

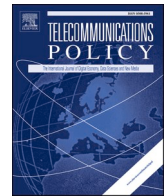


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Can digitization mitigate the economic damage of a pandemic? Evidence from SARS

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ABSTRACT

The work presented in this paper uses empirical evidence to highlight the important role digital technology plays in mitigating a pandemic's economic disruption. As extensive datasets including the effect of the current COVID-19 pandemic are still unavailable, this study provides an assessment of the role of digitization at the time of SARS in 2003. Results are robust in pointing out that those countries with better broadband connectivity were able to mitigate some of the economic losses incurred by the pandemic. While anecdotal evidence is plentiful even for COVID-19, this study provides rigorous analysis to support that a reliable telecommunications infrastructure and a high level of digitization is crucial to keep the economy running under pandemic conditions. These results provide valuable evidence for the current context of COVID-19, which has resulted in several national lockdowns around the world. In consequence, we believe that the public and private sectors must collaborate and work together to promote the enhancement of the digital ecosystem. In the long run, a suitable regulatory framework seems crucial to stimulate private investments to close the digital supply gap, as well as promoting the digitization of business process and the training of the workforce to acquire digital skills. In the short term, we discuss several measures that can be taken to accommodate the expected increases in internet traffic in such circumstances and maintain the quality of service.

1. Introduction

The COVID-19 pandemic represents a fundamental challenge to the global socio-economic system. This crisis 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 -4.9% in 2020, much worse than during the 2008–09 financial crisis.

Following the initial wave of fear of contagion and the implementation of prophylactic measures, anecdotal evidence has 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.

This paper intends to provide an assessment of the role played by digitization to mitigate economic losses derived from pandemics.

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It is still too early to empirically assess the role of digitization in mitigating the economic damage from COVID-19, due to the lack of granular and comparable data across countries and the fact that the pandemic is far from being defeated. However, we provide econometric-based evidence based on the statistical series from one of the last pandemics: that of SARS in 2003. In particular, this paper investigates the extent to which digital infrastructure (in this case, fixed broadband) mitigated the negative economic impact within the countries affected by the SARS outbreak. The findings from this analysis should provide useful insights for the ongoing 2020 crisis.

Focusing on these key topics, this paper is structured as follows. Section 2 reports a literature review, analyzing the economic effects of digitization and the information reported from the SARS period to frame our main hypothesis. Section 3 provides the empirical model designed to test the hypothesis, and the corresponding dataset we relied upon. Section 4 presents and discusses the econometric results of the empirical estimate. Finally, Section 5 concludes with some policy implications.

2. Review of prior research and study hypothesis

The review of prior research has been structured into two main sections. First, we have compiled the limited evidence of why countries with advanced digitization are more capable to mitigate the economic losses of a disaster, such as a pandemic. Secondly, we describe the specific facts from the SARS pandemic, which are relied upon to frame the subsequent analysis. Following that, the main hypothesis of the analysis is presented.

2.1. Digitization as a mitigant of the economic impact of disasters

Studies on the economic impact of digital technologies have been produced for the past two decades confirming, to a large extent, that telecommunications and broadband in particular have an impact on economic growth and, in some cases, on employment and productivity (Arvin & Pradhan, 2014; Fornefeld et al., 2008; Hardy, 1980; Jensen, 2007; Karner & Onyeji, 2007; Katz, 2011; Katz & Callorda, 2018; Katz et al., 2008, 2012; Katz & Suter, 2009; Koutroumpis, 2009; Mack & Faggian, 2013; Rohman & Bohlin, 2012). Under normal conditions, broadband connectivity usually translates into productivity improvements by facilitating the adoption of more efficient business processes (e.g., marketing, inventory optimization, and streamlining of supply chains); in accelerated innovation by introducing new consumer applications and services (e.g., new forms of commerce and financial intermediation); and in more efficient functional deployment of enterprises by maximizing their reach to labor pools, access to raw materials, and consumers (e.g., outsourcing of services, virtual call centers). All these advantages provided by better connectivity can be crucial in a context of crisis in which face-to-face interactions must be avoided.

