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How important is mobile broadband latency for total factor productivity growth?*

By

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Abstract:

This paper investigates the relationship between the log change in mobile broadband latency and total factor productivity (TFP) growth based on data for 130 countries. It finds that there is a strong correlation between TFP growth and one year lag of latency growth once controlling for the growth of labor and capital services in OECD countries. The interpretation of the findings is that a 10 percentage points decrease in the growth of latency in period t-1 is associated with an increase of 0.3 percentage points in TFP growth. The findings are in accordance with the framework of general purpose technologies that suggests that the impact of new technologies often appear with a lag. Moreover, no relationship is found for non-OECD countries, which suggest that it is only OECD countries that are able to take advantage of the benefits of lower latency. One possible explanation could be that OECD countries have reached a higher maturity in digitalization and automation in production processes and thus are able to take advantage of the benefits of lower latency.

Keywords: ICT, Productivity, Latency, Mobile broadband networks, Economic development

JEL-codes: D24; O33; O47

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1. Introduction

During the last decade there has been a substantial decline in productivity growth in many OECD countries. *Figure 1* shows labor productivity growth for the largest economies in the world 1995–2021. The average labor productivity growth in the OECD countries decreased from 1.4 percent in 1995–2010 to 0.9 percent in 2010–2021. The average labor productivity growth in the world increased from 2.1 percent to 2.2 percent for the same periods, respectively. Thus, labor productivity growth has decreased in OECD countries, while it has increased in the rest of the world.

The declining productivity in OECD countries is a puzzle for many economists, especially considering that major investments have been made in digital infrastructure during the last decade. Some economists have even argued that the Solow paradox is back at the same time as a second wave of digitalization sweeps the world (Acemoglu *et al*. 2014). Over the last decade there has been large investment in new digital infrastructure e.g. 5G that was launched in several OECD countries in 2019. Moreover, there was also substantial investment in fixed broadband during the pandemic (ITU 2021). This has implied improved high-speed connectivity that has made it possible to connect billions of devices to the cellular network.

Since mobile broadband was launched in the early 2000s, the capabilities of cellular networks have improved tremendously. This has been driven by data growth in the networks. For example, the mobile data usage per mobile broadband subscription in OECD countries has increased from 1 GB to 8 GB per month in 2021 compared to 2014 (OECD 2023). Investing in 5G implies higher speed in the network, but also other capabilities are improved such as latency, reliability and spectrum efficiency.

Latency is the time it takes for a small data package to travel across a network from a sender to a receiver. Several studies have investigated the impact from broadband speed on economic development (see Rohman and Bohlin 2012; Kongaut and Bohlin 2014; Edquist 2022). However, there is, to my knowledge, no study that has investigated how latency affects productivity development. Thus, the purpose of this paper is to investigate if there is a relationship between the change in mobile broadband latency and productivity growth.

Based on data for 130 countries, the findings show a strong correlation between TFP growth and one year lag of latency growth once controlling for labor and capital services in OECD countries. Thus, a 10 percentage points decrease in the growth of latency in period t-1 is associated with an increase 0.3 percentage points in TFP growth. Moreover, no relationship is found for non-OECD countries, which suggest that it is only OECD countries that are able to take advantage of the benefits of lower latency. One possible explanation could be that OECD countries have reached a higher maturity in digitalization and automation in production processes and thus are able to take advantage of the benefits of lower latency.

The paper is organized as follows. Section 2 summarizes the findings from earlier research and position the study in current literature. Section 3 presents the methodological framework and describe the data. Sections 4 and 5 present the results and robustness checks. Finally, section 6 concludes.

2. Previous literature

2.1 The relationship between ICT and economic development

There is a broad literature showing that ICT has had substantial impact on economic development and productivity (see Bertschek *et al*. 2015; Vu *et al*. 2020). The 1980s was the decade of the personal computer in every home without any discernable effect on aggregated productivity (Solow 1987). Thus, it was first in the second half of the 1990s that there was substantial evidence of investment in ICT having considerable economic impact. Oliner and Sichel (2000) estimated that information technology accounted for about two-thirds of the step-up in U.S. labor productivity growth between the first and the second halves of the 1990s.

