bands, we measure the impact of that increased speed on GDP by using Katz and Callorda (2019) coefficient as presented above.

B.2.3.4. IoT deployment

The economic value linked to a wider deployment of IoT in enterprises includes the spillovers that this technology generates on the economy, which is focused on those sectors that are IoT intensive (i.e. logistics, healthcare, natural resources). As research has shown, the use cases associated with IoT (such as predictive maintenance, asset tracking, smart grid demand management, traffic coordination, and the like) have an impact on GDP growth. The evolution of cellular Machine to Machine (M2M) connections will be used jointly with the coefficient of M2M impact on GDP (from Frontier Economics) in order to assess the indirect impact of IoT on GDP (Figure B-13).

Figure B-13. Methodology for estimating IoT spillovers



Source: Telecom Advisory Services

Accelerated effect of IoT due to 6 GHz

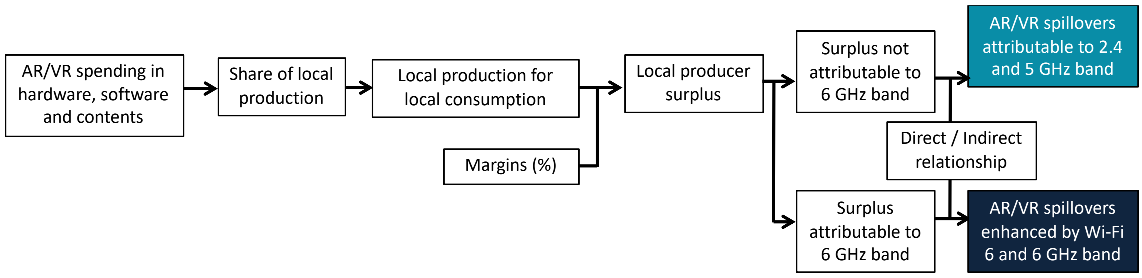
Spectrum availability is one of the barriers to IoT development. While IoT roll-out has already been proceeding for a few years in several countries, large scale deployment has suffered from the risk of congestion. The assignment of the 6 GHz band will result in a broader scale IoT deployment, as it will mitigate congestion. We will compute the economic value added by allocating the 6 GHz band related to the wider deployment of IoT, considering the spillover of IoT on the economy, which is focused on those sectors that are IoT intensive. In order to split the economic contribution linked to 6 GHz from that of the current bands, we will assume that part of the growth in M2M is driven by "natural" growth, and another portion will be triggered by 6 GHz.

B.2.3.5. AR/VR solutions deployment

Virtual Reality (VR) is already being used within a wide array of areas, ranging from the gaming industry and entertainment, to training and simulation, in particular in the medical field. Other areas of application include education and culture, sports, live broadcasting, real estate, advertising, architecture, and the arts. Augmented Reality (AR) has an almost limitless range of use in a wide variety of areas, be it commerce, technical applications, work processes or education. As previously mentioned, AR and VR serve both consumers and professional users that can be private and public.

The adoption of AR/VR among enterprises will in turn have a spillover effect on productivity, thereby contributing to the growth of GDP. The spillover effects range from improved training to the acceleration of product design and delivery. For example, automotive companies are already incorporating virtual reality in their product development processes to reduce the time incurred between initial design and physical modelling. AR glasses also help warehouse workers provide parts information for engineers and technicians in the field. Finally, AR/VR solutions can be used to sell and showcase products in retailing. Figure B-14 describes the methodology used for estimating the AR/VR spillovers.

Figure B-14. Methodology for estimating AR/VR spillovers



Source: Telecom Advisory Services

The direct/indirect relationship ratio was extracted from PwC (2019).

Wider deployment of AR/VR solutions (accelerated effect due to 6 GHz)

As stated for the baseline scenario, the adoption of AR/VR among enterprises produces spillovers effects on productivity, thereby contributing to the growth of GDP. Higher throughput enabled by the allocation of the 6 GHz band is expected to spur the adoption and use of AR/VR among enterprises, hence increasing the associated spillover effects. By relying on a ratio built from 5 GHz and 6 GHz AR/VR related products (from ABI research data[183]), we were able to split the economic contribution from both scenarios.

B.2.4. Internet Service Providers

As detailed in Table B-1, economic gains of ISPs comprise the following effects:

- Expenditure savings: the total cost of ownership—cumulative CAPEX and OPEX—required of cellular operators to accommodate future capacity requirements with Wi-Fi;
- Paid, public Wi-Fi: revenues from Wi-Fi carriers offering paid services in public spaces; and
- Revenues from WISPs.

B.2.4.1. Expenditure savings: total cost of ownership (cumulative CAPEX and OPEX) to accommodate future capacity with Wi-Fi

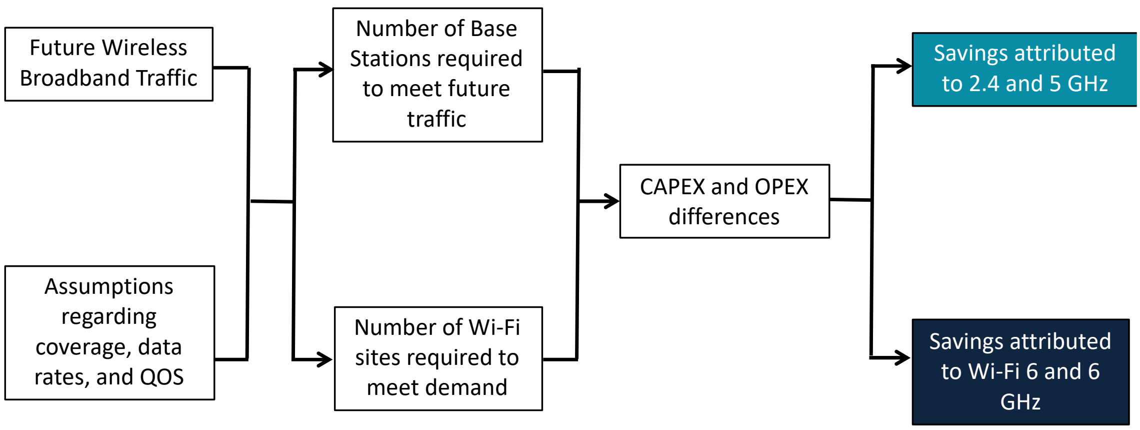
Wi-Fi yields a benefit to the producers of wireless communications. Carrier-class Wi-Fi allows the operator to leverage wideband access (for mobility) and Wi-Fi offloading (for network capacity).[184] By building hybrid networks, carriers preserve

[183] See ABI Research, *Augmented and Mixed Reality Market Data: devices, use cases, verticals and value chain*. MD-ARMR-103, QTR 4 2019, and ABI Research, *Virtual Reality Market Data: devices, verticals, and value chain*. MD-VR-108, QTR 1 2020.
[184] Carriers can also off-load traffic by deploying femtocells, which provide higher capacity. However, since these operate in licensed spectrum bands, they are not part of this analysis.

spectrum and reduce the capital expenditures required to deploy additional base stations.[185] In addition, some service providers also claim they monetize their Wi-Fi offerings by directly charging customers. Carriers also benefit from service differentiation and an improvement in the customer experience.

