Can digitization mitigate COVID-19 damages? Evidence from Developing Countries

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Abstract

The COVID-19 pandemic poses a fundamental challenge to the global socio-economic system, forcing countries to reexamine social practices and production systems otherwise considered normal until the end of last year. The work presented in this paper uses empirical evidence to highlight the important role digital technology could play in mitigating the pandemic's disruption while evaluating the level of preparedness of developing countries to face this challenge. We provide evidence on the evolution of current traffic and speed levels of broadband networks, and we use empirical data to analyze the digital resiliency of developing countries in terms of households, production processes, governments, and the extent of telecommuting. Our overall conclusion is that developing countries are significantly lagging the most advanced ones in terms of preparedness. Therefore, we believe that public and private sectors in these countries must collaborate and work together to promote the enhancement of the digital ecosystem. Several measures can be taken to accommodate the current increase in Internet traffic, such as accelerate the deployment of base stations for mobile broadband (by reducing the permit requirements), temporarily allocate additional spectrum to operators to face traffic spikes, require video streaming providers to reduce traffic from high definition content, and consider the need to increase unlicensed spectrum to resolve Wi-Fi router bottlenecks. Other relevant measures include stimulating technology companies to develop platforms that can improve efficiencies in the supply chains, and to encourage them to promote telecommuting. Finally, more investment will be needed in the training of the most vulnerable population groups to decrease unemployment rates.

JEL classification: O33, O38, L51

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1. 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, because of this novel Coronavirus, most economists predict a global recession this year. For instance, the International Monetary Fund (IMF, 2020) estimates that the global economy will contract by –3% in 2020, much worse than during the 2008–09 financial crisis.

Beyond the fact that COVID-19 has a worldwide impact, this paper focuses particularly on developing countries, as they are more exposed to the devastating consequences from the pandemic. This statement has been supported by a recent policy report from the United Nations, warning that in developing countries the health care systems may be unable to cope with a precipitous increase in infections, and the lack of resources from these economies will harm their capability to mitigate the socioeconomic consequences of lockdowns and quarantines, in comparison with most advanced nations.[1]

Following the initial wave of the fear of contagion and the implementation of prophylactic measures, anecdotal evidence emerged suggesting that digital technologies could contribute to counteract the isolation implied 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 (and the initial difficulty operators have had in maintaining service quality), the reliance on telecommuting, and the need to maintain high-performing supply and distribution chains support this claim. Even if most emerging countries have made significant strides in developing their digital infrastructures over the past decades, we must ask ourselves the following questions to assess whether the digital ecosystem,[2] its infrastructure, and level of digitization of these economies will be able to withstand the challenges posed by the pandemic:

- Can digitization effectively mitigate the disruption caused by the COVID-19 pandemic?
- To what degree are digital platforms adopted by consumers distributing health care information, facilitating e-commerce transactions, and educating students under quarantine conditions in the developing world?
- Can digital information flows efficiently support supply chains and production systems in developing countries?
- Can telecommunications networks sufficiently support the massive surge in telecommuting?

[1] UN/DESA Policy Brief #66: COVID-19 and the least developed countries

[2] A digital ecosystem is defined as a set of interconnected components operating within a socio-economic context impacted by the massive adoption of information and communication digital technologies. The study of the digital ecosystem involves new modes of production, and different social behaviors related to the use and consumption of digital goods (see Katz, 2015; and Katz and Callorda, 2018b)

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- Can developing country governments continue to operate effectively as they digitize administrative and management systems?
- What are the implications of these answers for public and private interventions to address ongoing and future threats?

We provide answers to these questions, based on different types of evidence. In the first place, we conduct an econometric analysis testing the link between highly developed digital ecosystems and a country preparedness to face pandemics. Secondly, we explore the role of digitization to increase resilience of households, production, and the State in developing countries. Finally, we explore how developing countries can handle lockdowns through telecommuting.

Focusing on these key topics, this paper is structured as follows. Chapter 2 analyzes the relationship between the level of digital infrastructure and economic resilience in the face of a health crisis by examining the experience of the SARS pandemic in 2003.[3] Building on the evidence that the use of digital technologies can act as a mitigant of the economic disruption associated with pandemics, Chapter 3 provides an overall analysis of the state of the digitization in developing countries. Chapter 4 focuses on the assessment of broadband infrastructure resilience, while Chapters 5, 6 and 7 analyze the resilience at households, production systems, and the State respectively. Chapter 8 performs an assessment of social resilience from the perspective of the workforce and its possibilities for telecommuting. Finally, Chapter 9 presents the implications of the situation in developing countries and proposes a number of initiatives of collaboration between the public and private sectors to address shortfalls in resilience.

2. Digitization and socio-economic resilience facing pandemics

This section investigates the role that digitization plays in mitigating the socio-economic impact of pandemics like the novel Coronavirus. It examines the SARS outbreak of 2003, and develops an econometric model to estimate the extent to which Internet infrastructure (in this case fixed broadband) mitigated the negative economic impact within the countries affected by the outbreak.

In 2003, the virus known as SARS-CoV spread from China to 26 other countries, resulting in approximately 800 deaths (Wilder-Smith et al, 2020; see Table A-1 in Appendix). These countries made efforts to isolate the population that had contracted or had been exposed to the virus and established quarantining and social distancing practices. While these practices were more limited and less stringent than the current measures taken to confront COVID-19, their purpose was to reduce face-to-face interactions with the consequent social and economic effects.[4]

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[3] We define socio-economic resilience as the ability of the system to overcome crucial challenges – like a war or a pandemic – to return to normalcy and encourage future development.

[4] Various countries required citizens to comply with legally enforced quarantine mandates. In Hong Kong, police reinforcements verified quarantine compliance, while Singapore installed cameras in the homes of citizens forced to isolate. In cases where all infected individuals could not be identified, governments mandated quarantines at the city or regional level. China enacted large-scale quarantines in various communities affected by the disease, closing schools, universities, and public areas and canceling the May 2003 holiday. China even closed its capital, Beijing. Hong Kong also imposed community quarantines, installing barricades to isolate specific areas within the city in

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According to Keogh-Brown and Smith (2008), SARS negatively impacted the economy in the first, second, and third quarters of 2003, with the most negative impact occurring when the disease peaked in the second quarter. During the outbreak, affected countries saw a notable decrease in economic activity. This translated to an estimated economic loss in the range of US$ 30–100 billion (Fan, 2003; Knapp et al, 2004; Lee and McKibbin, 2004). According to Keogh-Brown and Smith (2008), the health, tourism, hospitality, airline, retail, restaurant, leisure, and entertainment sectors felt the largest impact.[5]

Our objective in this chapter is to understand whether the countries with greater digital technology development and adoption were better positioned to mitigate the negative economic impact of SARS. At the time of the SARS outbreak, experts anticipated that the Internet would play an important role by promoting teleworking during a period of confinement (Bidaud and Chetham, 2003; Chal, 2003; Crozier, 2003; Flynn, 2003). In fact, there is plenty of anecdotical evidence suggesting the important role played by Internet and videoconferencing in support of telecommuting. For example, Nokia, Sun Microsystems, Intel, HP and IBM all cancelled their regional conferences at that time and replaced them with videoconferences (Chal, 2003). In addition, InterCall, a Chicago-based teleconference platform increased its subscribers in Hong-Kong by 200%, and 30% globally, during the SARS period (Flynn, 2003). Similarly, Integrated Vision, an Australian-based teleconference systems integrator, reported a 44% increase in sales (Crozier, 2003), while Singapore Telecom registered a 20% increase in videoconferencing demand, and 50% increase in the use of its videoconferencing facilities. As a trigger of digitization development, the SARS pandemic incited the development of e-commerce in China as its citizens began to shop online (Ghosh, 2016). Example of this is the case of JD.com, that, facing the need to close most retail outlets, deployed an e-commerce channel, based first on instant messaging and then through the Internet (Zheng, 2020). SARS also contributed to the transition of Alibaba from a small B2B e-commerce site to the Chinese (and then worldwide) e-commerce leader (Huddleston, 2020). In the face of this anecdotal evidence, we developed an econometric analysis aimed at testing whether countries that exhibited higher level of digital infrastructure development, were better prepared to deal with the pandemic disruption.