Beyond these effects, broadband can also be essential in providing economic resiliency under emergency situations. At the household level, broadband allows citizens to carry out many daily tasks that previously required physical contact. Examples of this are the possibility of buying online (e-commerce), of accessing health apps (e-health), of studying by virtual tools (e-education) or telecommuting.² At the enterprise level, the digitization of production is critical in keeping the economy running in the case of disruption. Beyond providing workers the possibility to telecommute, digitized supply chains and distribution channels can substantially contribute to keep the production activity operating in the situations in which face-to-face interactions with customers and suppliers must be avoided. Finally, broadband and digitization can increase resiliency at the government level, by allowing them to continue its operations and delivering public services. Beyond those services that are less impacted by the level of digitization (e.g., public health and safety), it is straightforward to see that a digitalized government has more capability to continue providing public services without interruption.

So far, empirical evidence on the role of digitization to mitigate the economic losses of these situations is scarce and focuses mainly on natural disasters. Teodorescu (2014) analyzes the role of information technologies (IT) for disaster mitigation, addressing the roles of the technology in improving resilience. He stresses that some IT tools, such as sensor networks or decision-supply systems, plus a reliable telecommunication infrastructure are crucial to create a comprehensive picture of an emergency in order to manage information and support decision-making. Similarly, O'Reilly et al. (2006) concentrate their analysis on the impact of recent hurricanes on the affected telecommunication networks in the United States. They highlight the role of telecommunications in supporting critical sectors such as emergency services, finance, and other basic industries required to provide services and conduct business in situations of natural disasters. In turn, the International Telecommunications Union (ITU, 2013) has provided technical reports on the role of the networks for weather or geophysical disaster mitigation. For the specific case of pandemics, Chamola et al. (2020) describe the use of technologies such as the Internet of Things (IoT), Unmanned Aerial Vehicles (UAVs), blockchain, Artificial Intelligence (AI), and 5G, among others, to help mitigate the impact of these outbreaks. That being said, the authors do not quantify their economic impact. In fact, to the best of our knowledge, there is no previous empirical estimate of the role of digitization in reducing the economic effects from a pandemic.

² Of course, this implies that being connected is not enough, as 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.

2.2. The case of the SARS in 2003

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). 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.

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 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). 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 \$1.3 billion in tourism losses.

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 into an estimated economic loss in the range of \$ 30–100 billion (Fan, 2003; Knapp et al., 2004; Lee & McKibben, 2004). According to Keogh-Brown and Smith (2008), the health, tourism, hospitality, airline, retail, restaurant, leisure, and entertainment sectors felt the largest impact. Fig. 1 represent selected examples of the economic losses faced by affected sectors in some countries during that period.

At the time of the outbreak, experts already anticipated that the internet would play an important role by promoting teleworking during a period of confinement (Bidaud & Chetham, 2003; Chal, 2003; Crozier, 2003; Flynn, 2003). In fact, there is plenty of anecdotal 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 outlets, deployed an e-commerce channel, based first on instant messaging and then through