The estimate of producer surplus is predicated on the assumption that in the absence of Wi-Fi, service providers would have to deploy cellular base stations to accommodate the growth in traffic. For example, a cellular pico-cell (needed to offer access via conventional cellular service) in the United States costs between $7,500 and $15,000,[186] while a carrier-grade Wi-Fi access point requires an investment of $2,500.[187] Thus, the calculation of producer surplus is based on the portion of capital investments (and potential incremental network operations and maintenance operating expenses) that service providers can avoid when they shift allocations from cellular network to carrier-grade Wi-Fi. Thus, the analysis is then based on the following methodology (see Figure B-15).

Figure B-15. Methodology for estimating producer surplus derived from cellular re-routing through Wi-Fi



Source: Telecom Advisory Services

Enhanced capability for cellular off-loading if 6 GHz is allocated

As mentioned before, another source of economic value is based on the complementarity between Wi-Fi and cellular networks, which allows cellular service providers to decrease the capital and operating expenses required to accommodate exploding data traffic. This feature remains for Wi-Fi 6E and 5G. To begin with, access devices like smartphones and sensors will tend to be equipped with both generations for users and service providers to optimize infrastructure use. This will be critical not only for traffic handling in densely packed environments, such as apartment complexes and hospitals, but also to support surveillance cameras, point of sale terminals, environmental sensors, and other IoT devices. Complementarity will also manifest itself at homes and enterprises,

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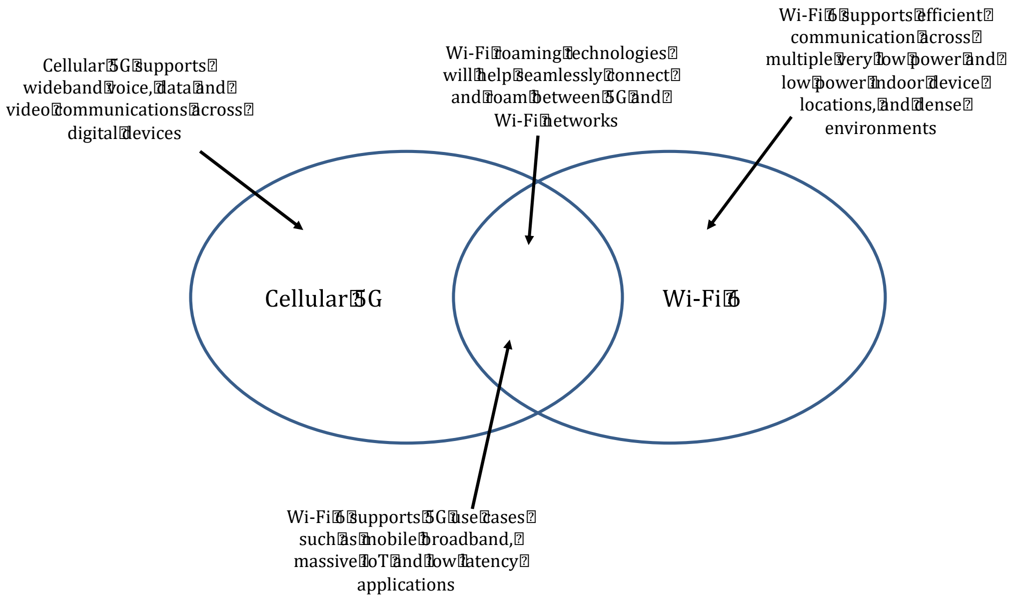
[185] Hybrid network architectures allow wireless operators to shift traffic away from the cellular network, where the capacity constraints are most acute, to cheaper shorter-range small cells network, connected over a variety of backhaul connections.
[186] “When Femtocells become Picocells”, the 3G4G Blog and Ubiquisys.
[187] Cisco Airnet 1552H Wireless Access Point.

although this benefit has already been accounted for in the sections above (see Figure B-16).

Figure B-16. Complementary nature of Wi-Fi 6 and 5G



Sources: Suarez (2020); Telecom Advisory Services analysis

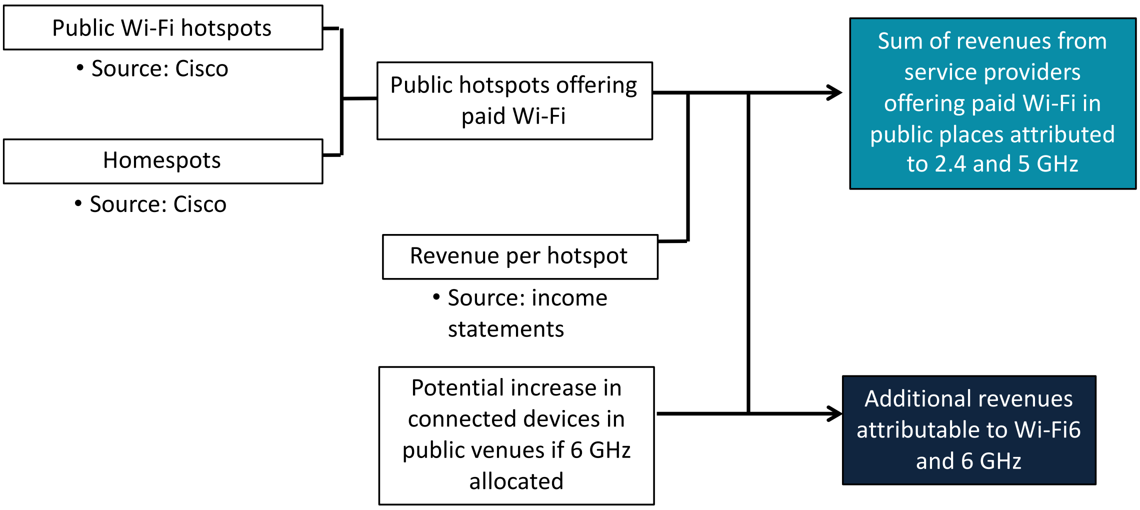
Consequently, the economic value of spectrum allocation in 6 GHz not only manifests itself in the ability of cellular carriers to reduce capital in 5G deployment by off-loading traffic, but, most importantly, to indirectly account for Wi-Fi use in calculating their investment.

B.2.4.2. Wi-Fi carrier revenues

In addition to the value generated by the other effects, Wi-Fi off-loading can create new business opportunities for service providers offering wireless broadband services in public places (airports, hotels) for a fee. In the last three years, operators in this space have deployed next-generation hotspot technologies to replicate the ease of access and security provided by cellular networks. At the same time, to facilitate interoperability, they are signing roaming agreements. From a business model standpoint, innovation has allowed this sector to expand beyond the original pay-as-you-go access offering. In particular, it is worth mentioning retailer "push" marketing and promotions, neutral host provision to multiple cellular carriers, and bandwidth exchange for Wi-Fi capacity[188] (Maravedis-Rethink, 2013).