The starting point to perform our empirical estimation is a Cobb-Douglas production function:

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order to prevent contagion. Based on World Health Organization (WHO) alerts and warnings, as of March 2003, all countries with imported SARS cases enacted airport controls to monitor passengers arriving from affected countries. Vietnam, Malaysia, Taiwan, New Zealand, and Australia tried to limit the arrival of travelers from affected countries as much as possible and required those passengers who did arrive to wear a mask for 10 days under threat of fines for non-compliance. Multiple governments recommended halting all non-essential travel to countries affected by SARS, although no explicit bans were ever put in place. Most airlines canceled flights to these regions. Many of these countries had not experienced a quarantine since the Spanish Flu of 1918-1919 (Mandavilli, 2003).

[5] Per data from the World Tourism Organization, international tourism fell 1.2% in 2003. In East Asia, the arrival of tourists dropped by 41% in the first 3 weeks of April when compared to the same period of the prior year. During the first 5 months of 2003, Beijing reported $1.3B in tourism losses.

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$$Y_{it} = A_{it} K_{it}^{\alpha} L_{it}^{\beta}$$

whereby Y represents the Gross Domestic Product (GDP) and K and L represent, respectively, capital and labor stocks of the i economy in the t period. However, unlike Solow's (1956) conventional model, we assume that Total Factor Productivity, represented by A, is not an unknown residual, but rather a function dependent on the penetration of telecommunications infrastructure. As mobile broadband was limited at the time of SARS, we use fixed broadband per household penetration rates to proxy for telecommunications infrastructure, which we will call *BB*.[6] To capture the economic effect of SARS, a dummy variable with the value of 1 is used to identify the countries affected by the pandemic in year 2003. For this analysis, we consider as affected all those countries that registered at least one positive case, according to Table A-1 in the Appendix. We do recognize, however, that SARS may have negatively impacted the economies of other countries not included in that list.

By applying logarithms to linearize the production function, the basic empirical model is defined as:

$$\log(Y_{it}) = \mu_i + \alpha \log(K_{it}) + \beta \log(L_{it}) + \emptyset \log(BB_{it}) + \Upsilon SARS_{it} + \zeta BB_{MED} * SARS_{it} + \mathcal{E}_{it}$$

whereby the symbol μ_i accounts for time-invariant unobservable country-level effects and $\mathcal{E}$ represents an error term, which we assume to verify the desired properties. As the parameter Υ captures the pandemic's impact on the GDP of the affected countries, we expect it to be negative ($\Upsilon < 0$). Lastly, the symbol ζ measures the relationship between countries with fixed broadband penetration levels above the median (identified as the dummy variable BB_{MED}) and countries impacted by the SARS epidemic. In this sense, a value of $\zeta > 0$ would suggest that countries with better connectivity infrastructure had the ability to offset, to some degree, the negative economic impacts of the disease. Table 1 describes the variables used to estimate the model, along with their sources. The sample is comprised by 178 countries for the period of 2000-2017.

Table 1. Description of the variables in the model

Variable	Description	Source
Y	GDP at constant 2011 prices (US$ million)	Penn World Table, version 9.1
K	Capital stock at constant 2011 prices (US$ million)	Penn World Table, version 9.1
L	Number of workers	Penn World Table, version 9.1
BB	Fixed broadband per household	World Bank – World Development Indicators
BB_{MED}	Dummy variable that takes the value of 1 for those countries with fixed broadband rates above the median	Our own construction from variable BB
$SARS$	Dummy variable that takes the value of 1 for those countries with at least one positive SARS case in 2003 (Table A-1 in Appendix)	Keogh-Brown and Smith (2008)

Source: Prepared by the authors

[6] Fixed broadband penetration is considered an adequate proxy to measure the state of digitization.

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Table 2 summarizes the results of the empirical estimates. The estimates in columns (i), (ii), and (iii) were conducted using the Ordinary Least Squares (OLS) method, while the estimate in column (iv) was carried out by the Instrumental Variables (IV) approach to control for potential endogeneity. All estimates incorporate robust standard errors clustered by country, as well as fixed effects by country and a time trend.[7]

Table 2. Economic Impact of SARS

	(i)	(ii)	(iii)	(iv)
$log(K)$	0.387*** [0.055]	0.387*** [0.055]	0.388*** [0.055]	0.365*** [0.058]
$log(L)$	0.345*** [0.091]	0.347*** [0.091]	0.347*** [0.091]	0.352*** [0.091]
$log(BB)$	0.027*** [0.005]	0.027*** [0.005]	0.026*** [0.005]	0.040*** [0.011]
$SARS$		-0.039** [0.016]	-0.086*** [0.031]	-0.099** [0.046]
$BB_{MED} * SARS$			0.065* [0.036]	0.086* [0.052]
Fixed effects by country	YES	YES	YES	YES
Time-trend	YES	YES	YES	YES
Restriction	$\Upsilon = 0$, $\zeta = 0$	$\zeta = 0$	-	-
Under identification contrast				34.404***
Weak identification contrast				103.52 (critical value 5%: 11.04)
Hansen test (over identification)				0.571
R^2	0.95	0.95	0.95	0.81
Observations	2.497	2.497	2.497	2.460
Estimation method	OLS	OLS	OLS	IV

*Note: robust standard errors in parentheses. *p<10%, **p<5%, ***p<1%*
Source: Prepared by the authors

In the case of column (i), the model estimates do not include the effects of SARS (that is to say, the $\Upsilon = \zeta = 0$ restriction is imposed). In this estimate, the parameters associated with capital and labor reflect the expected magnitudes and signs, while the coefficient measuring the link of fixed broadband penetration with GDP takes the value of 0.027, being highly significant. In other words, a 10% increase in fixed broadband penetration rate is associated with a 0.27% growth in GDP, which is consistent with the results found in other research (Katz et al., 2018a). Column (ii) incorporates the dummy variable used to identify countries affected by SARS in 2003 in an effort to analyze whether this pandemic negatively impacted their economies. The results do indeed suggest that the pandemic had a negative impact, with the coefficient Υ equal to -0.039 and, significant at a 5% level. These numbers demonstrate that, in 2003, the countries with SARS cases saw significant economic downturn. At any rate, we must evaluate this relationship cautiously. Given that it is a dummy variable, it does not identify heterogeneities by countries and may also be capturing other events and circumstances from that period.[8]

[7] Similar results when applying fixed effects by year (available upon request).
[8] For example, and as noted by Keogh-Brown & Smith (2008), SARS coincided with another critical international event, the 2003 Iraq War.

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In order to evaluate whether the economic impact within SARS-afflicted countries was heterogeneous in terms of the development of their broadband infrastructure, column (iii) presents an estimate including the interaction between the SARS variable and BB_{MED}. The results of this interaction variable indicates a positive and significant coefficient of 10%, suggesting that countries with the most-developed broadband infrastructures were able, at least partially, to offset the negative effects of the pandemic**.** In other words, although all impacted countries did experience some negative economic effects, these were significantly less in countries with high fixed broadband penetration rates. This finding suggests that Internet usage mitigated the economic damage by keeping the economy up and running by allowing, for example, citizens to telecommute.

As already mentioned, it is important to exercise caution when reviewing these results. The direct comparison between the Υ and ζ variables shown in column (iii) allows us to estimate the extent to which connectivity infrastructure mitigated economic losses. In this sense, the ratio between both coefficients suggests that good connectivity infrastructure could have mitigated approximately 75% of the economic loss.

Lastly, column (iv) replicates the estimate of column (iii), but applies the IV method to control for potential endogeneity associated with the broadband variable.[9] As usual with this type of estimations, the greatest challenge is finding suitable instruments that have explanatory power over the potentially endogenous variable (fixed broadband penetration), but not directly over the model-dependent variable (GDP). In this case, we will be using the fixed telephony penetration variable with a five-year lag.[10] The fact that broadband deployments largely depend on pre-existing phone lines justifies this choice.[11] In this case, a 5-year time lag is applied to the variable to eliminate any possible impact of contemporary shocks and to avoid concerns related to reverse causality. It is important to note that the contrasts carried out and reported in Table 2 verify the quality of the instruments; the hypotheses of null or weak identification are rejected, confirming that they do explain the potentially endogenous variable, while the Hansen overidentification test provides evidence about the exogeneity of the instruments. The IV estimation confirms the results previously reported for the OLS case; those countries with the largest broadband infrastructure had the ability to offset, at least partially, the negative effects of the pandemic.

[9] The presence of endogeneity can result from several factors. For instance, it may be the result of the omission of variables that simultaneously affect GDP and the level of broadband penetration. To the extent that these unobserved variables do not variate over time, the incorporation of fixed effects allows for their control. Secondly, endogeneity may be a result of the presence of reverse causality; just as broadband penetration impacts GDP, GDP also impacts penetration levels. Lastly, the existence of measurement errors in the variables could also contribute to endogeneity.

