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COVID-19 AND THE ECONOMIC VALUE OF Wi-Fi

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I. INTRODUCTION

The COVID-19 pandemic is unusual in that it poses a fundamental challenge to the global socio-economic system. This challenge is forcing countries to reexamine social practices and production systems otherwise considered normal until the end of last year. In fact, this pandemic has caused a contraction to the global economy in 2020, with growth only expected to resume in 2021. The International Monetary Fund (IMF, 2020) estimates that the global economy will contract by 4.70 percent in 2020, much worse than during the 2008-2009 financial crisis, but will bounce back with 4.80 percent growth in 2021 (See table 1 for selected country-specific projections).

Table 1. GDP Projections

Country	2020	2021
Australia	-4.2	3.0
Brazil	-5.8	2.8
France	-9.8	6.0
Germany	-6.0	4.2
Japan	-5.3	2.3
Korea	-1.9	2.9
Mexico	-9.0	3.5
Netherlands	-5.4	4.0
Poland	-3.6	4.6
Spain	-12.8	7.2
United Kingdom	-9.8	5.9
United States	-4.3	3.1
Argentina	-11.8	4.9
Canada	-7.1	5.2
China	1.9	8.2
Indonesia	-1.5	6.1
Italy	-10.6	5.2
Kazakhstan	-2.7	3.0
Malaysia	-6.0	7.8
Nigeria	-4.3	1.7
Philippines	-8.3	7.4
Russia	-4.1	2.8
Saudi Arabia	-5.4	3.1
South Africa	-8.0	3.0
Thailand	-7.1	4.0
Latin America and the Caribbean	-8.1	3.6
Emerging and Developing Asia	-1.7	8.0
World Growth Based on Market Exchange Rates	-4.7	4.8

Source: International Monetary Fund. World Economic Outlook (2020)

Beyond the economic recession, the lockdowns and quarantines enacted to limit infection have resulted in significant social disruption. Following the initial wave of contagion and the implementation of prophylactic measures, anecdotal evidence emerged suggesting that digital technologies help counteract the isolation caused by social distancing measures, increase the awareness of virus prevention measures, and allow economic systems to continue to operate—at least partially. The exponential increase in Internet traffic, the reliance on telecommuting, and the need to maintain high-performance supply and distribution chains support this claim.

In this context, Wi-Fi represents a critical component of every country's digital infrastructure. Accordingly, Wi-Fi networks are a significant contributor to national resilience in the face of COVID-19. The purpose of this paper is to demonstrate the importance of Wi-Fi under pandemic conditions. Chapter II provides the empirical evidence that underlines the value digital infrastructure brings in mitigating the negative impact of pandemics. Chapter III reviews the particular role Wi-Fi holds in improving economic resilience vis-à-vis the COVID-19 disruption. Chapter IV provides examples of Wi-Fi's contribution to use cases critical to increasing digital resilience.

II. TECHNOLOGY MITIGATES THE SOCIO-ECONOMIC DISRUPTION OF COVID-19

Research evidence generated so far indicates that telecommunications technology is a critical contributor to mitigating the disruptive social and economic impact of global events, such as pandemics. At a general level, telecommunications technology can be essential in increasing economic resiliency during emergency situations. At the household level, broadband access allows citizens to carry out many daily tasks that previously required physical contact. Examples include buying goods and services online via e-commerce, using e-health applications, studying and attending school online with virtual tools, and telecommuting.[1]

At the enterprise level, the digitization of production is critical to keep the economy running when disruption occurs. Beyond providing workers with the possibility to telecommute, digitized supply chains and distribution channels can substantially contribute to keeping production activity operating in situations where face-to-face interactions with customers and suppliers must be avoided. Finally, broadband and digitization can increase government resiliency by allowing institutions to continue their operations and deliver public services.