[188] BandwidthX offers an open market exchange of capacity between public Wi-Fi operators and any partners in need of Wi-Fi capacity. The solution allows carriers to bid for and purchase Wi-Fi capacity dynamically from available WISPs, with pricing based on a range of network selection policies, including place, time of day, etc.

Figure B-17. Methodology for estimating the economic value generated by paid public Wi-Fi services



Source: Telecom Advisory Services

The methodology described in Figure B-17 starts by estimating the number of paid access points, subtracting the home spots from overall public hotspots reported by Cisco. Revenue per hotspots is estimated from the financial statements of the biggest enterprises offering these services. Once the number of public hotspots is estimated, this can be multiplied by the revenue expected for each one, allowing a straightforward assessment of the overall revenue figures.

Increased revenues of Wi-Fi carriers in public places due to 6 GHz

When the 6 GHz band is opened and added to the existing unlicensed bands in 2.4 GHz and 5 GHz, a higher number of devices will be supported by each access points. Therefore, Wi-Fi carriers offering paid services in public places will be able to widen their user base and increase revenues. By assuming a conservative growth of 40% in their user base, weighted by the expected gradual increase in traffic over the 6 GHz channels, we can calculate the additional revenues attributed to 6 GHz.

B.2.4.3. Wireless ISP revenue

Revenues from WISPs would not exist if Wi-Fi technology was not available. By considering the estimated ARPU figures from WISP providers and their user base, it is straightforward to estimate overall revenues for these players.

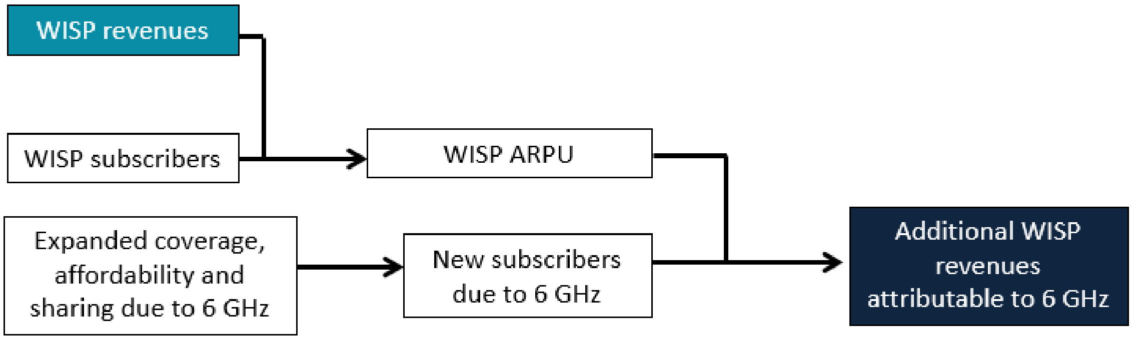
Increased revenues of WISPs due to 6 GHz[189]

As described before in section 2.5, the allocation of the 6 GHz band is expected to increase the number of WISP subscribers due to expanded coverage, better

[189] Another potential gain for WISPs from opening the 6 GHz band is derived from increased capacity in backhaul, that is, in the network linking the consumer connection point (edge network) and the core network (Internet connection point). This higher throughput can be leveraged to bring down CAPEX requirements, hence, the producer surplus is increased. However, due to lack of reliable data, this specific effect was not assessed.

affordability, and potential sharing. Considering the WISP average revenue per user (ARPU) and the estimated incremental subscriptions, it is straightforward to assess the additional revenue figures after the 6 GHz band is opened. Figure B-18 describes this procedure.

Figure B-18. Methodology for estimating the economic value generated by WISPs as a result of Wi-Fi 6 and 6 GHz



Source: Telecom Advisory Services

B.2.5. Wi-Fi ecosystem

Wi-Fi technology generates value for IT companies from the following sources:

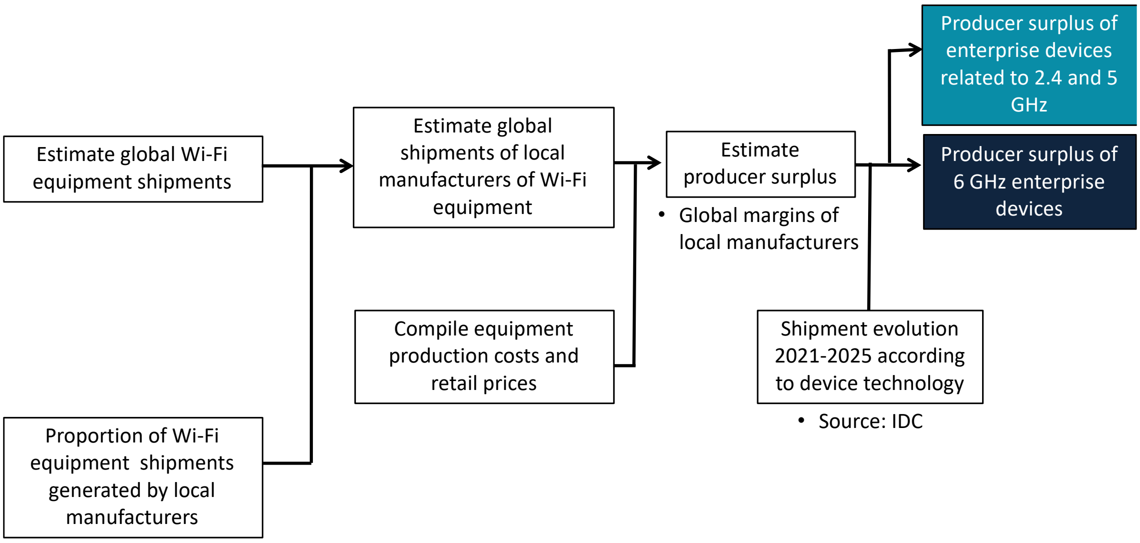
- Producer surplus derived from locally manufactured Wi-Fi devices and equipment for residential and enterprise use; and
- Margins from firms belonging to the ecosystem of IoT and AR/VR.

B.2.5.1. Locally manufactured residential Wi-Fi devices and equipment

The difference between market prices and locally manufactured costs of Wi-Fi enabled residential products represents the manufacturer's margin and, consequently, producer surplus. Such products include those previously reported in Table B-2.

Once the list of equipment is defined, we start by compiling statistics on worldwide shipments (even if a piece of locally produced equipment is shipped beyond the borders of the local market, that yields economic value to the country of origin). With these statistics, we calculate average retail value and gross margins. The margin represents producer surplus. An alternative approach could have been to consider the weight of the production of devices in the GDP, rather than the production surplus. However, a deep analysis suggested that a large share of the costs of these enterprises are attributed to equipment imports, which means that part of the economic value is originated abroad if we followed this approach. Therefore, we understand that it is more appropriate to measure this economic contribution as producer surplus.

Figure B-19. Methodology for estimating economic value derived from locally manufactured Wi-Fi devices



Source: Telecom Advisory Services

Locally manufactured Wi-Fi 6 devices and equipment for residential use

As we have seen before, we will follow the forecasts provided by IDC regarding the evolution of consumer devices shipments until 2025 in order to extrapolate the evolution of those Wi-Fi 6 devices and equipment, and therefore, the producer surplus generated as a result.