[10] The instrument is introduced at both in levels and in interaction with the SARS variable and, replicating what was done with BB_{MED}, a dummy is added to identify countries that had fixed penetration rates above the median 5 years ago.

[11] In this sense and following Czernich et al (2011), the fact that an existing infrastructure, such as fixed telephony, is required for broadband deployments makes existing phone lines an appropriate instrument. Czernich followed this strategy, using pre-existing fixed and cable telephone line data to measure national broadband penetration levels. Similarly, Bertschek et al (2013) perform an econometric analysis using ADSL availability as an instrument for the broadband variable.

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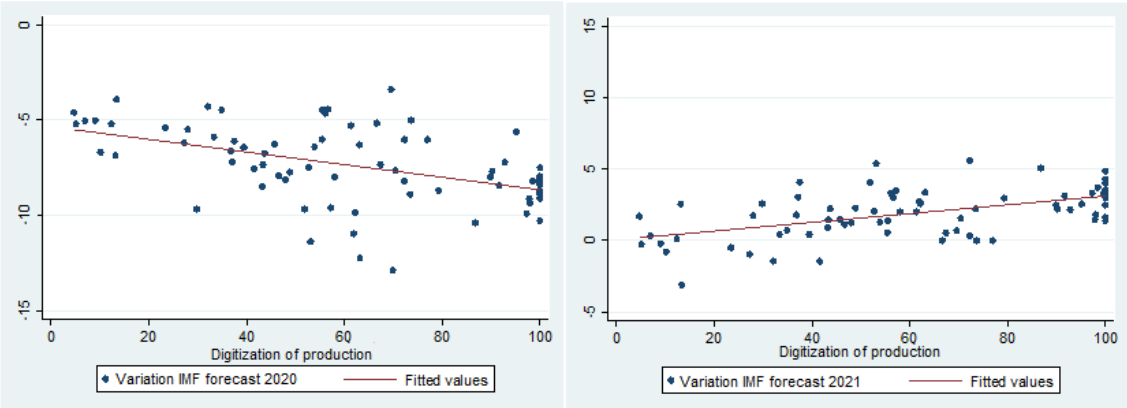
While it is still too early to perform a similar analysis for the current COVID-19 pandemics, first hints may allow us to foresee a similar effect. Recently, the IMF downward adjusted its GDP growth forecasts as a result of the pandemic.[12] The relationship between the change in the forecast from October 2019 to April 2020 and the degree of digitization of production[13] provides some interesting evidence (Figure 1). The graphic of the left in Figure 1 reflects the 2020 forecast correction due to the pandemic. The downward adjustment is negative in all cases, and not positively related to the level of digitization. In contrast, the graphic of the right in Figure 1 exhibits the 2021 forecast changes, reflecting in most cases upward corrections indicating the expected recovery once the pandemic becomes under control. This correction seems to be positively related to the level of digitization. Therefore, the correlations appear to suggest that next year's economic recovery will be faster in more digitized countries.

Figure 1. Change in IMF forecast for 2020-21 vs. digitization of production



Source: IMF and authors analysis

As a result, as a first conclusion, we can argue that digitization contributes to partially mitigate the effects of pandemic. This leads to a second fundamental question: if digitization is a mitigant factor of pandemics, developing countries with advanced digitization development will be better prepared to tackle the implicit social and economic disruption resulting from COVID-19.

3. The State of the Digitization in Development Countries

To assess the current digitization level of the developing countries, we developed an index composed of eight pillars and sixty-four indicators (see Katz and Callorda, 2018a) (Figure 2). The index is designed to take values within the scale of 0 – 100 (for full details of index structure and calculation see CAF, 2017).

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

[13] To measure digitization of production we relied on the respective pillar of the index that is presented below in Chapter 3. See Figure 2 for details.

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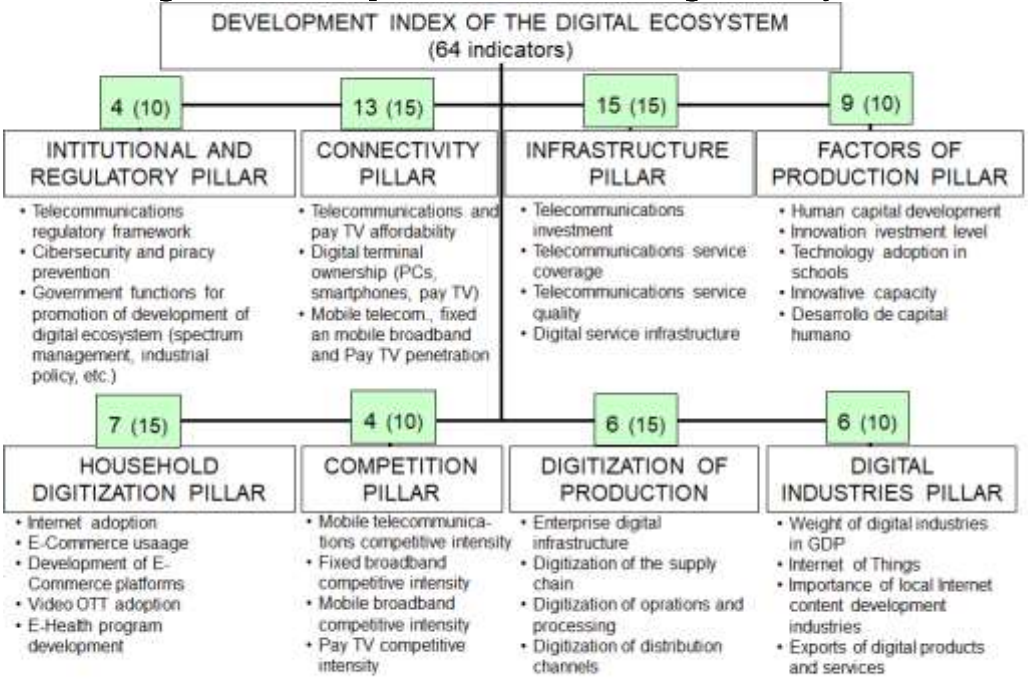
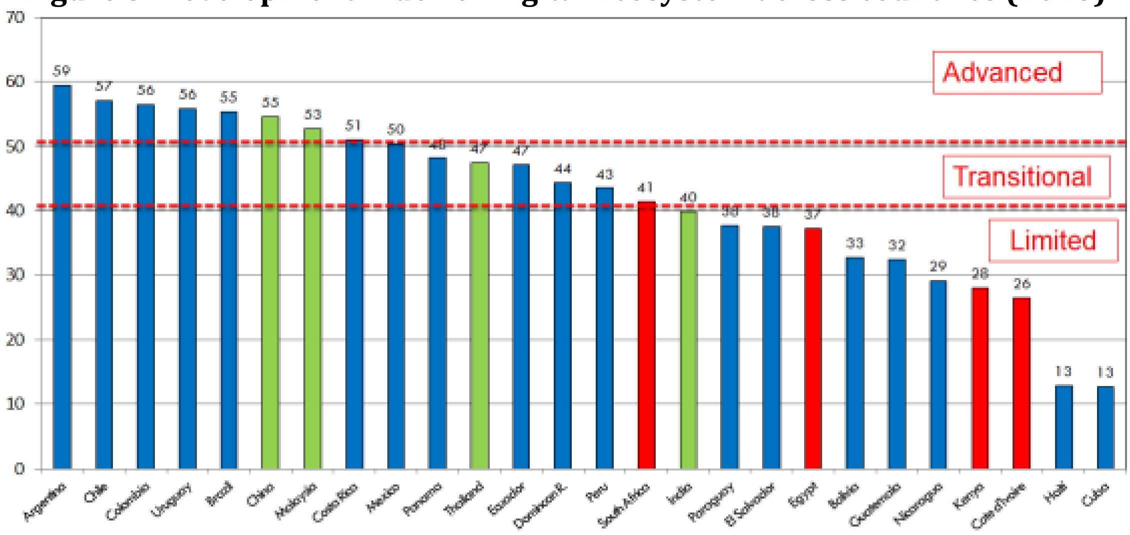
Figure 2. Development Index of the Digital Ecosystem



Source: Telecom Advisory Services

The country-level analysis for selected developing regions suggests important differences, even within those within the same region (Figure 3). By defining thresholds to classify the countries across different levels of development (limited, transitional and advanced[14]), one can see that Latin America exhibits important disparities, with countries from this region distributed across all three development levels, while Asia Pacific countries are either at advanced or transitional levels. In contrast, African countries lie mostly at the limited development stage.