The study of the role of digitization to mitigate the economic losses triggered by natural emergencies initially focused on natural disasters[2]. In the specific case of pandemics, Chamola et. al. (2020) pointed out the use of advanced digital technologies to help mitigate the impact of these outbreaks. Coincidentally, in a recently published study, Katz et. al. (2020d) provided econometric-based evidence indicating that countries with better digital infrastructures were able to counteract part of the economic losses generated by the SARS pandemic of 2003. In other words, although all pandemic-impacted countries experienced some negative

[1] The way in which individuals use internet may hinder their ability to offset the economic damages. For instance, in most developing countries internet is typically used primarily to communicate and access social networks, and not for more sophisticated uses which are key to the above-mentioned resiliency.

[2] Prior research highlighted the importance of telecommunications in supporting critical sectors such as emergency services, finance, and other basic industries during and after natural disasters. Teodorescu (2014) analyzed the role of information technologies (IT) for disaster mitigation, addressing the roles of technology in improving resilience. Similarly, O'Reilly et. al. (2006) analyzed the impact of hurricanes on the affected telecommunication networks in the United States.

economic effects, there was significantly less impact in countries with high fixed broadband penetration rates. This finding suggests that internet usage mitigates economic damage by keeping the economy up and running—allowing citizens to telecommute and enterprises to continue operating.

While it is still too early to conduct similar studies for the current COVID-19 pandemic, initial data hints at a similar effect. As presented in table 1, the IMF adjusted its country GDP growth forecasts downward for 2020 and 2021 from what was originally published in 2019.[3] The 2020 forecast correction is due to the pandemic. In contrast, the 2021 forecast indicates the expected recovery of approximately 5 percent once the pandemic comes under control. More importantly, the forecasted correction for 2021 seems to be positively related to the level of digitization. In other words, the higher the level of digitization in an economy, the faster the expected economic recovery. As a confirmation of this finding, a preliminary analysis was conducted (Katz et. al., in process), regressing GDP impact (including a 2021 IMF forecast) against the impact of COVID-19, fixed broadband penetration, fixed capital, labor and per capita spending on healthcare. The number of COVID-19 deaths per 1,000,000, indicates that countries with highly developed digital infrastructures can reduce the long-term negative economic impact implied by COVID-19 by more than half.

Since Wi-Fi technology represents a critical component of a country's digital infrastructure, it is pertinent to investigate its role in driving social and economic resilience under COVID-19.

III. WI-FI: KEY TO DIGITAL RESILIENCE

A global study on the economic value of Wi-Fi recently completed by the authors (Katz et. al., 2020e) demonstrated the growing importance of Wi-Fi in driving a country's digital resilience. Among some of the most important areas of impact, Wi-Fi has been shown to fulfill a critical contribution in several domains, namely:

- Benefit to consumers accessing free Wi-Fi sites in public locations (government offices, guest accounts in private enterprises, retail locations, etc.);
- Consumer savings in wireless cellular services when accessing the Internet from residences;
- Expansion of broadband coverage in rural and isolated areas through Wireless ISPs (WISPs); and
- Enterprise savings in wireless cellular services in support of innovative use cases based on Wi-Fi use for IoT (Internet of Things) and AR/VR (Augmented Reality/Virtual Reality).

Based on this evidence, it is relevant to analyze Wi-Fi's contribution to building digital resilience in the face of pandemics. One of the most immediate effects of COVID-19 has been the shuttering of offices, schools, and factories to prevent contagion. This has led to a dramatic increase in telecommuting, and consequently,

[3] Full details in the recently published *World Economic Outlook* (IMF, 2020)

in data traffic from households and businesses. Based on its economic value, Wi-Fi builds digital resilience in multiple areas (see table 2).