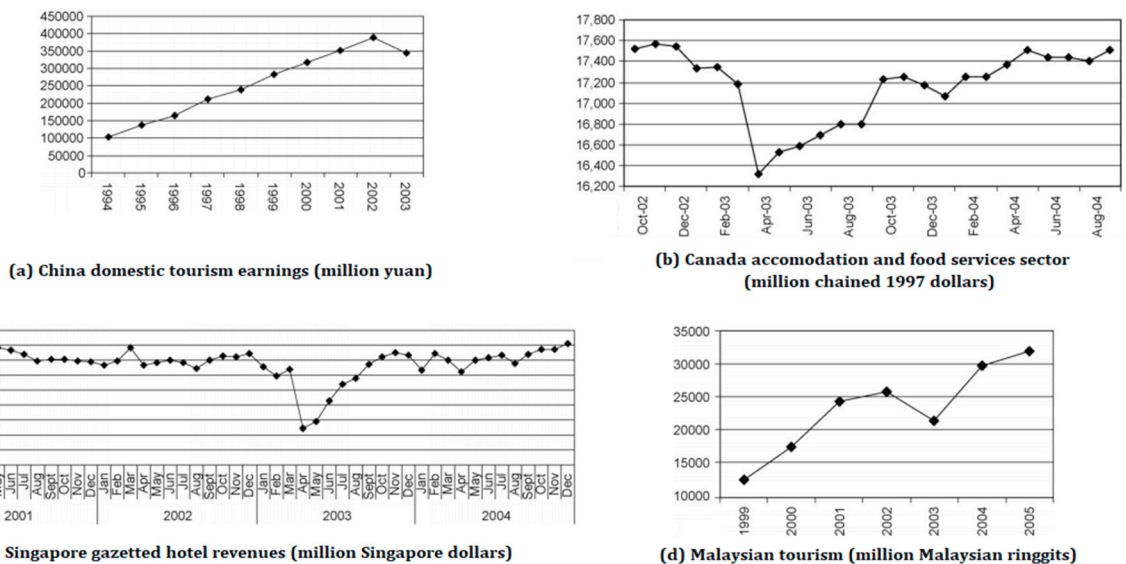


Fig. 1. Examples of affected economic sectors in selected countries. Source: extracted from the research carried out by Keogh-Brown and Smith (2008).

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).

2.2.1. Hypothesis

Considering the surveyed literature, it seems clear that we can expect a more digitized economy to be more resilient in the case of a pandemic disruption. All in all, we can sketch our main hypothesis as follows:

The economic losses of the SARS outbreak in 2003 were not equal for every country affected. Rather than that, when controlling for a range of variables, the countries with better digital infrastructure were able to counteract part of the negative economic impact, allowing households, enterprises, and governments to continue functioning during that time.

In the following sections we provide the empirical specification, the dataset, and the econometric results aimed to test this hypothesis.

3. Empirical specification and dataset

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

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

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 degree of digitization of the economy. We will proxy for the digitization level with broadband penetration, variable which we will call BB . This assumption is based on several empirical articles that have found a positive link between the spread of digital technology and productivity (Fornefeld et al., 2008; Mack & Faggian, 2013; Katz & Callorda, 2018; just to mention a few examples). The reason to rely on fixed broadband as a determinant of productivity (rather than mobile) is that wireless internet was limited at the time of SARS. To capture the economic effect of SARS, we will consider two different variables: in the first place a dummy is used to identify the countries affected by the pandemic, taking value of 1 when at least one positive case has been reported. Secondly, considering that the economic losses may depend on the severity of the pandemic expansion at each country, we construct a continuous variable based on the number of people infected every 100.000 inhabitants. For this analysis, we relied on the official SARS statistics provided by the World Health Organization (WHO),³ regarding the countries that registered positive cases of people infected. We do recognize, however, that SARS may have also negatively impacted the economies of other countries with no positive cases, and that other countries may have experienced positive cases not reported by the WHO.

By applying logarithms to linearize the production function, the basic empirical model is defined as in the following equation [1]:

$$\log(Y_{it}) = \mu_i + \alpha \log(K_{it}) + \beta \log(L_{it}) + \varnothing \log(BB_{it}) + \gamma SARS_{it} + \eta SARS_{it}^2 + \zeta \log(BB) * SARS_{it} + \theta_t + \epsilon_{it} \quad [1]$$

whereby the symbol μ_i accounts for time-invariant unobservable country-level effects, θ_t captures time-related fixed effects and ϵ represents an error term, which we assume to verify the desired properties. The SARS variable will be gradually introduced under several specifications: as a dummy, as a continuous variable, and in squares to account for non-linearities. Therefore, the parameters γ and η intend to capture the pandemic's impact on the GDP of the affected countries. Lastly, the symbol ζ measures the variable built as the interaction between fixed broadband penetration and the SARS indicator. 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 impact of the disease. Table 1 describes the variables used to estimate the model, along with their respective sources.