Figure 3. Development Index of Digital Ecosystem across countries (2018)



Source: Prepared by the authors

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[14] As presented in Figure 3, we can classify as advanced countries those with an index above 50, while those below 40 are considered limited. Countries that reach index values between the 40 and 50 thresholds are classified as transitional.

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All in all, most developing countries exhibit intermediate to low level of digitization. This provides us with the baseline statistic to assess the remaining questions, related to the resilience of infrastructure, households, production, and the States to face the pandemic disruption.

4. Resilience of digital infrastructure

The deployment of prophylactic measures taken to confront COVID-19, such as the closure of workplaces and home quarantine, has led to a spike in telecommunications network usage. Table 3 provides some examples.

Table 3. Internet usage increase triggered by COVID-19 (examples)

Area	Service Provider	Area of Usage Percent Increase	Source
Telecommunications traffic	AT&T (US)	Core network traffic (22%)	AT&T
	British Telecom (UK)	Fixed network traffic (60% on weekdays)	British Telecom
	Telecom Italia (Italy)	Internet traffic (70%)	Telecom Italia
	Vodafone	Mobile data traffic in Italy and Spain (30%)	Vodafone
Over The Top	Facebook	Facebook Messenger (50%)	Facebook
		WhatsApp (Overall: 50%; Spain: 76%)	WhatsApp
		Video calling (100%)	Facebook
	Netflix	Subscriber base (9.6% or 16 million)	Netflix
	E-commerce (Mexico)	Number of Users (8%)	Competitive Intelligence
Video conferencing	Zoom	Daily usage (300%)	JP Morgan
	Cisco Webex	Subscribers (33%)	Cisco
	Teams (Italy)	Monthly users (775%)	Microsoft

Source: Compiled by the authors

The above reported increases in usage have led, consequently, to an erosion in certain network quality indices in some developing countries. According to Ookla / Speedtest, the average Internet speed and latency indices of several countries saw major changes in the last two weeks of March and the month of April. Figure 4 presents some selected examples across developing countries.

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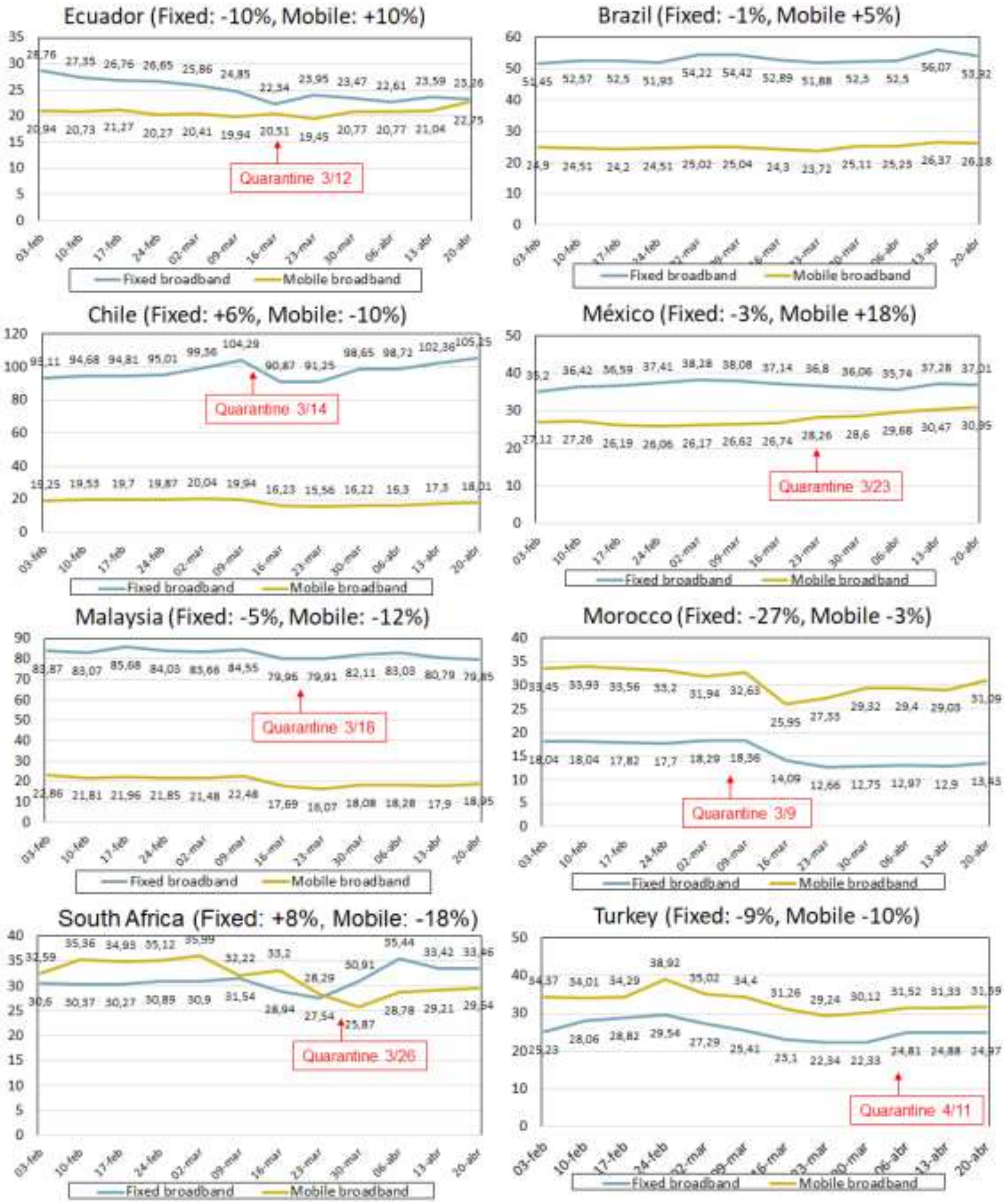
Figure 4. Internet speed in selected countries (February-April 2020)



Note: The percentages indicate the change in average speed in the last month
Source: Ookla/Speedtest

The data presented in Figure 4 show decreases in broadband speed during March and April, likely reflecting peaks in Internet access combined with changes in behavior and traffic flow as, for instance, more people began to work from home. This is particularly is evident in the case of fixed broadband in all reported cases, although with more intensity in Ecuador, Chile, Morocco, South Africa and Turkey. In the case of mobile broadband, significant variations were identified in Morocco, South Africa, and Turkey.

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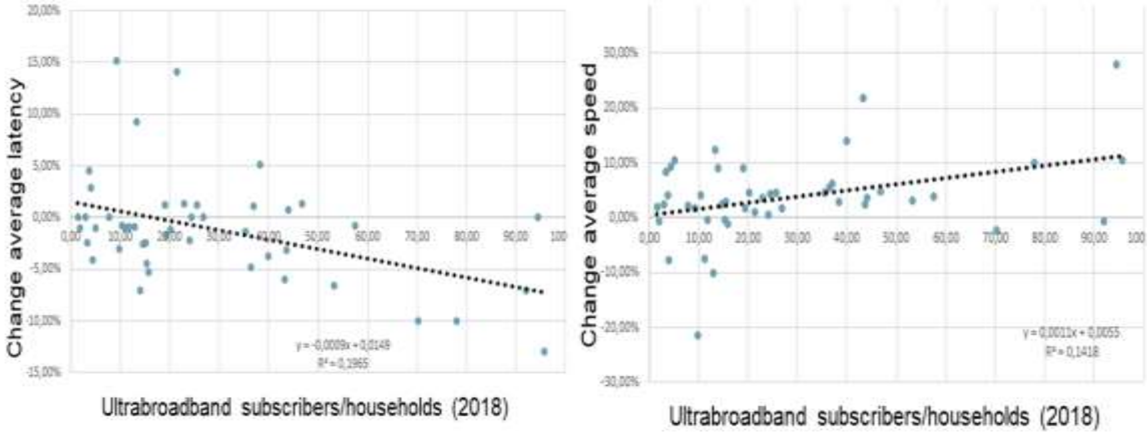
As expected, the countries that have a higher level of ultra-fast broadband infrastructure deployed (for example, those with higher penetration of fiber optics) appear to be handling better the increase in traffic. Correlations shown in Figure 5 provide evidence that the higher the ultrabroadband penetration is, the less is the increase in latency and the decline in download speed from the levels before the pandemic.