Table 2. Value of Wi-Fi to face COVID-19

Economic effect		Contribution to Digital Resilience under COVID-19
1. Free Wi-Fi	1.1. Benefit to consumers of free Wi-Fi traffic offered at public sites	Provide Internet access to consumers that cannot afford to purchase broadband service
2. Consumers	2.1. Benefit to consumers from speed increases	Support simultaneous access of multiple devices for distance learning, telecommuting, telemedicine, and information distribution in residences
	2.2. Consumer savings in wireless data usage	Prompted by isolation and confinement, consumers tend to rely more on wireless devices, with Wi-Fi becoming a key approach to limiting wireless expenditures
	2.3. Closing the digital divide: use of Wi-Fi to increase coverage in rural and isolated areas	Provide internet access for underserved communities through WISPs
3. Enterprises	3.1. Business internet traffic transmitted through Wi-Fi	Enable businesses to digitally transform by supporting virtualization of business processes
	3.2. Reduction in enterprise costs	Support telecommuting

Source: Telecom Advisory Services

Each of these areas will be reviewed in turn.

III.1. Free Wi-Fi

COVID-19 triggered lockdowns globally. Shelter-in-place orders have reduced the use of Wi-Fi in public venues, such as coffee shops, hotels and airports. However, free public hotspots have been deployed in such places as outdoor COVID-19 wards, other makeshift healthcare facilities, and in parking lots where in-vehicle wireless access is required. In addition, schools and libraries have deployed hotspots outside buildings to facilitate access to distance learning for students and teachers that lack fixed broadband service at home. In some cases, school buses have also been equipped to provide "Wi-Fi on wheels," and families in need are issued personal Wi-Fi hotspots for students to use for online learning. With access to these newly available hotspots, consumers that do not have broadband service because of an affordability barrier can rely on free Wi-Fi to gain Internet access.

III.2. Consumer savings in wireless data usage

The worldwide lockdowns and stay-at-home orders prompted by COVID-19 resulted in a natural increase in wireless broadband use to address telecommuting needs, provide online education, entertain, and connect with others to avoid social isolation. In this context, Wi-Fi became a critical technology to limit expenditures associated with cellular data usage. COVID-19 lockdown measures have had an impact on residential Wi-Fi on multiple levels:

- Global increase in home Wi-Fi activity triggered in part by growth in the number of connected devices[4];
- Surge in upstream connections triggered by video conferencing[5];
- Video-streaming and online gaming throughout the day rather than during a "busy hour"[6];
- Wi-Fi usage in areas of the home with weaker coverage[7]; and
- Eleven percent increase in number of devices connected to Wi-Fi networks, with greatly increased simultaneously connected devices during the typical workday (up to 60 percent or more)[8].

The amount of time spent at home has yielded a dramatic increase in home Wi-Fi activity, as demonstrated by the time smartphone users spend on Wi-Fi. For example, in the United States the percent of time spent by a smartphone user on Wi-Fi jumped from 54.3 percent to 59.9 percent. In Brazil, the increase amounted to eleven percentage points (see table 3).

Table 3. Time of smartphone users spent on Wi-Fi, March 2020

Country	Mar 2-8	Mar 9-15	Mar16-22	% increase
Australia	49.7 %	50.5 %	52.4 %	5.43%
Indonesia	33.4 %	33.7 %	34.7 %	3.89%
Malaysia	27.1 %	27.8 %	30.5 %	12.55%
Philippines	53.6 %	55.8 %	63.3 %	18.10%
Singapore	54.4 %	54.9 %	55.5 %	2.02%
Vietnam	68.7 %	69.5 %	69.9 %	1.75%
Egypt	54.8 %	56.9 %	61.2 %	11.68%
Germany	65.4 %	65.9 %	71.4 %	9.17%
Italy	52.3 %	56.2 %	59.2 %	13.19%
Saudi Arabia	48.7 %	49.3 %	51.9 %	6.57%
South Africa	50.4 %	47.4 %	51.2 %	1.59%
Spain	61.3 %	62.6 %	73.1 %	19.25%
Switzerland	53.2 %	53.4 %	58.9 %	10.71%
United Kingdom	64.5 %	64.7 %	68.9 %	6.82%
Argentina	64.3 %	64.8 %	72.5 %	12.75%
Brazil	65.1 %	64.8 %	72.5 %	11.37%
Mexico	59.9 %	60.6 %	64.0 %	6.84%
United States	54.3 %	54.9 %	59.9 %	10.31%