The sample is comprised by 178 countries for the period of 2000–2017. A large sample provides the advantage to maximize the asymptotic properties of the Ordinary Least Squares (OLS) estimation method, to ensure consistency. Despite the extension of the panel, the SARS variables were built in such a way that can only take values different than zero in year 2003, therefore limiting the supposed negative economic effect only to that year, as suggested in the literature.

4. Econometric results

Table 2 summarizes the results of the empirical estimates conducted using the OLS method. All estimates incorporate robust standard errors clustered by country, as well as fixed effects by country and by year. The introduction of fixed effects for both country and year minimizes the risk of omitted variables bias.

In the case of column (i), the model estimates do not include the effects of SARS (that is to say, the $\gamma = \zeta = \eta = 0$ restriction is imposed in equation [1]). 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 value of 0.025, being highly significant. In other words, a 10% increase in fixed broadband penetration rate is associated with a 0.25% growth in GDP, which is consistent with the results found in the literature (Koutroumpis, 2009).⁴ Columns (ii) and (iii) incorporate the SARS variables in order to analyze whether this pandemic negatively impacted the economies of the affected countries. The introduction of the dummy SARS variable in

³ Full list available at: https://www.who.int/csr/sars/country/table2004_04_21/en/.

⁴ The difference of this coefficient with results of other recent studies conducted by the authors is explained in Appendix A.

Table 1
Description of the variables in the model.

Variable	Description	Source
<i>Y</i>	GDP at constant 2011 prices (\$ million)	Penn World Table, version 9.1
<i>K</i>	Capital stock at constant 2011 prices (\$ million)	Penn World Table, version 9.1
<i>L</i>	Number of workers	Penn World Table, version 9.1
<i>BB</i>	Fixed broadband per household	World Bank – World Development Indicators and ITU
SARS(dummy)	Dummy variable that takes the value of 1 for those countries with at least one positive SARS case in 2003	World Health Organization
SARS(cases by population)	SARS infected people every 100.000 inhabitants in 2003	World Health Organization

Source: Prepared by the authors

Table 2
Economic Impact of SARS – Fixed Effects estimate.

	(i)	(ii)	(iii)	(iv)	(v)
$\log(K)$	0.395*** [0.061]	0.394*** [0.060]	0.395*** [0.061]	0.395*** [0.061]	0.393*** [0.060]
$\log(L)$	0.336*** [0.091]	0.338*** [0.091]	0.336*** [0.091]	0.335*** [0.091]	0.337*** [0.090]
$\log(BB)$	0.025*** [0.007]	0.025*** [0.007]	0.025*** [0.007]	0.025*** [0.007]	0.025*** [0.007]
SARS(dummy)		-0.036* [0.022]			
SARS(cases by population)			-0.007*** [0.001]	-0.037*** [0.013]	0.082*** [0.017]
SARS (cases by population) ²				0.001** [0.000]	-0.001** [0.000]
$\log(BB)*SARS(cases by population)$					0.117*** [0.013]
Fixed effects by country	YES	YES	YES	YES	YES
Fixed effects by year	YES	YES	YES	YES	YES
Restriction	$\gamma = 0,$ $\zeta = 0,$ $\eta = 0$	$\zeta = 0,$ $\eta = 0$	$\zeta = 0,$ $\eta = 0$	$\zeta = 0$	-
R ²	0.95	0.95	0.95	0.95	0.95
Observations	2.497	2.497	2.497	2.497	2.497
Estimation method	OLS	OLS	OLS	OLS	OLS

Note: robust standard errors in parentheses. *p<10%, **p<5%, ***p<1%.