Figure 5. Impact of COVID-19 induced traffic increase on latency and speed (changes from November 2019 – January 2020 and March 2020)



Source: Ookla/Speedtest, IDATE, authors analysis

The slow-down in broadband speeds may have economic consequences, if they become permanent. Numerous studies of the so-called "return to speed" have quantified the relationship between higher broadband speed and increases in GDP and productivity (Rohman, and Bohlin, 2012; Kongaut and Bohlin, 2014; Briglauer and Gugler, 2018; Carew et al, 2018; Ford, 2018; Grimes et al, 2009; Mack-Smith, 2006; Katz and Callorda, 2019). Accordingly, the reverse scenario is also valid: a decrease in download speed has an inverse economic impact. While the data related to the decrease in download speeds because of the pandemic is so far limited to the months of March and April, it will be necessary to consider the potential negative economic impact if this situation continues.

Beyond the impact in broadband networks, the increase in traffic has also affected the Wi-Fi capacity at home routers. One of the most immediate effects of the pandemic has been the shuttering of offices, schools, and factories to prevent contagion, which has led in turn to a dramatic increase in telecommuting, and consequently, in data traffic from households. This natural increase in the number of devices using video conferencing platforms and cloud computing now connected at home has created a bottleneck in Wi-Fi routers that operate on non-licensed spectrum. Based on traffic measurement statistics, this technology has experienced peaks as a result of increased telecommuting (see Figure 6).

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Figure 6. Global Wi-Fi Traffic Growth (December 2019 – April 2020)

Source: Assia (2020)

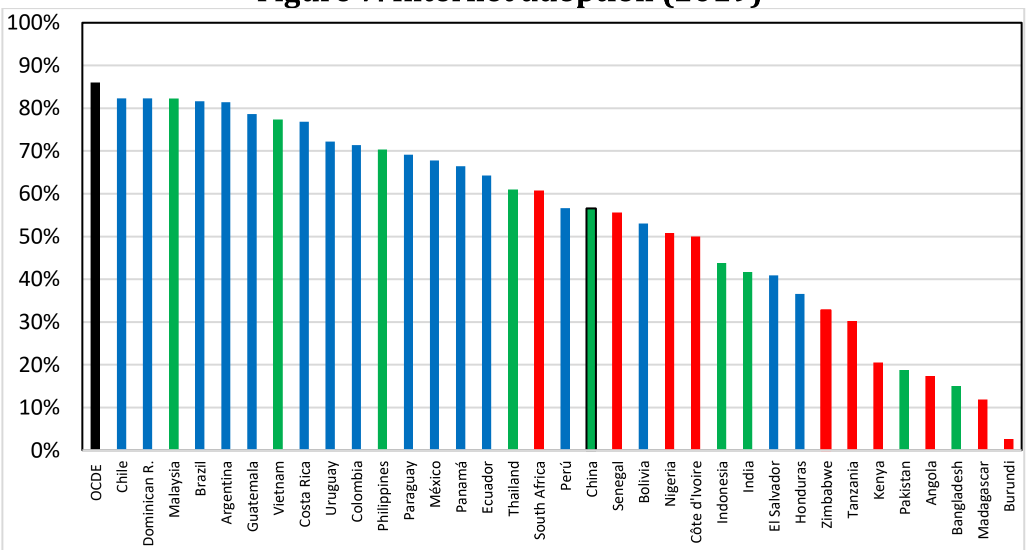
As depicted in Figure 6, data collected from 125 million Wi-Fi routers around the world show an 80% increase in PC uploads to cloud computing with additional peaks from video conference calls observed since the end of March. This increase has contributed to the saturation of the unlicensed spectrum bands (generally 2.4 GHz and 5 GHz).

To conclude, digital infrastructure is crucial for economic resilience. In order for networks to accommodate the increased communication needs resulting from COVID-19, all involved actors must take action.

5. Resilience of digital households

Household Internet penetration is essential in facing the pandemic. Residential digitization allows citizens to carry out many daily tasks that previously required physical contact (telecommuting is specifically analyzed in Chapter 8). Most developing countries lag advanced economies in terms of Internet adoption, although some nations, such as Chile or Malaysia, are very close to OECD levels (Figure 7).

Figure 7. Internet adoption (2019)



Note: The latest data provided by the ITU are from 2017 or 2018 depending on the country. The data from 2019 has been extrapolated based on last year's growth rate with information from the ITU.
Source: ITU and authors analysis

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As depicted in Figure 7, low Internet adoption in many African and some Asian nations highlights the first obstacle in utilizing digital technologies to tackle the pandemic disruption at the household level. This indicates the marginalization of important segments of the population who cannot gain access to online services that could replace activities typically requiring physical contact.

Even for those countries with high Internet adoption level, national averages mask significant adoption disparities within regions. Urban areas, for instance, usually have much higher Internet adoption levels than rural areas. As an example, 20.6% of the urban population of Bolivia had home Internet access in 2014, compared to just 1.7% of the rural population. Similar patterns were verified in 2017 for Brazil (65.1% urban vs 33.6% rural) and Ecuador (46.1% vs 16.6%).[15]

In addition, limited penetration of devices in some countries represents an important usage barrier. PC adoption per household in Latin America is 44.89%, in Asia Pacific is 37.35%, while in Africa is only 8.45%.[16] Among the adopting households, this represents only one PC, which limits simultaneous use by parents and children.

Although aggregated Internet adoption in most developing countries show significant progress, a more in-depth analysis reveals that the way in which users utilize Internet hinders their ability to offset the impact of the pandemic. As an example, Internet in most developing countries is typically used primarily to communicate and connect socially.[17] Thus, despite communication through social networks, Internet users' limited adoption of services that allow for a "virtualization" of physical activities reduces the power of digitization to face the pandemic. In order to measure the ability of connected homes to carry out activities over the Internet, we created an index of "household digital resilience" that combines four indicators:

- Number of health apps downloaded annually per population: we assume that users who download health apps are more likely to use the Internet to obtain information related to healthcare, the pandemic, COVID-19 testing points, etc. (source: *App Annie*).
- Number of educational apps downloaded annually per inhabitant: we assume that users who download educational apps are more likely to have the capability to educate children at home (source: *App Annie*).
- Number of fintech platforms per million inhabitants: we assume that the density of a country's fintech platforms aligns with a demand to carry out financial transactions online (source: *Crunchbase*).
- E-Commerce as a percentage of total retail commerce: we assume that e-commerce indicates an ability to continue activities like purchasing food and household supplies without leaving the home (source: *Euromonitor).*

[15] Source: ITU World Telecommunications / ICT Indicators database
[16] Source: extrapolation to 2019 of 2018 indicators in the ITU World Telecommunications / ICT Indicators database
[17] However, we are not discrediting the use of WhatsApp to communicate information related to health emergencies. See the use of WhatsApp by the WHO and the British government.

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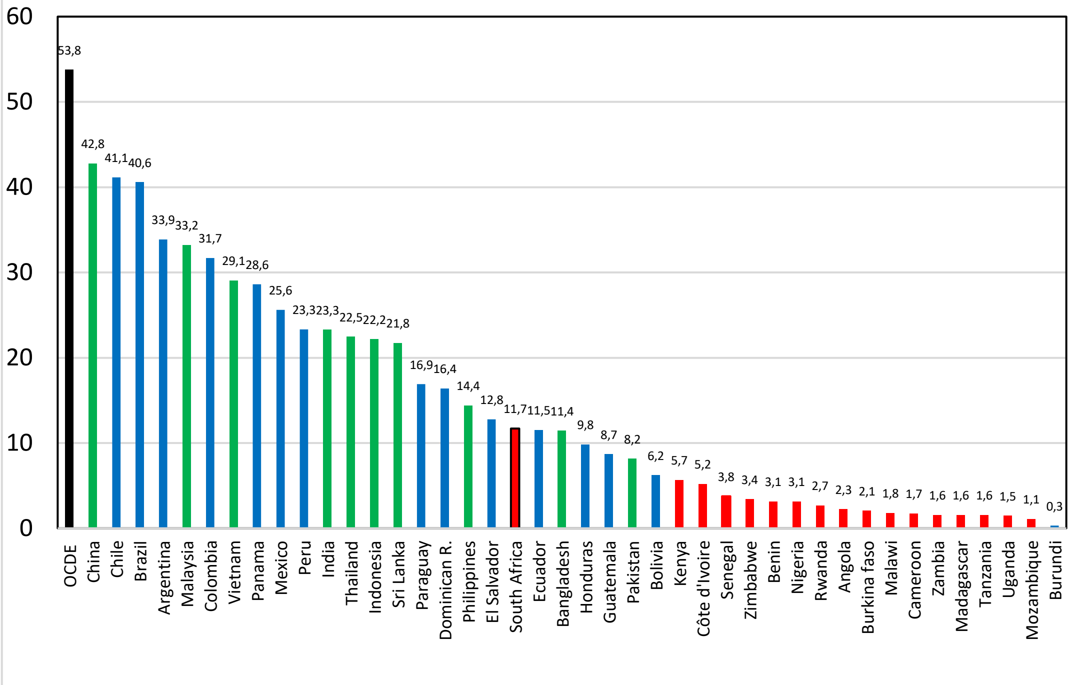
Combining each of these four indicators[18] to create a "Digital Household Resilience Index" allows us to visualize whether the population of emerging countries is prepared to face the quarantine. The higher the index, the better prepared the population will be to face isolation and quarantine conditions. Results by country are presented in Figure 8.