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

On average, the time smartphone users spend on Wi-Fi rather than on cellular networks since the outbreak of COVID-19 increased by 9.11 percent. If this traffic

[4] Khatri, H. and Fenwick, S. (2020). "Analyzing mobile experience during the coronavirus pandemic: Time on Wi-Fi". *Opensignal* (March 30).
[5] Gil, T. (2020). "Lockdown effect on home Wi-Fi: 'New normal is Christmas Day level'", *Wi-Fi Now* (March 30).
[6] Vercammen, B. and Delbar, J. (2020). *The catalyst effect: Understanding the impact of lockdown on residential Wi-Fi and Future applications*. Brussels: Airties.
[7] Spirent (2020). *Wi-Fi in the Post-COVID19 Era*.
[8] Vercammen, B. and Delbar, J. (2020). *The catalyst effect: Understanding the impact of lockdown on residential Wi-Fi and Future applications*. Brussels: Airties.

had to be transported by cellular networks at an average price per GB ranging from $ 3.39 in the United States to $1.35 in Germany and $0.65 in the United Kingdom, that would result in a significant increase in consumer telecommunications spending. In the United States, consumers would face an increase in cellular spending of $5.79 per month[9].

III.3. Wi-Fi as an enabler of digital transformation

Lockdowns during COVID-19 have had an impact on business operations, in particular all the business processes related to supply chain management (e.g. purchasing, logistics, etc.). While trends toward process automation, deployment of robotic systems, and other advanced digital technologies have been present for a number of years, the pandemic-induced disruption has accelerated development in these areas because enterprises need to increase their operational resilience.

In this context, all the technologies that rely on Wi-Fi, such as IoT and robotics used in warehouse management, will require accelerated deployment. Some 5G deployments may be delayed due to capital spending constraints as a result of COVID-19. This, in turn, may result in further emphasis on Wi-Fi in industrial settings.

Even under conditions of 5G roll-out, Wi-Fi will continue to coexist in enterprise facilities, serving as the technology of choice for indoor coverage[10]. In some cases, Wi-Fi has become critical in the wireless operation of "pandemic-proofed" facilities, focusing on occupancy measurements and infection control. Wi-Fi sensors provide the necessary technology for monitoring indoor occupancy levels and relaying health metrics, such as temperature checking.

III.4. Enterprises support telecommuting

As alluded to in Chapter II, there has been a massive upsurge in telecommuting, resulting in an increase in Wi-Fi traffic. Several pieces of research have been released since the outbreak of the pandemic focused on estimating the portion of the labor force that could continue to work from home.

For example, in a recent study of the impact of the pandemic on the labor force in emerging markets, we analyzed data for Chile[11] to determine what percentage of the

[9] A smartphone user in the United States generates 25.97 GB per month (source: Cisco's Annual Internet Report Highlights Tool 2018-2023). An increase of percent time on Wi-Fi from table 3 results in a growth from 14.02 GB to 15.56 GB. The price per GB averaged from the most economic plan of cellular providers is $3.776. Therefore, if Wi-Fi would not be able to handle the increase in traffic, consumers would face an incremental cost of $ 5.79 per month.

[10] We anticipate that 5G will remain the preferred technology for wide-area coverage, while Wi-Fi 6 will remain the preferred technology for indoor use, thanks to its much lower deployment costs. Furthermore, the trend towards providing seamless wireless broadband connectivity, as well as smaller-cell network architectures with increasingly flexible and spectrum-agile technologies, is blurring the traditional boundaries that differentiated earlier generations of cellular and Wi-Fi.