Although there were sceptics about the impact from ICT (Gordon 2000), a number of studies clearly found evidence of a substantial impact on productivity and economic growth from ICT. Stiroh (2002b) found that ICT producing and intensive ICT using industries accounted for all of the productivity revival in the US. Moreover, ICT remained an important source to economic growth in the US also after the 1990s (Jorgenson *et al*. 2008). Van Ark *et al*. (2008) noted that many European countries initially was lagging behind because of slower TFP growth in market services such as trade, finance and business services. However, the

overall impact of ICT-capital in 59 different countries pointed towards a positive effect on GDP growth in 1995–2010 (Niebel 2018).

In the mid-1990s there was additional evidence of the economic impact of ICT at more disaggregated levels. Basu and Fernald (2007) found that with long time lags, ICT capital growth was positively associated with the industry TFP acceleration. Additional evidence based on industry data showed a positive return of ICT capital on output growth (O'Mahony and Vecchi). Moreover, there was evidence that European industries, that were relatively ICT intensive before 1995, outperformed the other industries post-1995 in terms of both labor productivity and TFP growth (Dahl *et al*. 2010). There were also studies that could not find robust correlations between ICT and economic development based on industry data (Stiroh 2005; Basu *et al*. 2003). However, the overall conclusion based on the literature points in the direction of a positive correlations between ICT and economic development.

Research analyzing the firm level found a robust relationship between ICT and economic development. Brynjolfsson and Hitt (2003) showed that computer capital was correlated with TFP growth for U.S. firms when the average growth rates over longer time periods were used. The results were not robust to using first differences, but the estimated coefficients increased in size when the length of the growth period increased. Additional studies found evidence of economic impact from ICT at the firm level (van Leeuwen and van der Wiel 2003; Van Reenen *et al*. 2010; Zhang *et al*. 2022). Moreover, based on two European datasets, it was also shown that US multinationals appeared to obtain higher productivity than non-US multinationals from their ICT capital investments (Bloom *et al*. 2012). Thus, ICT may lead to changes in firms' organizational structure that differs across firms.

2.2 Investigations of the "C" in ICT

While there has been a plethora of papers investigating the economic impact of all types of ICTs, there are much less research investigating the impacts of specific varieties of ICT equipment. Goodridge *et al*. (2019) divided ICT capital into computer software, hardware and communication capital. Their findings suggested that price deflators are important for estimating the contribution of each capital type.

In a seminal paper, Röller and Waverman (2001) found a significant relationship between telecommunications infrastructure and aggregate output based on 21 OECD countries in

1971–1990. Their findings suggested that one third of economic growth could be attributed to telecommunications after controlling for simultaneity and country specific fixed effects. Moreover, Gruber and Koutroumpis (2011), based on data for 192 countries, found that investment in telecommunications infrastructure contributed 0.20 percentage points to economic growth in high income countries in 1990–2007.

There are also a number of papers investigating the impact of fixed broadband. Czernich *et al*. (2011) found that a 10 percentage points increase in fixed broadband penetration raised annual per capita growth by 0.9–1.5 percentage points in 21 OECD countries in 1996–2007. Gruber *et al*. (2014) also found evidence that fixed broadband had a positive effect on GDP for 27 EU-countries in 2005–2011. On the contrary, Thomson and Garbacz (2011) found no strong significant impact from fixed broadband adoption on GDP per household based on 43 different countries in 2005–2009. However, the results based on mobile broadband suggested a significant impact on GDP per household. Moreover, Edquist *et al*. (2018) found that there was a statistically significant effect from mobile broadband on GDP in 2002–2014. The results were significant both when mobile broadband was first introduced and gradually as it diffused in different economies.