Figure 8. Developing Countries: Digital Household Resilience Index (2019)



Source: Prepared by the authors

The first observation from the indices shown in Figure 8 is the difference between most developing countries and the OECD index, indicating that households in richer nations are –from a digital perspective- better prepared to face the pandemic. The second observation is the heterogeneity of the index across different developing countries. China, Chile, and Brazil have higher household digital resilience rates compared to the rest of the developing countries in our sample. On the other hand, most African countries are at the lower end of the ranking. In most countries the index reaches values lower than 30 (compared to an OECD prorated index of 53.8), suggesting that the ability to educate children, complete financial transactions, and benefit from e-commerce in developing nations is considerably limited. If this index could be broken down by social group, we would expect to see that the more economically vulnerable populations within each country are disproportionally affected.

6. Resilience of digital production

The digitization of production is critical in keeping the economy running despite COVID-19 disruptions. To analyze "production resilience," we consider the extent to

[18] Fintech indicator was weighted 10% in the index, while the remaining three categories were 30% weighted each one. The indicators used in the index were normalized.

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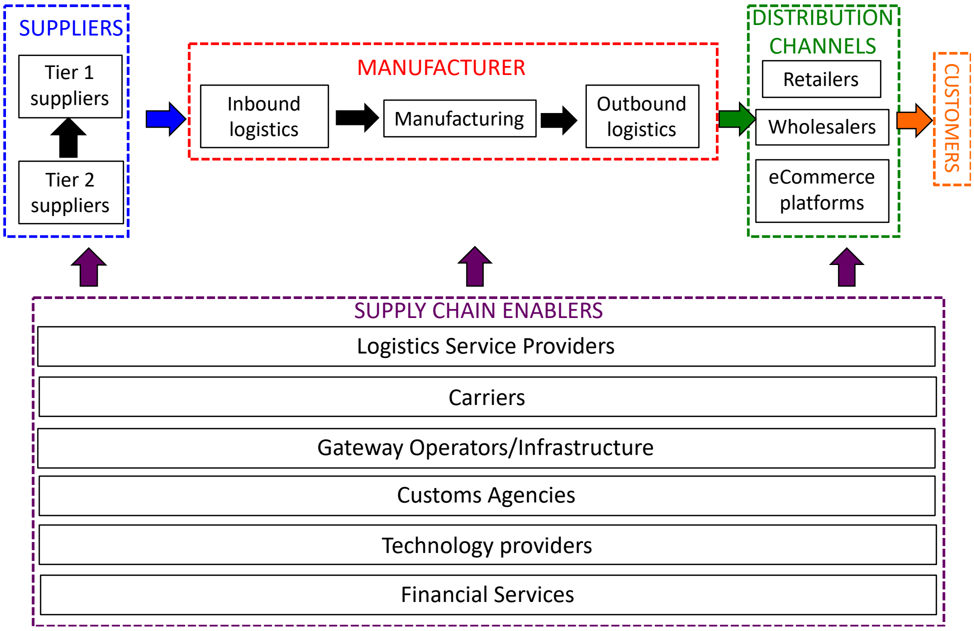
which production systems can continue to operate under current conditions, paying particular attention to supply chains and distribution channels.

For this analysis, we an expanded notion of the supply chain that spans beyond a limited definition of a firms' acquisition of inputs (Calatayud and Katz, 2019). This view includes the multitude of processes and intervening players who facilitate the flow of products and information throughout the chain. In order to operate seamlessly, these chains require logistical support from financial and technology service providers, as well as support from the public sector to facilitate the efficient functioning of infrastructure and establish a healthy business climate conducive to high-performance of logistics (see Figure 9).

Figure 9. Main stakeholders in the supply chain



Source: Calatayud and Katz (2019)

Figure 9 presents the main stakeholders who participate in the supply chain. This expanded analytical framework implies that in order for a production system to function resiliently in the face of the pandemic, all supply chain actors must have a high level of digitization. Manufacturing companies must not only be sufficiently digitized in order to handle purchase orders, but they also must be prepared to collaborate with logistics companies in order to trace goods in transit and/or interact with customs and port operators to make the transportation of products more efficient.

Figure 10 provides evidence that suggests that while Internet adoption at the enterprise level in developing countries is high the use of the Internet in supply chain operations is low.

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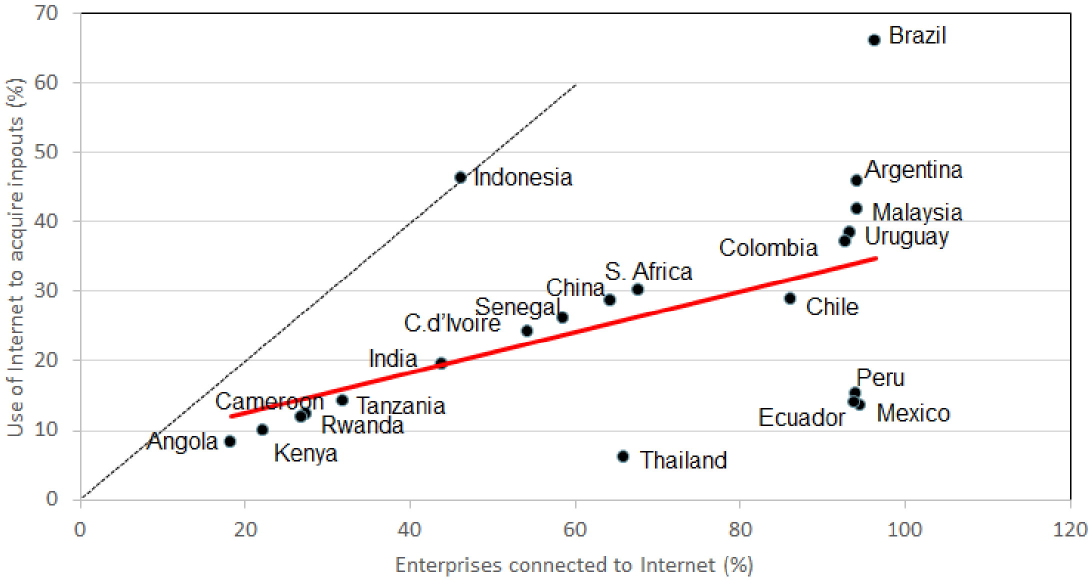
Figure 10. Percent of Enterprises connected to the Internet vs. Percent of Enterprises using the Internet to acquire inputs (2018)



Note: The difference between countries is mainly due to differences in survey sampling approaches (e.g. inclusion or not of microenterprises)
Sources: Statistic offices and Ministers of the respective countries; authors analysis.

From the sample of nations presented in Figure 10, only Indonesia seems to have a level of use of the Internet in the supply chain comparable with its level of Internet adoption among enterprises.

Another example of bottlenecks in the supply chain is related to governments' limited capacity to support foreign trade. Despite the progress in many nations that has occurred in recent years, developing countries continue to lag behind international best practices. We see evidence of this lag, for example, in the time required to process foreign trade documentation by customs agencies (see Table 4).

Table 4. Time required to process foreign trade documentation (2018, in hours)

Region	Exports	Imports
Asia Pacific	55.6	53.7
Latin America & Caribbean	35.7	43.2
MENA	66.4	72.5
South Asia	73.7	93.7
Africa	71.9	96.1
OECD	2.3	3.4

Source: World Bank. Doing Business 2019

Therefore, the limited digitization of companies –mainly SMEs– along with logistics chain bottlenecks represent obstacles to the development supply chain resilience to deal with COVID-19.