[11] Source: Government of Chile. Ministry of Social Development (2017). *Survey of National Socio-Economic Characteristics.*

Chilean labor force was able to continue working under lockdown conditions (Katz et. al., 2020a). We assessed the likelihood of: a) occupations whose workers were likely to continue going to the workplace location (e.g. essential workers), and b) occupations that could not rely on telecommuting (for example, a factory operator cannot continue working if staying at home).[12] Once completed, the probability analysis yielded the percentage of the workforce that could work from home, the percentage that were obliged to continue to go to their workplace, and the percentage that could not telecommute. The analysis showed that under lockdown conditions, 20.6 percent of the total employed workers in Chile had to continue going to their workplace because their occupations were considered to be essential. Based on lockdown rules, the remaining workers (79.4 percent) could not go to their workplace. Of these, 28.9 percent could continue to work by telecommuting from home, by relying on access through collaborative tools via fixed broadband and Wi-Fi.[13]

A similar analysis was conducted by Katz et al. (2020b) for South Africa. In this case, 81.2 percent of the labor force could not go to their workplace because their occupation was not considered essential. Of these, 25.9 percent could continue to work by telecommuting from home. Similarly, Albrieu (2020) estimates that in the case of Argentina, between 27 percent and 29 percent of the labor force could rely on telecommuting during temporary lockdowns.

That said, countries with more advanced levels of digitization have been better prepared to support telecommuting, which in turn keeps economies running. In nearly every market, Wi-Fi has been leveraged heavily to support telecommuting workers. For example, Dingel et. al., (2020) estimate that 37 percent of jobs in the United States could rely on telecommuting. In fact, some businesses have supported employee telecommuting through enhanced fixed broadband service, upgraded Wi-Fi home equipment, and configuration and troubleshooting support. This type of support might extend into the future, becoming the "new normal".

Even after the COVID-19 crisis passes, researchers do not expect a full return to prior working and studying patterns. Many companies will keep their offices closed, expecting employees to continue working from home or to limit their presence in company facilities. It is estimated that once the pandemic subsides, the labor force, especially in in advanced economies, will end up with a hybrid version of telecommuting, with approximately 54 percent of the workforce working full or part time from home, as opposed to what it was prior to the crisis.[14] Many more may continue to work from home several days a week, thus still needing the telecommuting infrastructure even if they do return to the office on a semi-regular

[12] The probabilities for (a) were based on the official rules issued by governments for the so-called "essential" occupations, while the likelihood of (b) was based on the authors' understanding of work an occupation entails.

[13] This percentage is consistent with the estimate of Hevia & Neumeyer (2020) who calculated the number of affected employees per company based on PIAAC data. The authors estimated that 53 per cent of the workforce in Latin America could risk unemployment because they work for companies with five or fewer employees and with limited access to emergency funding.

[14] According to Global Workplace Analytics' analysis of 2018 American Community Service (ACS) data, only 3.6 percent of the workforce worked from home, while Gallup State of the American Workplace 2016 estimated that 43 percent of employees worked remotely with some frequency.

basis. Working from home will push companies to continue upgrading fixed broadband service and Wi-Fi for their employees.

IV. THE ROLE OF WI-FI IN SPECIFIC USE CASES

Having presented the preeminent role of Wi-Fi in the current pandemic conditions, we have selected three use cases that have significant social impact: distance learning, telecommuting, and elder care.

IV.1. Wi-Fi and distance learning

Lockdowns and school closures have compelled students to attend classes via broadband access at home, relying on digital learning platforms, message boards, and collaborative tools for remote education. In this context, access to technology has been critical to support the move to home schooling. The impact of home broadband access on student performance was an area of research that had already garnered considerable attention before the pandemic.[15] The more robust analyses resulted in the following conclusions:

- Having a computer at home increased school enrollment by 1.4 percent, after sociodemographic controls.[16]
- Teenagers who have access to home computers are 6 to 8 percent more likely to graduate from high school than teenagers who do not have access, when controlling for socio-demographics.[17]
- High school students with home computer access have a strong positive relationship with academic performance.[18]
- Access to broadband among junior high school students increased their test scores, range of college applications, and rate of admission.[19]
- Minority students are more likely to graduate from community college if they have access to a computer at home.[20]

It is important to note that the research presented above was conducted when classes were still delivered in schools. Under these conditions, home computer and broadband access represented a *complement* to the education received in class. Conditions resulting from the COVID-19 pandemic proved that Wi-Fi is *critical* to