B.2.5.2. Locally manufactured enterprise Wi-Fi devices and equipment

The procedure to estimate the producer surplus attributed to enterprise devices and equipment is like that for residential products, although focusing exclusively on access points and controllers for enterprises. To isolate the economic contribution of Wi-Fi 6 devices and equipment, we will follow the forecasts provided by IDC regarding the evolution of shipments for industrial purposes of 802.11ax devices for the 6 GHz band.

B.2.5.3. Firms belonging to the IoT ecosystem

The economic value linked to a wider deployment of IoT includes the development of firms within the IoT ecosystem, which generate a producer surplus (i.e. margin) through selling their output. It is important to distinguish the different components of the ecosystem, which includes hardware, software, and services. As it is clear, this distinction is grounded in traditional IT components, although their combination within the IoT value proposition represents a different format. The ecosystem contributing to delivery of the IoT economic value comprises multiple types of companies (see Table B-4).

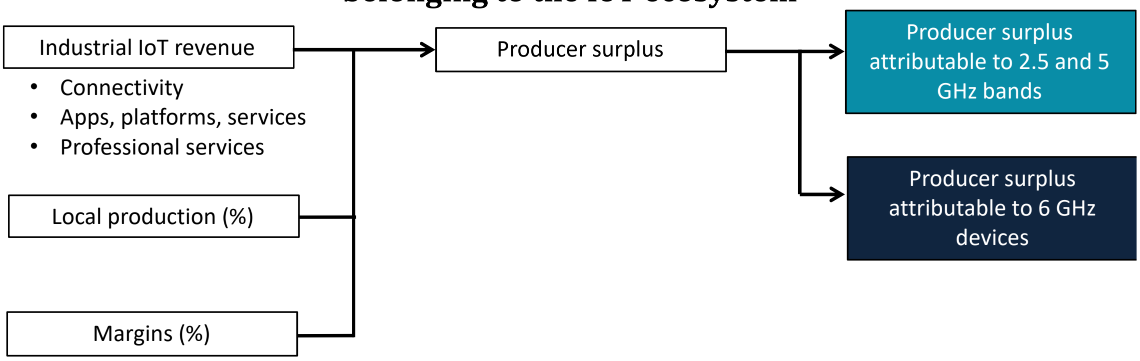
Table B-4. IoT Ecosystem

Categories	Components	Type of firms
Hardware	Sensors/chips	Manufacturers of sensors and compute components
	Miniature devices	Specialized providers of small-scale sensors
	Connectivity	Manufacturers of network equipment
Software	Apps	Connectivity software
	Cloud service providers	Software provided by public cloud providers
	Platform providers	New operating systems
	Carriers	Telecom players providing cloud-based solutions
Services	Systems integration	Integration of devices and components within a single platform
	Analytics	Providers of data warehousing and analytic tools
	IT services	Platform providers
	Security	Developers of security protocols and technologies

Source: Telecom Advisory Services

The methodology for estimating economic value derived from firms belonging to the IoT ecosystem is described in Figure B-20.

Figure B-20. Methodology for estimating economic value derived from firms belonging to the IoT ecosystem



Source: Telecom Advisory Services

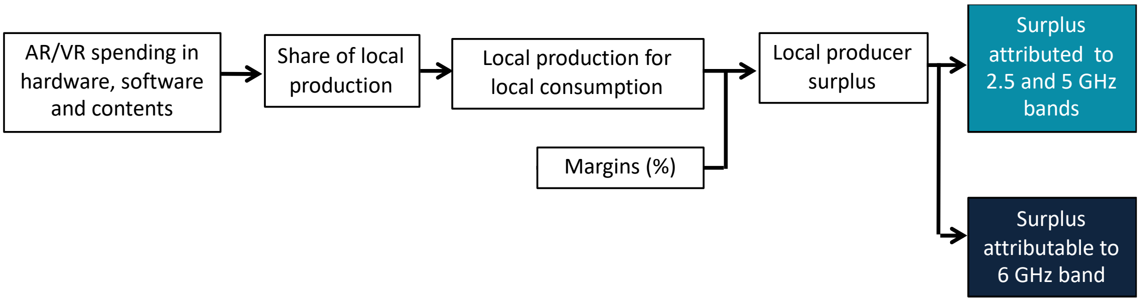
Wider deployment of Internet of Things under 6 GHz

The assignment of the 6 GHz band will result in a broader scale IoT deployment. Thus, we will compute the economic value added by allocating the 6 GHz band related to the wider deployment of IoT specifically related to the development of firms within the IoT ecosystem, which generate a producer surplus (i.e. margin) by selling.

B.2.5.4. Firms belonging to the AR/VR ecosystem

As stated above, the AR/VR solutions market is developing at a fast pace driven by a broad range of applications. The development and diffusion of AR/VR applications in the production side of the economy is being driven by an ecosystem comprised of firms ranging from software development to hardware production and applications development. The margins of firms involved in this endeavor represent producer surplus (Figure B-21).

Figure B-21. Methodology for estimating economic value derived from firms belonging to the AR/VR ecosystem



Source: Telecom Advisory Services

Wider deployment of AR/VR solutions if 6 GHz allocated

The introduction of Wi-Fi 6E is expected to accelerate the development and diffusion of AR/VR applications. As one of the economic effects of AR/VR is related to the production of firms belonging to its ecosystem (software, hardware, applications development), the margins of those firms represent producer surplus. In this section we will calculate the margins specifically attributed to developments linked to Wi-Fi 6E.

B.2.6. Wi-Fi contribution to employment

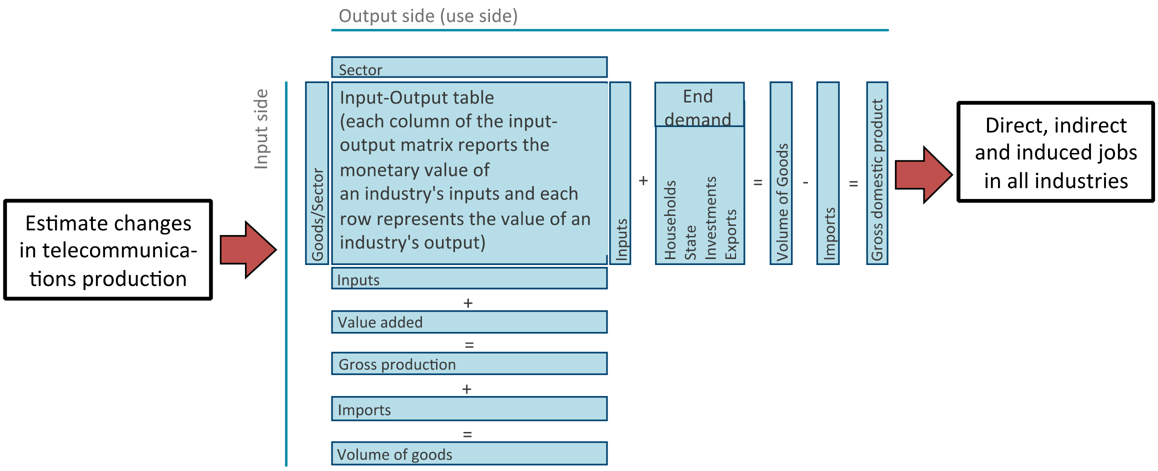
This economic technique, which measures the interdependence of an economy's various productive sectors, has been applied to estimate what the impact on all sectors of employment might be because of changes in output of the telecommunications sector. According to this approach, telecommunications output related to Wi-Fi is defined as a factor of production of other goods and services, creating spillover economic effects, with significant job creation effects.