Source: Prepared by the authors

column (ii) is related to a negative economic effect of the pandemic, with the coefficient γ equal to -0.036 , although significant at only 10%. However, by construction, the dummy variable is built in such a way that considers as affected any country which reported a positive case, measuring a similar effect regardless of the quantity of infected people. As we can expect countries with more positive cases to have been hit more severely,⁵ in column (iii) we introduce the continuous variable, measured as the quantity of positive cases every 100.000 people. The results do indeed suggest that the pandemic had a negative impact, and that the economic losses tend to be of greater magnitude as the pandemic becomes more severely expanded in the country. In this case, the coefficient γ equal to -0.007 and is significant at a 1% level. These numbers demonstrate that, in 2003, the countries with SARS cases saw significant economic downturn. Considering the results of column (iii), in the remaining columns we will continue with the estimates relying only in the continuous variable.

Column (iv) tests for economic losses depending on the magnitude of the expansion of the pandemic, while relying on the possibility non-linearity effect. To test for non-linearities we introduce the SARS variables both in level and in squares. Results of this estimate suggest a non-linear effect, with the coefficient of the squared variable being positive, although small. This is an unexpected result which seems to suggest that the more expanded the pandemic is, the economic damage is more mitigated. However, a deeper analysis provided us with an explanation for this result, which is explained by the case of Hong-Kong, as the country more severely affected by the pandemic, which at the same time was still able to grow at a rate over 3% in 2003 (if we exclude that country from the sample, the squared coefficient becomes non-significant).

⁵ We thank an anonymous referee for raising up this point.

To evaluate whether the economic impact within SARS-afflicted countries was heterogeneous in terms of the development of their broadband infrastructure, column (v) presents an estimate including the interaction between the SARS and the broadband penetration variable. In this estimate, the signs of the SARS coefficients again prove a non-linear effect, in this case with the expected signs, as the squared variable exhibits a negative coefficient. This provides evidence of an intuitive nonlinear effect: as the pandemic expands, the economic damage increases. The parameter ζ , which measures the interaction between broadband and SARS, is verified to be positive and highly significant at 1%, providing evidence that more digitized countries were able to counteract to some degree the effects of the pandemic.

The economic implications of this result are evident. Those countries with better digital infrastructures were able to counteract part of the economic losses, as they were more resilient to the lockdown generated by 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 and enterprises to continue operating. This is consistent to the surveyed literature and seems to confirm our main hypothesis.

In order to verify the robustness of our analysis, in [Table 3](#) we replicate the former estimates by using the Instrumental Variables (IV) approach, therefore controlling for potential endogeneity associated with the broadband variable. 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 vary over time, the incorporation of fixed effects allows for their control. On the other hand, the introduction of year fixed effects controls for international shocks which may have a worldwide effect, such as variations in commodity prices. Secondly, endogeneity may be a result of the presence of reverse causality; just as broadband penetration impacts GDP, GDP can also impact penetration levels. Lastly, the possible existence of measurement errors in the variables could also contribute to endogeneity.

As usual with this type of estimates, 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). The fact that an existing infrastructure, such as fixed telephony, is required for broadband deployments makes existing phone lines an appropriate instrument. [Czernich et al. \(2011\)](#) followed this strategy, using pre-existing fixed and cable telephone line data to measure national broadband penetration levels. Similarly, [Bertschek et al. \(2013\)](#) performed an econometric analysis using ADSL availability as an instrument for the broadband variable. Following [Czernich et al. \(2011\)](#), we will use the fixed telephony penetration variable as an instrument, with a 5-year time lag to eliminate any possible impact of contemporary shocks and to avoid concerns related to reverse causality.