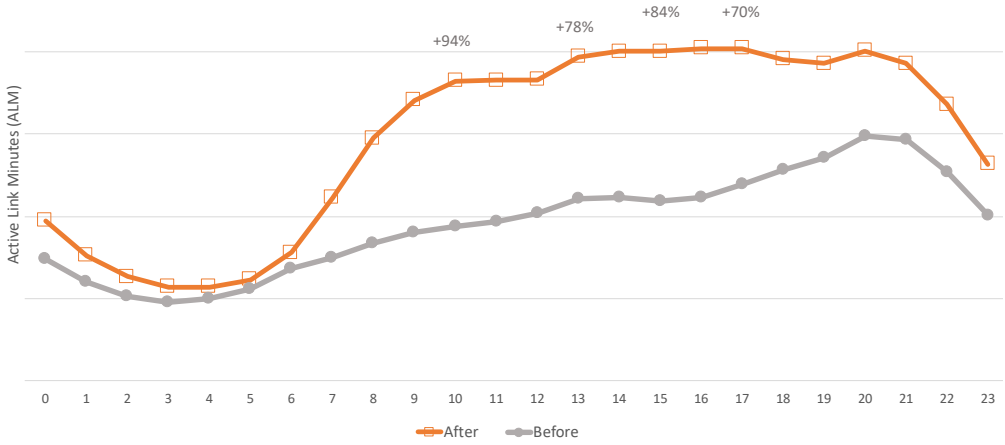
[15] For survey of the research literature, see Bulman, G. and Fairlie, R. *Technology and Education: Computers, Software, and the Internet.* National Bureau of Economic Research Working Paper 22237, Cambridge, Massachusetts, 2016, retrieved from: http://www.nber.org/papers/w22237.
[16] Fairlie, Robert W. 2005. "The Effects of Home Computers on School Enrollment," *Economics of Education Review* 24(5): 533-547.
[17] Beltran, Daniel O., Kuntal K. Das, and Robert W. Fairlie. 2010. "Home Computers and Educational Outcomes: Evidence from the NLSY97 and CPS," *Economic Inquiry* 48(3): 771- 792.
[18] Ibid.
[19] Dettling, L., Goodman, S. and Smith, J. (2012). *Every little bit counts: the impact of high-speed internet on the transition to college.* Finance and Economics Discussion Series 2015-108. Washington: Board of Governors of the Federal Reserve System, retrieved from: http://dx.doi.org/10.17016/FEDS.2015.1.
[20] This estimate is conservative since dropout rate is expected to be higher in rural counties than the national average.

enabling remote learning, and in many cases becomes the only link existing between the student and the teacher.

IV.2. Wi-Fi and telecommuting

Wi-Fi is the key technology enabling telecommuting. Based on traffic measurement statistics, Wi-Fi has experienced peaks with increased telecommuting (see Graphic 1).