- Employment effects are calculated based on input/output table (I/O table) for each country's economy. I/O tables depict the interdependencies between economic sectors and are used to estimate the impact of positive or negative economic shocks through an economy.

- I/O tables assume that some inputs are used by sectors that produce output (intermediate output), which in turn is sold to another sector for consumption (final output); total output adds intermediate and final outputs. By using labor productivities, one can calculate job creation from output.

The structure of an I/O table comprises horizontal rows describing how an industry's total output is divided among various production processes and final consumption, and each column denotes the combination of productive resources used within one industry (see Figure B-22).

Figure B-22. Example of an Input / Output Table



Source: Katz (2012)

Each country has a specific table to reflect the particularities of its economy.

In order to calculate employment impact, the multiplier cumulative impact on GDP resulting from the effects analyzed above would become an input that would generate employment effects through different sectors of the economy of the country under study. Employment effects can be disaggregated among direct, indirect, and induced.

C. COMPARISON OF CURRENT STUDY WITH PRIOR STUDY RESULTS

C.1. The 2018 study assessing the global value of Wi-Fi

In 2018, we published a study assessing the worldwide economic value of Wi-Fi.[190] The study's purpose was to measure Wi-Fi's economic surplus to consumers and producers, as well as Wi-Fi's direct net contribution to output (Gross Domestic Product, or GDP) and employment between 2018 and 2023. The analysis focused on the United States, United Kingdom, France, Germany, Japan, and South Korea and used the detailed country estimates to extrapolate the results to the whole world. We concluded at the time that global economic value of Wi-Fi in 2018 was $1.96 trillion, and that by 2023, global value of Wi-Fi should increase to $3.47 trillion[191] (see Table C-1).

Table C-1. Wi-Fi Global Economic Value (2018 Study) (in $billion)

	2018	2023
United States	$499.1	$1,002.4
United Kingdom	$54.5	$71.2
France	$44.2	$63.9
Germany	$94.0	$132.0
Japan	$171.5	$247.5
South Korea	$67.6	$137.6
Six countries total	$930.9	$1,654.6
Rest of World	$1,033.7	$1,827.1
Total	$1,964.6	$3,472.7

Source: Katz, R. and Callorda, F. (2018a). The Economic value of Wi-Fi: A Global View (2018 and 2023). New York: Telecom Advisory Services.

The study also estimated that, as a derived contribution to economic value, Wi-Fi generated 616,000 jobs in 2018 and was expected to create 934,000 jobs in 2023.

Significant changes have taken place since 2018 in the Wi-Fi ecosystem, warranting a new study. Starting in 2019, Wi-Fi equipment manufacturers launched Wi-Fi 6, a sixth generation of consumer and enterprise Wi-Fi devices offering higher performance, lower latency, and faster data rates. Concurrently with the launch of Wi-Fi 6 and in anticipation of the WRC-23 conference of the International Telecommunication Union, regulators in many countries have recognized the importance of unlicensed spectrum in driving the performance of Wi-Fi. Triggered by the allocation of new Wi-Fi spectrum and the release of Wi-Fi 6 and Wi-Fi 6E devices capable of operating in the 6 GHz band, new sources of Wi-Fi economic value have become prominent since our 2018 study. For example, the creation of a Very Low Power (VLP) device category will enable the deployment of a new generation of Augmented Reality/Virtual solutions and unlock wide deployment of IoT devices. In sum, the combination of enhanced devices, additional unlicensed spectrum, and new sources of value has yielded an increase in Wi-Fi economic contribution when compared to the 2018-23 study estimate.

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[190] Katz, R. and Callorda, F. (2018a). *The Economic value of Wi-Fi: A Global View (2018 and 2023).* New York: Telecom Advisory Services. October.
[191] All values in this report are in U.S. dollars.

In parallel with the changes in the Wi-Fi technology and the regulatory context, a major disruption has taken place in the world economy. COVID-19 has resulted in a downward adjustment in the economic forecast. While before the pandemic the world economy was projected to grow at 2.90% in 2020, the International Monetary Fund now projects a contraction of 6.10%. This revised perspective has had an impact of the base upon which Wi-Fi's economic value is projected.

To trace the new projections vis-à-vis the 2018-2023 study, we estimate Wi-Fi economic value for two scenarios: (i) a baseline case that addresses only Wi-Fi's value dependent on the 2.4 GHz and 5 GHz original unlicensed bands, and (ii) an acceleration scenario of value creation considering the 6 GHz spectrum band allocation and the release of Wi-Fi 6 equipment. Both scenarios reflect the changes in the economic context.

C.2. Increase in the value of Wi-Fi in the original unlicensed bands

The changes in the Wi-Fi ecosystem, while occurring concurrently with the economic contraction, have yielded an increase in Wi-Fi value. As indicated in Table C-1, the updated Wi-Fi value for the six countries analyzed in the 2018 study is estimated at $1,602.6 billion in 2021 and projected to reach $2,165.8 billion in 2025.

Table C-1. Wi-Fi Economic Value: 2018 Study versus Current Study (in $Billions)

		2021	2022	2023	2024	2025
United States	2018-2023 Study	$801.8	$894.8	$1,002.4		
	Current study (baseline scenario)	$979.0	$1,026.0	$1,115.8	$1,243.8	$1,392.7
United Kingdom	2018-2023 Study	$64.0	$67.5	$71.2		
	Current study (baseline scenario)	$96.9	$93.2	$87.6	$91.9	$97.8
France	2018-2023 Study	$55.2	$59.4	$63.9		
	Current study (baseline scenario)	$61.2	$63.4	$73.2	$83.0	$95.0
Germany	2018-2023 Study	$115.3	$123.6	$132.0		
	Current study (baseline scenario)	$132.6	$135.4	$140.2	$149.9	$158.0
Japan	2018-2023 Study	$213.7	$230.0	$247.5		
	Current study (baseline scenario)	$245.7	$246.5	$240.5	$267.5	$296.2
South Korea	2018-2023 Study	$103.5	$119.3	$137.6		
	Current study (baseline scenario)	$87.2	$93.4	$102.6	$113.5	$126.1
Six countries	2018-2023 Study	$1,353.5	$1,494.6	$1,654.6		
	Current study (baseline scenario)	$1,602.6	$1,657.9	$1,759.9	$1,949.6	$2,165.8

Note: It should be noted that the decline economic value in 2023 in Japan is due to a decreasing growth rate of M2M and IoT installed base.
Source: Katz, R. and Callorda, F. (2018a). The Economic value of Wi-Fi: A Global View (2018 and 2023). New York: Telecom Advisory Services; Telecom Advisory Services analysis