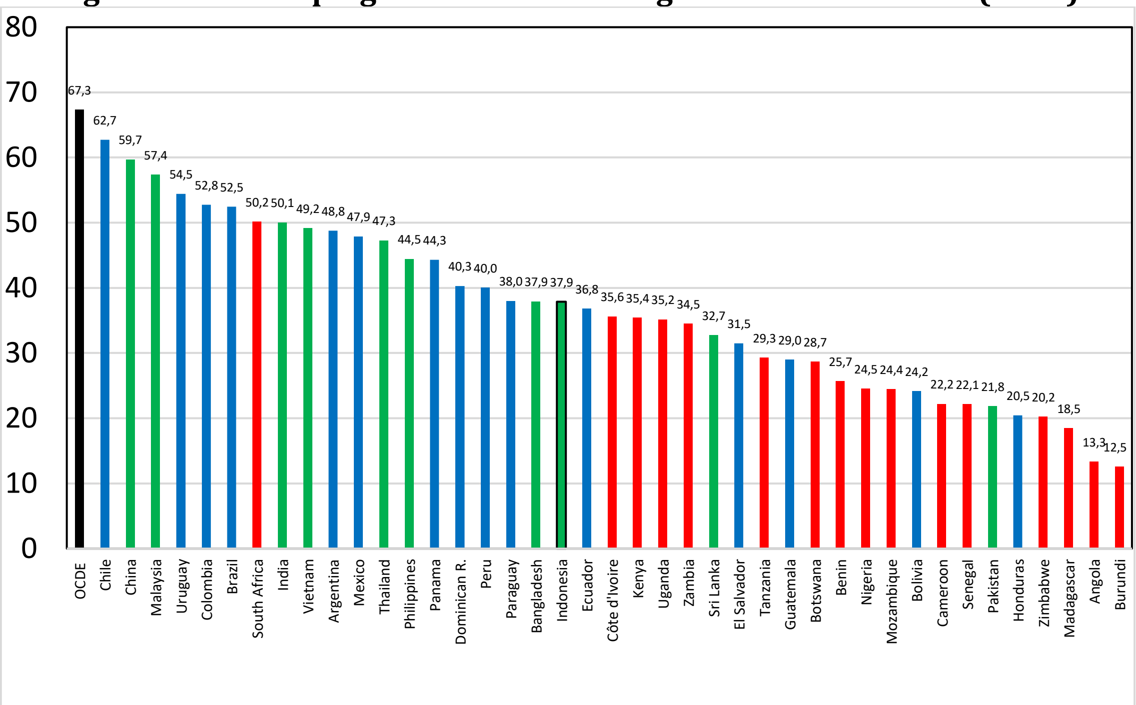
Electronic copy available at: https://ssrn.com/abstract=3600829

7. Resilience of the State

The State's resilience to the pandemic relies on its ability to continue its operations and delivering public services. When looking at this, there are services that are less impacted by the level of digitization (e.g., public health and safety). On the other hand, the digitization of other services like foreign trade processing may enhance the ability to deal with COVID-19.

We developed a "State Digital Resilience Index" based in two equally weighted pillars. The first pillar is related to the state administration, and is composed by the ease of doing business, the ease to conduct foreign trade and the level of logistics performance (the source of these indicators is the World Bank). The second pillar is related to public service platforms, offering a perspective on the digitization of public services. It is composed by an e-government development index, a measure of the quality of government sites and the presence of national telemedicine plans (the sources are UNDP and WHO) (see Figure 11).

Figure 11. Developing Countries: State Digital Resilience Index (2019)



Source: World Bank, UNDP, WHO; authors analysis

Figure 11 suggests that Chile, China and Malaysia seem better positioned among developing countries to face disruption.

The positive relationship between this index presented and the number of COVID-19 tests performed per 100,000 inhabitants demonstrates the states' resilience to face the disruption of the pandemic (see Figure 12).

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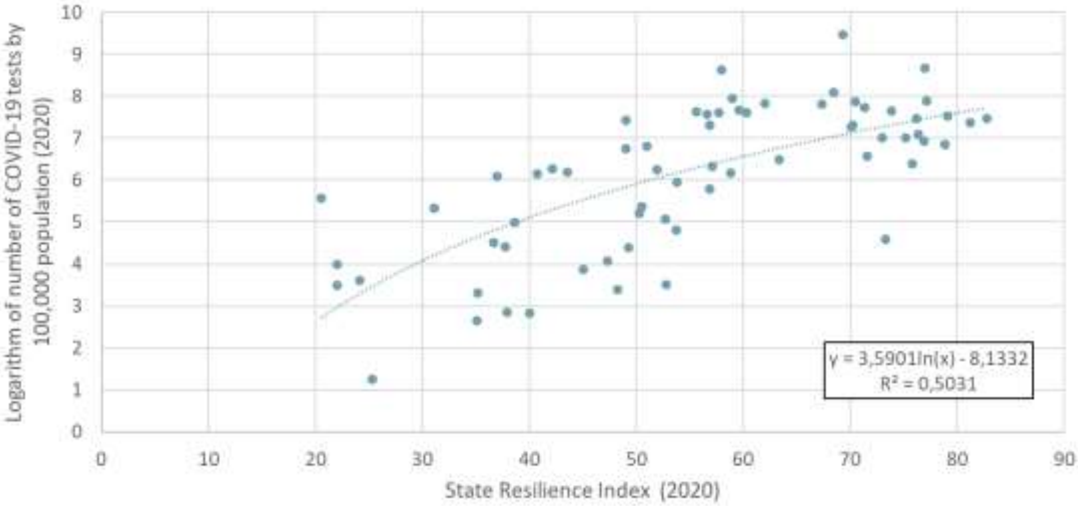
Figure 12. Relationship between the State Resilience Index and the Logarithm of Number of COVID-19 Tests per 100,000 Inhabitants (2020)



Source: Public information available by country, authors analysis

The correlation in Figure 12 shows that the greater the resilience of the State, the greater the capacity to administer COVID-19 tests.

8. Digitization and social resilience

When looking at the increase in Wi-Fi traffic and its impact on telecommunications networks, we alluded in Chapter 4 to the massive eruption of telecommuting. Along these lines, it is also pertinent to examine teleworking's impact on the labor market and its social implications. What is the magnitude of the changes caused by the pandemic as measured by the number of workers who now work from their homes? Can we establish some perspective as to which sectors are most- and least-affected? In theory, knowledge workers (e.g., researchers and software developers) would adapt most-easily to this new way of working. It is important to know, then, the number of workers who –due to their occupations– cannot work from home. In March alone, over 20,000,000 workers collected unemployment insurance in the United States. What does this situation look like in developing countries?

To make this estimate, we focus on South Africa as a case study. We relied on statistics from South Africa's Quarterly Labour Force Survey carried out by the Department of Statistics in Q4 2019. Conducted every quarter, the survey compiles information on more than 67,000 individuals that (using expansion codes) represent the entire labor force of the country. Because each respondent answers questions about their occupation, we were able to focus on the individuals employed at the time of the survey, purposely excluding the unemployed from the sample. By examining each of the 395 occupations listed in the dataset, the analysis assessed the likelihood of: (a) an occupation that has to continue to operate in its workplace (e.g., health professionals will likely continue to work in hospitals), and (b) an occupation that can or cannot rely on telecommuting (e.g., a factory operator cannot continue working if staying at home). The probabilities for (a) were based on the official rules issued by governments for the so-called "essential" occupations, while

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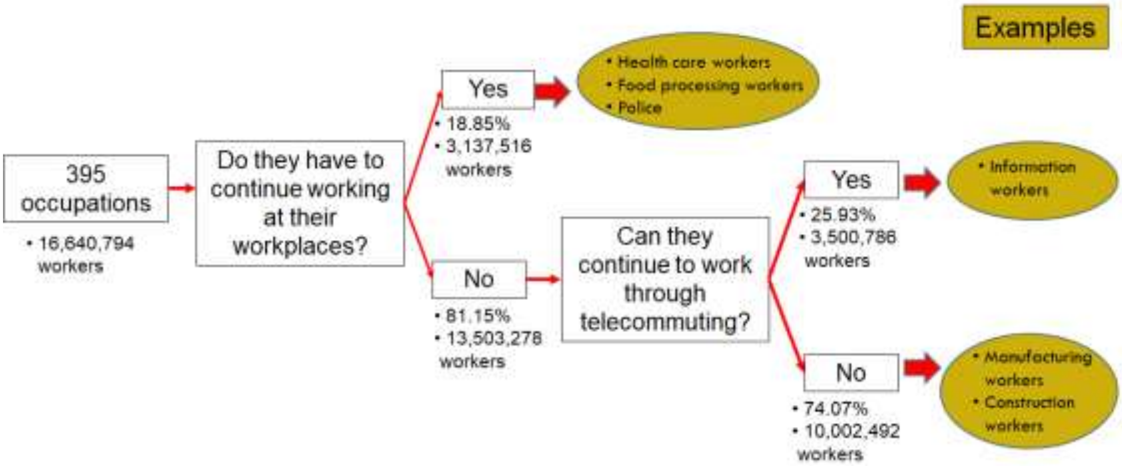
the likelihood of (b) was based on our own understanding of work an occupation entail.[19]

Once completed, the probability analysis yields the percentage of the workforce that can work from home, the percentage that must continue to go to their workplace, and the percentage that cannot telework. Similarly, the database allows us to analyze each of the three categories based on level of education, gender, and level of formality. Figure 13 shows the main results for the overall sample.