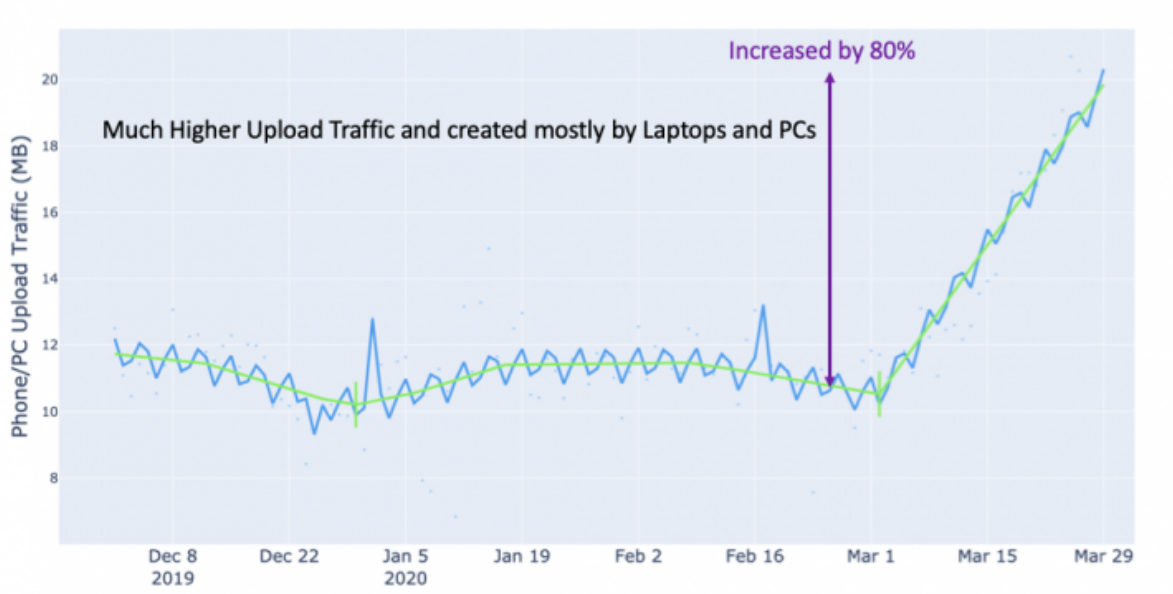
Graphic 1. Wi-Fi Link Activity Throughout the Day Before and After COVID-19 (Active Link Minutes)



Source: Vercammen and Delbar (2020)

As indicated in Graphic 2, Wi-Fi activity increased and stabilized at approximately 82 percent higher than in pre-pandemic conditions. Beyond this change in daily traffic distribution, Wi-Fi use peaked due to the use of bandwidth intensive applications, such as online videoconferencing (see Graphic 2).

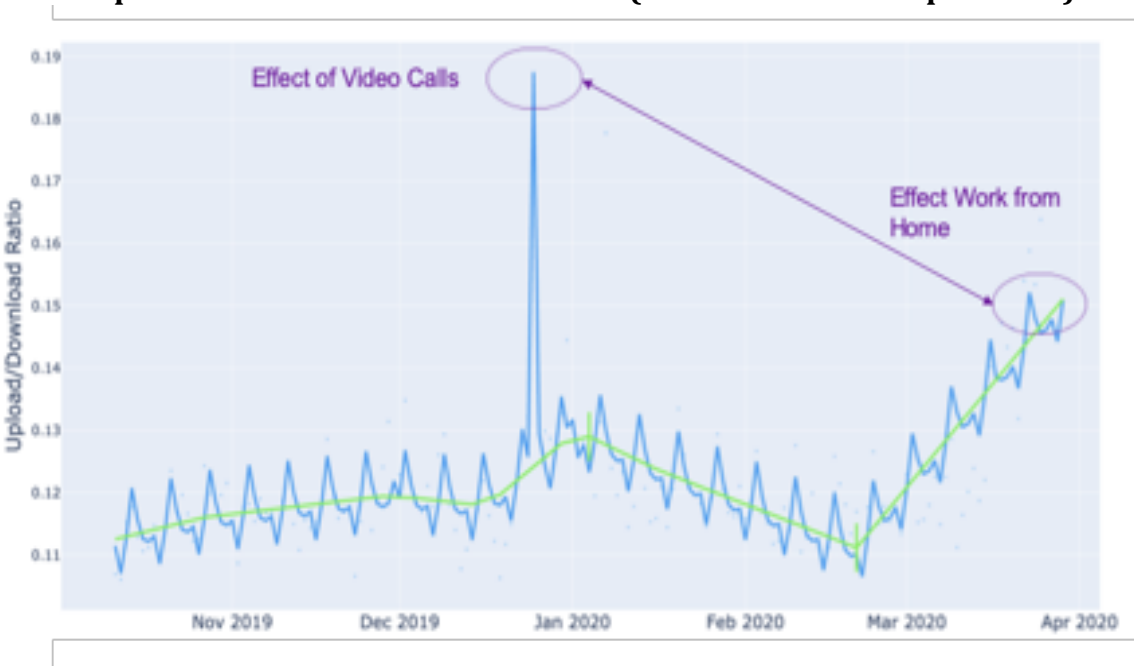
Graphic 2. Global Wi-Fi Traffic Growth (December 2019 – April 2020)



Source: Gil, T. (2020). Lockdown effect on home Wi-Fi: "New normal is Christmas Day level", Wi-Fi Now (March 30).