While our original estimate for the baseline scenario (that is, without considering Wi-Fi 6 and the 6 GHz allocation) for the six countries in 2023 amounted to $1,654.6 billion, the consideration of new sources of value in the updated study has resulted in an increase to $1,759.9 billion for the same year (an increase of 6.36%). The increase between the two forecasts is primarily due to the following factors:

- In most countries Wi-Fi traffic has grown at a faster rate than originally envisioned (the only exception being Japan);

- Wi-Fi speed from mobile devices has increased faster than originally forecasted, yielding a larger economic impact;
- New sources of economic value have become more relevant in this study and must be addressed:
  - Contribution of free Wi-Fi to provide Internet to unconnected households (a critical contribution to address the digital divide under the ongoing pandemic);
  - Consumer surplus (social benefit) derived from the increase of Wi-Fi speed as an enabler of new applications; and
  - Accelerated deployment of Internet of Things and Augmented Reality/Virtual Reality solutions with their corresponding economic spillovers.

To reiterate, despite the economic contraction caused by COVID-19, the economic value of Wi-Fi in the six countries originally studied has continued to grow over time despite momentary declines. That said, the economic value of Wi-Fi will undergo an additional boost, driven by the launch of Wi-Fi 6 and the corresponding allocation of 6 GHz spectrum to Wi-Fi.

C.3. Increase in Wi-Fi value yielded by Wi-Fi 6 and the allocation of the 6 GHz band

The sum of the value in the traditional Wi-Fi spectrum bands coupled with the additional boost driven by Wi-Fi 6, Wi-Fi 6E, and the 6 GHz band will yield an increase in economic value for the six countries originally studied, amounting to $1,631.2 billion in 2021 and reaching $2,430.4 billion in 2025 for the six countries analyzed in the 2018 study (see Table C-2).

Table C-2. Six countries in 2018 study: Wi-Fi Economic Value (in $Billions)

		2021	2022	2023	2024	2025
United States	2018-2023 Study	$801.8	$894.8	$1,002.4		
	Current study (baseline scenario)	$979.0	$1,026.0	$1,115.8	$1,243.8	$1,392.7
	Current study (Wi-Fi 6 and 6 GHz)	$16.0	$56.8	$93.1	$134.9	$187.4
	Current Study (total)	$995.0	$1,082.8	$1,208.9	$1,378.7	$1,580.1
United Kingdom	2018-2023 Study	$64.0	$67.5	$71.2		
	Current study (baseline scenario)	$96.9	$93.2	$87.6	$91.9	$97.8
	Current study (Wi-Fi 6 and 6 GHz)	$1.9	$3.9	$5.6	$8.0	$10.7
	Current Study (total)	$98.8	$97.1	$93.2	$99.9	$108.5
France	2018-2023 Study	$55.2	$59.4	$63.9		
	Current study (baseline scenario)	$61.2	$63.4	$73.2	$83.0	$95.0
	Current study (Wi-Fi 6 and 6 GHz)	$1.3	$3.7	$6.2	$8.2	$9.0
	Current Study (total)	$62.5	$67.1	$79.4	$91.2	$104.0
Germany	2018-2023 Study	$115.3	$123.6	$132.0		
	Current study (baseline scenario)	$132.6	$135.4	$140.2	$149.9	$158.0
	Current study (Wi-Fi 6 and 6 GHz)	$1.9	$5.1	$8.4	$12.0	$15.3
	Current Study (total)	$134.5	$140.5	$148.6	$161.9	$173.3
Japan	2018-2023 Study	$213.7	$230.0	$247.5		
	Current study (baseline scenario)	$245.7	$246.5	$240.5	$267.5	$296.2
	Current study (Wi-Fi 6 and 6 GHz)	$5.4	$10.9	$15.0	$21.0	$28.7
	Current Study (total)	$251.1	$257.4	$255.5	$288.5	$324.9
South Korea	2018-2023 Study	$103.5	$119.3	$137.6		
	Current study (baseline scenario)	$87.2	$93.4	$102.6	$113.5	$126.1

		2021	2022	2023	2024	2025
	Current study (Wi-Fi 6 and 6 GHz)	$2.1	$5.1	$7.9	$10.6	$13.4
	Current Study (total)	$89.3	$98.5	$110.5	$124.1	$139.5
Six countries total	2018-2023 Study	$1,353.5	$1,494.6	$1,654.6		
	Current study (baseline scenario)	$1,602.6	$1,657.9	$1,759.9	$1,949.6	$2,165.8
	Current study (Wi-Fi 6 and 6 GHz)	$28.6	$85.5	$136.2	$194.7	$264.6
	Current Study (total)	$1,631.2	$1,743.4	$1,896.1	$2,144.3	$2,430.4

Source: Katz, R. and Callorda, F. (2018a). The Economic value of Wi-Fi: A Global View (2018 and 2023). New York: Telecom Advisory Services; Telecom Advisory Services analysis

When compared to the 2018 study estimate for 2023, the economic value of Wi-Fi for the six countries originally studied has increased by 15.6%. The value derived from Wi-Fi 6, and the devices operating in the 6 GHz band represent the primary driving force behind the future growth of Wi-Fi's economic value. Given the compound annual growth rates of the baseline scenario (5.02%) versus the 6 GHz outlook (61.53%), it is fair to conclude that the latter represents the primary source of economic growth going forward.

The importance of Wi-Fi 6 devices and the allocation of the 6 GHz spectrum increases the economic value of Wi-Fi as a result of the following factors, among others:

- Wi-Fi 6 represents an important performance improvement in comparison to prior generations, supporting a higher number of devices on a single public access point, allowing WISPs to increase the number of subscribers within their same coverage footprint;
- Through the use of multiple bands and spatial streams, Wi-Fi 6 routers have total throughput capabilities well in excess of the speeds they can enable for individual devices, eliminating congestion and, consequently driving additional consumer benefit;
- Enterprises benefit from additional Wi-Fi speed and the enablement of newly developed use cases built around advanced technologies such as AR/VR; and
- Wi-Fi 6 will result in a broader scale of IoT deployment, without the risk of congestion.

C.4. Economic value of Wi-Fi in new countries included in this study

The combination of all the changes that have taken place since the publication of our 2018 study have prompted us to develop an updated version of Wi-Fi's global economic value. In addition, since Wi-Fi has become a more prevalent communications technology around the world, it has required us to enhance our original assessment by adding countries to the detailed analysis. More specifically, in Europe the economic value for Poland and Spain was also calculated. In Asia Pacific, we conducted assessments for Australia, India, New Zealand, and Singapore. In Latin America, the economic value of Wi-Fi was estimated for Brazil, Mexico, and Colombia. We also added detailed assessments in Middle East and North Africa (Egypt, Jordan, Morocco, Oman, and Saudi Arabia), and Sub-Saharan Africa (Cameroon, Democratic Republic of Congo, Gabon, Kenya, Nigeria, Senegal, South Africa, and Uganda). The combined value of Wi-Fi derived from the baseline scenario and the availability of Wi-Fi 6 and the 6 GHz band for these nations in 2021 amounts to $522.1billion, reaching $824.7 billion in 2025 (see Table C-3).