Figure 13. South Africa: Telecommuting impact analysis methodology



Source: Quarterly Labour Force Survey - Quarter 4: 2019; authors analysis

The results from Figure 13 leads to the following insights:

- Based on the total workforce registered in 2019 (including informal employment, but excluding the unemployed), South Africa had 16,640,794 employed workers.
- Of those employed workers, 3,137,516 (18.85%) must continue to go to their workplace (e.g., health care professional, security forces, food processing workers, etc.).
- Under lockdown conditions, the remaining 13,503,278 workers (81.15%) cannot go to their workplace.
- Of these 13,503,278 workers, 3,500,786 (25.93%) can continue to work by telecommuting from home. This is the number that caused the spike in network usage as analyzed in Chapter 4.
- The remaining 10,002,492 workers (74.07%) cannot work remotely from home.
- In sum, of the 16,640,794 total workers in South Africa, 60.11% are either not allowed to go to work or cannot continue to work by telecommuting.

It is especially important to consider the social implications of these numbers. While some members of the workforce will continue to work, a large proportion of the total workforce will face unemployment when the companies they work for cease operations, with each company choosing whether or not to continue paying its

[19] Complete detail of the probabilities for each occupation is available by the authors upon request.

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employees (as permitted by labor law). These social implications are even more serious when examining the number of affected workers with low education and/or working within the informal sector (see Table 6).

Table 6. South Africa: The discriminatory impact of COVID-19 on job type

South Africa 2019		Percentage that stay employed	Workers who must go to work	Telecommuting workers	Workers unable to work
Total Population		39.89%	3,137,516	3,500,786	10,002,492
By gender	Men	40.48%	1,966,476	1,809,202	5,552,625
	Women	39.15%	1,171,040	1,691,584	4,449,867
By education level	No education	14.44%	34,740	7,842	252,211
	Less than primary	17.89%	151,282	27,466	820,543
	Primary completed	18.20%	91,283	17,512	488,980
	Less than secondary	26.66%	1,173,631	255,690	3,931,812
	Secondary completed	40.80%	1,119,965	1,156,320	3,302,212
	Tertiary	70.14%	540,704	2,018,836	1,089,396
	Other education	26.83%	25,910	17,122	117,337
By formality	Formal sector	46.41%	2,381,863	2,692,540	5,858,689
	Informal sector	19.87%	684,433	290,549	3,932,330
	Other	73.58%	71,221	517,698	211,473

Source: Quarterly Labour Force Survey - Quarter 4: 2019; authors analysis

The analysis by educational and inclusion within the formal sector indicates the disproportionate impact of disruption on the most vulnerable social groups. The percentage of people that remains employed is, as expected, much larger for highly educated people and for those workers associated to the formal sector. Of the 10 million workers (60% of the workforce) that cannot go to work or telecommute, 39% are in the informal sector. In contrast, there are no big differences by gender in the percentage that stays employed.

9. Conclusion and Policy Implications

The COVID-19 pandemic is unusual in that it poses a challenge to the global socio-economic system. Following the initial implementation of prophylactic measures as well as the fear of contagion, anecdotal evidence emerged suggesting that digital technologies could counteract the isolation enforced by social distancing, increase awareness of virus prevention measures, and allow economic systems to continue to operate. The work presented in this paper uses empirical evidence to highlight the important role digital technology could play in mitigating the pandemic's disruption while evaluating the level of preparedness of developing countries to face this challenge, from different perspectives.

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In this sense, public and private sectors, with the support of civil society, must collaborate and work together to promote the enhancement of certain components of the digital ecosystem. First and foremost, it is necessary to consider how to limit the negative effects that an increase in traffic has on the quality of the networks. Measures that require the deployment of infrastructure to accommodate a systemic increase in traffic usually take too long to complete in a situation of emergency. That said, three initiatives that require considerably less time can be taken as soon as possible:

- Deployment of a larger number of base stations for mobile broadband. Every operator normally deploys base stations for mobile broadband when facing spikes in traffic. To speed up this process, the permits and requirements needed to deploy antennas should be relaxed to allow operators to react quickly.
- Temporary allocation of additional spectrum to mobile operators. Additional spectrum allows operators to handle heavier traffic loads without the need to deploy additional infrastructure. As an example, the US regulatory agency has temporarily granted mobile operators the use of spectrum in pre-determined regions of the country (FCC, 2020).
- The requirement of streaming service providers to reduce the traffic volume generated. Streaming video services consume a large amount of network traffic.[20] Some operators have already responded: Google announced the reduction in YouTube video definition quality, Disney delayed the launch of its Disney+ streaming service in France, while Microsoft slowed the pace of its Xbox gaming platform updates.

Other relevant measures include stimulating technology companies to develop platforms that can improve the efficiencies in the supply chains, particularly between logistics providers and transportation services. In addition, it will be necessary to encourage enterprises to further digitize business processes in order to increase the percentage of the workforce that can work remotely, and to invest in the training of the most vulnerable population groups in order to decrease unemployment rates.

Looking to the future it is critical that countries begin work immediately on a Digital Resilience Plan to address future pandemic disruptions. This will require, in the first place, to conduct a comprehensive diagnostic of country resilience, considering all those axes covered in this paper. After that, countries will be able to develop plans to address their respective shortfalls and to be better prepared for next time.

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[20] According to Sandvine, only Netflix comprises 12.6% of total Internet download traffic.

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Appendix

Table A-1. Countries affected by SARS.

Country	Infected persons	Deaths	Mortality rate	Date of first case	Date of last case
Australia	6	0	0%	26-feb.-03	1-apr.-03
Canada	251	43	17%	23-feb.-03	12-jun.-03
China	5327	349	7%	16-nov.-02	3-jun.-03
France	7	1	14%	21-mar.-03	3-may.-03
Germany	9	0	0%	9-mar.-03	6-may.-03
Hong Kong	1755	299	17%	15-feb.-03	31-may.-03
India	3	0	0%	25-apr.-03	6-may.-03
Indonesia	2	0	0%	6-apr.-03	17-apr.-03
Ireland	1	0	0%	27-feb.-03	27-feb.-03
Italy	4	0	0%	12-mar.-03	20-apr.-03
Korea	3	0	0%	25-apr.-03	10-may.-03
Kuwait	1	0	0%	9-apr.-03	9-apr.-03
Macao	1	0	0%	5-may.-03	5-may.-03
Malaysia	5	2	40%	14-mar.-03	22-apr.-03
Mongolia	9	0	0%	31-mar.-03	6-may.-03
New Zealand	1	0	0%	20-apr.-03	20-apr.-03
Philippines	14	2	14%	25-feb.-03	5-may.-03
Romania	1	0	0%	19-mar.-03	19-mar.-03
Russia	1	0	0%	5-may.-03	5-may.-03
Singapore	238	33	14%	25-feb.-03	5-may.-03
South Africa	1	1	100%	3-apr.-03	3-apr.-03
Spain	1	0	0%	26-mar.-03	26-mar.-03
Sweden	5	0	0%	28-mar.-03	23-apr.-03
Switzerland	1	0	0%	9-mar.-03	9-mar.-03
Thailand	9	2	22%	11-mar.-03	27-may.-03
Taiwan	346	37	11%	25-feb.-03	15-jun.-03
United Kingdom	4	0	0%	1-mar.-03	1-apr.-03
United States	27	0	0%	24-feb.-03	13-jul.-03
Vietnam	63	5	8%	23-feb.-03	14-apr.-03

Source: *Keogh-Brown and Smith* (2008)

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