As depicted in Graphic 3, data collected from 125 million Wi-Fi routers around the world show an 80 percent increase in PC uploads to cloud computing and document sharing through Dropbox, OneDrive, and SharePoint. Graphic 3 shows additional peaks from video conference calls observed since the end of March.

Graphic 3. Global Wi-Fi Traffic Growth (December 2019 – April 2020)



Note: The December peak of video calls is driven by holiday traffic.
Source: Gil, T. (2020). Lockdown effect on home Wi-Fi: "New normal is Christmas Day level", Wi-Fi Now (March 30).

This increase has contributed to the saturation of the unlicensed spectrum bands, generally 2.4 GHz and 5 GHz. In this context, the efforts already initiated by many countries in the world (e.g. United States, South Korea, United Kingdom, Chile) to provide Wi-Fi access to the 6 GHz band can help Wi-Fi support the increasing needs of telecommuting and distance learning.

IV.3. Wi-Fi and elderly care

In light of the pandemic, some Wi-Fi enabled consumer applications have become even more important to address social isolation. One of them is delivering remote virtual reality platforms aimed at mitigating the isolation of the elderly. Some nursing homes have already adopted virtual reality (VR) platforms that provide a 360-degree travel experience[21], while some providers are delivering a blend of entertainment and therapy with VR programming for senior residences. Research has shown that VR can capture memory-care patients' attention longer than traditional senior-living programming[22]. These two technologies—virtual reality and augmented reality—can become very bandwidth intensive and are therefore suited

[21] Lumpkin, L. (2019). A recent college graduate helps nursing-home residents see the world — without leaving home. *Washington Post*. (October 14).
[22] Read, K. (2019). Virtual Reality lets seniors travel without leaving home. *Star Tribune* (July 123).

to operate in a broadband environment enabled by Wi-Fi, supported by Wi-Fi 6 devices.

V. CONCLUSIONS

Research evidence indicates that telecommunications technology is a critical contributor to help mitigate the disruptive social and economic impact of pandemics and other crises. As such, since Wi-Fi technology is a critical component of a country's digital infrastructure, it is reasonable to state that Wi-Fi technology fulfills a critical role in helping societies deal with economic disruption from emergencies such as COVID-19. Among some of the most important areas of impact, Wi-Fi has been shown to deliver critical contributions in several domains, namely:

- Providing Internet access through free access points to consumers that cannot afford to purchase broadband service
- Supporting efficient simultaneous access of multiple devices for distance learning, telecommuting, telemedicine, and information distribution
- Reducing consumer wireless expenditures, even while consumer reliance on wireless devices increases
- Providing internet access for broadband in unserved communities through WISPs
- Enabling digital transformation of businesses by supporting virtualization of business processes

Not only is Wi-Fi key to economic resiliency, from a social perspective Wi-Fi is a critical enabler in the delivery of online social, education, and work collaboration tools. Wi-Fi support for working from home enables families to stay safe while continuing to contribute to the economy. Wi-Fi has also proven key in limiting the impact of social isolation resulting from emergencies like COVID-19—for individuals and families, including populations in healthcare and elderly care facilities.

Enhancing digital technology and global proliferation of Wi-Fi access is important for both established and developing economies. The flexibility and benefits Wi-Fi brings to digital economies have proven to provide essential benefits during the COVID-19 pandemic. We believe that economies with more advanced digital technology tend to experience higher levels of economic resilience in potentially catastrophic situations. Thus, the opportunities afforded through Wi-Fi provide not only economic, but also social, humanitarian benefits.

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