Table C-3. New countries under study: Wi-Fi Economic Value (in $Billions)

		2021	2022	2023	2024	2025
Spain	Current study (baseline scenario)	$39.7	$39.6	$41.8	$44.7	$49.6
	Current study (Wi-Fi 6 and 6 GHz)	$0.6	$2.1	$3.5	$4.5	$4.5
	(Current Study (total)	$40.4	$41.8	$45.3	$49.2	$54.1
Poland	Current study (baseline scenario)	$15.9	$15.8	$16.0	$15.9	$15.9
	Current study (Wi-Fi 6 and 6 GHz)	$0.2	$1.6	$3.1	$4.6	$5.7
	(Current Study (total)	$16.1	$17.3	$19.1	$20.6	$21.6
Australia	Current study (baseline scenario)	$34.1	$28.0	$31.2	$33.3	$36.3
	Current study (Wi-Fi 6 and 6 GHz)	$0.6	$1.6	$2.9	$4.1	$5.4
	(Current Study (total)	$34.7	$29.6	$34.1	$37.4	$41.7
India	Current study (baseline scenario)	$130.0	$134.3	$145.1	$160.2	$176.8
	Current study (Wi-Fi 6 and 6 GHz)	$1.2	$13.2	$26.4	$45.2	$63.4
	(Current Study (total)	$131.3	$147.5	$171.5	$205.4	$240.2
New Zealand	Current study (baseline scenario)	$6.6	$6.7	$7.3	$8.0	$8.8
	Current study (Wi-Fi 6 and 6 GHz)	$0.1	$0.3	$0.5	$0.7	$1.0
	(Current Study (total)	$6.7	$7.0	$7.8	$8.7	$9.8
Singapore	Current study (baseline scenario)	$10.4	$7.2	$8.3	$9.4	$10.4
	Current study (Wi-Fi 6 and 6 GHz)	$0.2	$0.5	$0.9	$1.4	$2.0
	(Current Study (total)	$10.6	$7.7	$9.2	$10.8	$12.4
Brazil	Current study (baseline scenario)	$102.5	$100.7	$117.8	$104.6	$109.6
	Current study (Wi-Fi 6 and 6 GHz)	$2.7	$4.6	$8.8	$11.5	$14.7
	(Current Study (total)	$105.2	$105.3	$126.6	$116.2	$124.4
Mexico	Current study (baseline scenario)	$56.0	$64.4	$76.4	$90.9	$109.0
	Current study (Wi-Fi 6 and 6 GHz)	$0.6	$2.2	$4.0	$6.3	$8.5
	(Current Study (total)	$56.7	$66.7	$80.3	$97.3	$117.5
Colombia	Current study (baseline scenario)	$18.7	$20.4	$22.6	$30.8	$36.0
	Current study (Wi-Fi 6 and 6 GHz)	$0.2	$1.0	$2.0	$3.4	$5.4
	(Current Study (total)	$18.9	$21.4	$24.6	$34.1	$41.4
Egypt	Current study (baseline scenario)	$9.0	$9.0	$9.6	$10.4	$16.3
	Current study (Wi-Fi 6 and 6 GHz)	$0.1	$0.3	$0.5	$0.7	$0.9
	(Current Study (total)	$9.1	$9.3	$10.1	$11.1	$17.2
Jordan	Current study (baseline scenario)	$2.2	$2.1	$2.2	$2.2	$2.5
	Current study (Wi-Fi 6 and 6 GHz)	$0.0	$0.2	$0.4	$0.7	$1.5
	(Current Study (total)	$2.2	$2.3	$2.7	$2.8	$4.1
Morocco	Current study (baseline scenario)	$6.0	$6.3	$8.2	$5.6	$6.2
	Current study (Wi-Fi 6 and 6 GHz)	$0.1	$0.3	$0.6	$0.9	$1.3
	(Current Study (total)	$6.1	$6.7	$8.8	$6.5	$7.5
Oman	Current study (baseline scenario)	$2.6	$2.6	$2.7	$2.6	$2.6
	Current study (Wi-Fi 6 and 6 GHz)	$0.0	$0.1	$0.2	$0.3	$0.4
	(Current Study (total)	$2.6	$2.7	$2.8	$2.9	$3.0
Saudi Arabia	Current study (baseline scenario)	$16.9	$16.3	$15.9	$16.4	$17.9
	Current study (Wi-Fi 6 and 6 GHz)	$0.4	$1.1	$1.8	$2.8	$5.8
	(Current Study (total)	$17.3	$17.3	$17.7	$19.3	$23.7
Cameroon	Current study (baseline scenario)	$1.0	$1.2	$1.4	$1.7	$2.3
	Current study (Wi-Fi 6 and 6 GHz)	$0.0	$0.0	$0.1	$0.1	$0.2
	(Current Study (total)	$1.0	$1.2	$1.5	$1.8	$2.6
DRC	Current study (baseline scenario)	$0.7	$0.7	$0.8	$0.9	$1.4
	Current study (Wi-Fi 6 and 6 GHz)	$0.0	$0.1	$0.2	$0.3	$0.4
	(Current Study (total)	$0.7	$0.8	$1.0	$1.2	$1.8
Gabon	Current study (baseline scenario)	$0.6	$0.6	$0.7	$0.9	$1.1
	Current study (Wi-Fi 6 and 6 GHz)	$0.0	$0.0	$0.0	$0.1	$0.1

		2021	2022	2023	2024	2025
	(Current Study (total)	$0.6	$0.7	$0.8	$0.9	$1.2
Kenya	Current study (baseline scenario)	$12.2	$12.0	$12.6	$14.4	$15.3
	Current study (Wi-Fi 6 and 6 GHz)	$0.0	$0.2	$0.4	$0.7	$1.0
	(Current Study (total)	$12.2	$12.2	$13.0	$15.1	$16.3
Nigeria	Current study (baseline scenario)	$15.9	$17.6	$22.5	$24.3	$29.8
	Current study (Wi-Fi 6 and 6 GHz)	$0.2	$0.6	$1.3	$2.4	$3.3
	(Current Study (total)	$16.1	$18.2	$23.8	$26.7	$33.1
Senegal	Current study (baseline scenario)	$1.2	$1.4	$1.7	$2.1	$2.8
	Current study (Wi-Fi 6 and 6 GHz)	$0.0	$0.0	$0.0	$0.0	$0.1
	(Current Study (total)	$1.2	$1.4	$1.7	$2.1	$2.8
South Africa	Current study (baseline scenario)	$30.7	$34.3	$37.5	$42.0	$41.1
	Current study (Wi-Fi 6 and 6 GHz)	$0.1	$0.8	$1.5	$2.3	$3.1
	(Current Study (total)	$30.9	$35.1	$39.0	$44.2	$44.2
Uganda	Current study (baseline scenario)	$1.4	$1.7	$2.0	$3.4	$4.0
	Current study (Wi-Fi 6 and 6 GHz)	$0.0	$0.1	$0.1	$0.2	$0.2
	(Current Study (total)	$1.4	$1.8	$2.1	$3.6	$4.2
Total new countries	Current study (baseline scenario)	$514.5	$522.9	$584.3	$624.7	$695.7
	Current study (Wi-Fi 6 and 6 GHz)	$7.6	$31.1	$59.1	$93.3	$129.0
	(Current Study (total)	$522.1	$554.0	$643.5	$717.9	$824.7