The IV estimate reported in [Table 3](#) confirms the previous results 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. Beyond that, there are some differences in the results provided by both estimation strategies. In the case of the IV, the broadband coefficients turn out to be larger. This effect is in line with [Bertschek et al. \(2013\)](#) and [Czernich et al. \(2011\)](#), who report that OLS estimates may be downward biased. In any case, we believe that these results must be taken with caution, and hence, we will continue our analysis by relying in the more conservative OLS estimates.

Having been able to verify our hypothesis regarding of the positive role of digital transformation to mitigate the economic losses of the pandemic, we will provide an insight regarding the degree of impact depending on each penetration level. From equation (1), we can compute the elasticity of GDP with respect to an increase in the SARS variable:

$$\epsilon_{Y, SARS} = \frac{\partial \log(Y_{it})}{\frac{\partial SARS}{SARS}} = (Y + 2\eta SARS_{it} + \zeta \log(BB_{it}))^* SARS_{it} \quad [2]$$

As described in equation (2), the degree of impact will vary across different countries, depending on their broadband infrastructure and on the expansion of the disease. Using the estimated coefficients from column (v) of [Table 2](#), we can simulate the elasticity for specific scenarios of broadband penetration ([Fig. 2](#)).⁶

The pattern seems to be clear: the more connected a country is, the lower the economic damage of the outbreak. [Fig. 1](#) suggests that the GDP contraction after an increase in the infected ratio varies with the level of broadband connectivity, becoming negligible for those cases above 20%. On the other hand, the economic damage for a hypothetical country with a 10% broadband penetration can be offset in 12.94% if it increases in 1% its penetration level (to 11%). If the same country increased in 5% its broadband penetration (to 15%), then it can mitigate over half of the losses. Of course, these are just simulations based on the estimated coefficients, but still constitute an interesting exercise to assess the relevance of broadband infrastructure for such situations. While it is still too early to perform a similar analysis for the current COVID-19 pandemic, the initial evidence may allow us to foresee a similar situation. As a result, we can argue that digital infrastructure contributes to partially mitigate the effects of pandemic, although, in order to apply a similar model to COVID-19, a new specification should be done, because the patterns of economic impact of each pandemic are dramatically different. Further research should be conducted for COVID-19 as soon as data becomes available.

⁶ Assuming that the SARS variable presents a level equal to the mean of the affected countries.

Table 3
Economic Impact of SARS – Fixed Effects IV estimate.

	(i)	(ii)	(iii)	(iv)	(v)
$\log(K)$	0.353*** [0.007]	0.352*** [0.030]	0.354*** [0.030]	0.353*** [0.030]	0.353*** [0.030]
$\log(L)$	0.350*** [0.035]	0.353*** [0.035]	0.350*** [0.035]	0.349*** [0.035]	0.350*** [0.035]
$\log(BB)$	0.044*** [0.007]	0.044*** [0.007]	0.044*** [0.007]	0.044*** [0.007]	0.043*** [0.007]
SARS(dummy)		-0.050** [0.023]			
SARS(cases by population)			-0.008*** [0.002]	-0.042*** [0.013]	0.104*** [0.039]
SARS (cases by population) ²				0.001*** [0.000]	-0.001* [0.001]
$\log(BB)*SARS(cases by population)$					0.141*** [0.038]
Fixed effects by country	YES	YES	YES	YES	YES
Fixed effects by year	YES	YES	YES	YES	YES
Restriction	$\gamma = 0,$ $\zeta = 0,$ $\eta = 0$	$\zeta = 0,$ $\eta = 0$	$\zeta = 0,$ $\eta = 0$	$\zeta = 0$	-
Under identification contrast	158.6***	159.3***	158.6***	158.2***	157.9***
Weak identification contrast	291.2 [†]	291.5 [†]	291.8 [†]	290.9 [†]	145.1 ^{††}
R ²	0.81	0.81	0.81	0.81	0.81
Observations	2460	2460	2460	2460	2460
Estimation method	IV	IV	IV	IV	IV

Note: robust standard errors in parentheses. *p<10%, **p<5%, ***p<1%. (†) denotes critical value at 10% of 16.38. (††) denotes critical value at 10% of 7.03. All equations exactly identified.