Source: Telecom Advisory Services analysis

C.5. An updated view of Wi-Fi economic value

The economic value calculated in detail for fourteen countries was used to estimate through a leading indicators methodology the total value for the European Union and the world. In summary, Wi-Fi global economic value according to the current study in 2021 is $3,302.1 billion and is expected to reach $4,875.9 billion by 2025. For comparative purposes, the estimation for the global economy calculated for 2023 in the 2018 study was $3,472.4 billion. The updated view accounting for new sources of value and the effect of Wi-Fi 6 and the allocation of the 6 GHz band is 11 percent higher (see Table C-4).

Table C-4. Wi-Fi Economic Value (in $Billions)

	2021	2022	2023	2024	2025
United States	$995.0	$1,082.8	$1,208.9	$1,378.7	$1,580.1
United Kingdom	$98.8	$97.1	$93.2	$99.9	$108.5
France	$62.5	$67.1	$79.4	$91.2	$104.0
Germany	$134.5	$140.5	$148.6	$161.9	$173.3
Spain	$40.4	$41.7	$45.3	$49.2	$54.1
Poland	$16.1	$17.3	$19.1	$20.4	$21.6
Rest of European Union	$204.1	$214.7	$235.4	$259.8	$284.2
Australia	$34.7	$29.6	$34.0	$37.4	$41.7
India	$131.3	$147.5	$171.5	$205.4	$240.2
Japan	$251.1	$257.4	$255.5	$288.5	$324.9
South Korea	$89.3	$98.5	$110.5	$124.1	$139.5
New Zealand	$6.7	$7.0	$7.8	$8.7	$9.8
Singapore	$10.6	$7.7	$9.2	$10.8	$12.4
Brazil	$105.2	$105.3	$126.6	$116.1	$124.3
Mexico	$56.6	$66.6	$80.3	$97.2	$117.5
Colombia	$18.9	$21.4	$24.6	$34.2	$41.4
Egypt	$9.1	$9.3	$10.1	$11.1	$17.2
Jordan	$2.2	$2.3	$2.7	$2.8	$4.1
Morocco	$6.1	$6.7	$8.8	$6.5	$7.5
Oman	$2.6	$2.7	$2.8	$2.9	$3.0
Saudi Arabia	$17.3	$17.3	$17.7	$19.3	$23.7
Cameroon	$1.0	$1.2	$1.5	$1.8	$2.6
DRC	$0.7	$0.8	$1.0	$1.2	$1.8
Gabon	$0.6	$0.7	$0.8	$0.9	$1.2
Kenya	$12.2	$12.2	$13.0	$15.1	$16.3
Nigeria	$16.1	$18.2	$23.8	$26.7	$33.1
Senegal	$1.2	$1.4	$1.7	$2.1	$2.8
South Africa	$30.9	$35.1	$39.0	$44.2	$44.2
Uganda	$1.4	$1.8	$2.1	$3.6	$4.2
Rest of World	$944.5	$992.3	$1,076.6	$1,195.7	$1,336.5
Total World	$3,302.1	$3,504.1	$3,851.5	$4,317.4	$4,875.9

Source: Telecom Advisory Services analysis

In addition to the economic surplus benefitting consumers and enterprises, Wi-Fi represents a net contribution to the GDP of all nations driven by productivity spillovers (for example in IoT and VR/AR) and revenues of providers of Wi-Fi services, such as WISPs and operators of Wi-Fi services (see Table C-5).

Table C-5. Total world: Wi-Fi enabled GDP contribution (2021-2025)

Year	GDP contribution enabled by Wi-Fi ($Billion)		
	Attributed to 2.4 and 5 GHz bands	Attributed to Wi-Fi 6 / 6 GHz	Total
2021	$626.3	$23.7	$650.0
2022	$537.1	$86.2	$623.2
2023	$480.3	$138.8	$619.1
2024	$504.4	$198.1	$702.5
2025	$541.6	$264.6	$806.3

Source: Telecom Advisory Services analysis

Based on its GDP contribution, Wi-Fi will generate approximately 3,200,000 jobs in 2021 and is expected to generate over 4,000,000 in 2025 worldwide (see Table C-6).

Table C-6. Wi-Fi Economic Value: Employment impact

	2021	2022	2023	2024	2025
United States	541,626	549,985	561,743	622,480	720,804
United Kingdom	95,268	68,757	33,756	38,291	44,906
France	34,646	42,936	52,907	67,478	82,493
Germany	92,969	81,425	73,468	81,312	89,934
Spain	32,900	33,916	41,579	49,630	54,409
Poland	29,506	30,627	39,326	49,149	53,730
Rest of European Union	152,994	152,095	166,890	199,328	225,896
Australia	22,303	25,139	31,623	34,236	37,813
India	251,607	273,321	304,871	349,867	418,026
Japan	285,168	236,621	191,136	217,453	252,935
South Korea	188,008	184,224	185,008	202,543	219,754
New Zealand	3,516	3,299	3,724	4,229	4,699
Singapore	13,263	9,772	11,971	14,821	18,026
Brazil	346,567	336,976	357,711	382,112	421,576
Mexico	128,953	119,272	128,654	158,021	176,979
Colombia	98,639	110,351	128,353	152,437	187,321
Egypt	25,955	19,256	17,350	15,429	13,617
Jordan	6,085	7,670	9,590	12,537	22,320
Morocco	19,981	21,414	22,881	25,832	29,064
Oman	4,604	4,519	5,004	6,081	7,345
Saudi Arabia	51,151	51,143	51,175	62,606	94,047
Cameroon	2,579	2,541	3,093	3,846	8,002
DRC	1,730	1,309	1,707	2,257	6,346
Gabon	804	939	1,082	1,397	2,659
Kenya	92,227	84,507	84,377	87,000	91,992
Nigeria	107,823	119,185	130,479	144,165	169,770
Senegal	893	712	993	1,349	3,805
South Africa	159,004	166,251	171,488	176,735	184,077
Uganda	2,042	2,209	2,151	2,654	5,982
Rest of World	418,360	345,031	306,208	367,887	378,642
Total World	3,211,172	3,085,400	3,120,296	3,533,162	4,026,968

Source: Telecom Advisory Services analysis

In conclusion, this updated study indicates that Wi-Fi represents one of the most important contributors to economic value in the telecommunications ecosystem. Governments around the world should develop the right incentives to stimulate the social and economic benefits of Wi-Fi. This includes assigning enough spectrum to avoid congestion, promoting the development of start-ups that rely on Wi-Fi to create new applications, and relying on the technology to address the digital divide barrier.