Source: Prepared by the authors

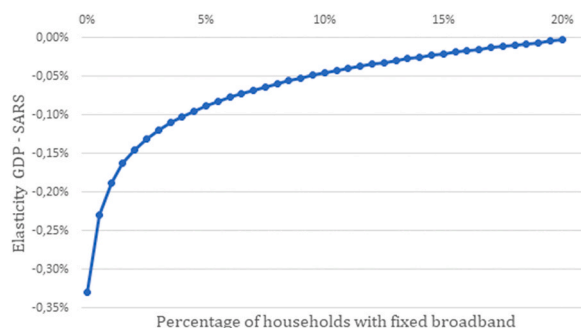


Fig. 2. Economic impact of SARS vs. Fixed Broadband penetration. Source: Developed by the authors.

5. Conclusion and policy implications

In times of pandemics, the implementation of prophylactic measures as well as the fear of contagion generate an enforced social distancing. In a much less degree than the current COVID-19 situation, seventeen years ago some countries experienced such situation in the case of SARS. The work presented in this paper uses empirical evidence to highlight the important role digital technology played at that time in mitigating the pandemic's disruption. Results seem to be robust to point out that in 2003, those countries with higher broadband penetration were able to counteract part of the economic losses derived from SARS. This evidence seems to be critical in the current context resulting from COVID-19.

Given the relevance of digitization to face an emergency, countries will have to prepare themselves in terms of the development of a digital infrastructure, entailing not only fixed, but also mobile broadband to face similar future situations. Along these lines, a number of initiatives can be taken.

In a context of emergency, measures can be taken to provide flexibility for operators to accommodate the resulting increases in internet traffic, as we are currently seeing worldwide because of COVID-19. This is critical to ensure a consistent service quality during lockdowns. It is clear that infrastructure deployments usually take too long to complete in a situation of emergency. Even if specific policy measures were not tested in our empirical analysis, it could be positive for public authorities to evaluate some initiatives that

should require considerably less time in implementing: (i) 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 may be relaxed to allow operators to react quickly; (ii) 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); (iii) the requirement of streaming service providers to temporarily reduce their traffic by reducing the definition of video content.⁷

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. After that, countries will be able to develop plans to address their respective shortfalls and to be better prepared for the next crisis.

Appendix A

The economic impact of broadband on the economy has been extensively studied in the literature. One of the most recent contributions was performed by Katz and Callorda (2018) for the ITU, covering a sample of 139 countries for period 2004–2017, finding that a 10% increase in fixed broadband yielded an increase in per capita GDP of 0.77%. With respect to the results reported in this paper in Table 2 (0.25%) and 3 (0.44%), an initial comparison may suggest that our estimates are downward biased. However, a deep analysis indicates that the result seems reasonable. First, there are some differences among the methodologies followed in both studies. The ITU report uses a structural model of simultaneous equations, while here we rely in an IV two-step estimate. Secondly, there are differences in the definition of the variables as well. We used GDP as the dependent variable, while the ITU study analyzes the impact on GDP per capita. With respect to the explanatory variables, we use the physical capital stock and labor, while the ITU report relies on gross capital formation and human capital. That being said, the main reason to explain the differences in the results is related to differences in the sample of countries. Katz and Callorda (2018) use a smaller sample, which does not incorporate some low-income countries that are included in this study. The results reported in the ITU study when splitting the sample across development level of the countries, points out at a larger economic impact of broadband for high-income countries. On the contrary, their results for middle and low-income do not appear to be statistically significant. Therefore, as our sample incorporates additional low-income economies, it is reasonable that results reported in Tables 2 and 3 exhibit smaller comparative coefficients.

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⁷ According to Sandvine, Netflix alone generates 12.6% of total internet download traffic.

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