An additional stream of papers have investigated the economic impact from different capabilities of fixed and mobile broadband networks. These studies are primarily focused on the effect of download speed in the networks. Briglauer and Gugler (2019) found a small but significant effect of fixed fiber-based adoption on GDP compared to basic fixed broadband. Rohman and Bohlin (2012) showed that the doubling of fixed broadband speed contributed 0.3 percentage points to economic growth compared to growth rate in the base year in 34 OECD countries. Additional studies have found supporting evidence that fixed broadband speed contributed to GDP, but that the impact was greater in countries with lower incomes (Kongaut and Bohlin 2014). Moreover, Edquist (2022) investigated the impact of download speed in the mobile broadband networks in 116 countries in 2014–2019. The results showed that a one-year lag of median download speed was significantly associated with labor productivity, but there was no evidence of a contemporaneous association.

2.3 GPT and the lagged effect

According to Bresnahan and Trajtenberg (1995) whole eras of technical progress are driven by a few General Purpose Technologies (GPTs) with the following characteristics: (1)

pervasiveness, which implies that the technology diffuses extensively throughout the economy; (2) technical improvements, meaning that the technology continuously improves performance and lowers cost; (3) innovational complementarities, implying that the technology lead to improvements in R&D and innovational efforts.

The effects from GPTs on productivity are often delayed since many GPTs require organizational restructuring to reach their full potential (Helpman 1998). At first the new technology may only perform the same function as the old technology, which was the case when electric motors replaced steam engines in the early 20th century (Devine 1983). However, as more electric motors were installed in factories, it was possible to let each machine be run by an individual electric motor and thus reorganize the whole production layout of the factory in a more productive manner. According to Greenwood (1999) it was no longer necessary to shut down the entire power system for maintenance. Thus, the quantity and quality of output increased as each machine could be controlled individually and located to optimize flexibility in the production process. This process implied that existing productive capital was creatively destroyed which further delayed the positive productivity effects at the more aggregate level.

According to the GPT literature another reason for the delayed productivity effects from new technology is innovational complementarities. An invention by itself would have little economic effect if there was no scope for the users of the new technology to improve their own technologies (Edquist and Henrekson 2006). For example, before electricity could be used in manufacturing several types of electric machines had to be invented. Hence, it is rather the applications of a wireless networks that results in productivity gains than the network by itself.

ICT is believed to fulfill the requirements of being a GPT (Vu *et al*. 2020). There are a number of different studies that have pointed out that the effects on productivity from new technology often appear with a lag (David 1990; Brynjolfsson and Hitt 2003; Edquist and Henrekson 2017). These empirical findings support the view of the GPT framework that it takes time from the moment of the original invention until a substantial increase in the rate of productivity growth can be observed.

2.4 Latency and its implications for productivity

Latency is the time it takes for a small data package to travel across the network from a sender to a receiver and for the response to come back (Sundaresan *et al*. 2020). This way of measuring latency is known as Round Trip Time (RTT). RTT is the latency perceived by the end-user (NGNM 2015). There is also one way-latency which is the total time it takes for a package of data to travel from the sender to the receiver. According to Sundaresan *et al*. (2020) it may be complicated to measure one-way latency as it implies that the sender and receiver have synchronized clocks, which sometimes is a challenge to set up and maintain when the end points are across multiple domains.

Data on the Internet may travel with the speed of light, but the effects of distance and delays caused by the Internet infrastructure equipment implies that latency cannot be completely eliminated. Moreover, data traversing the Internet often has to cross multiple networks. The more networks the data package needs to pass through, the larger is the probability of delay.

As the world have become more digital, the impact from latency on productivity is believed to have increased substantially. One reason is that businesses have become more reliant on cloud applications (Dar 2018). In the last years it has become common that employees use video conferencing for sales purposes and information sharing. Moreover, cloud-based management tools are used to access information, share files and perform business processes. It is evident that high latency will slow down these processes, which most certainly also effects the productivity among employees.

In the last year the impact from Internet of Things (IoT) have become increasingly important for productivity (Edquist *et al*. 2021). The interconnected devices that are used for personal and business tasks are dependent on the fast transfer of information. Thus, latency and reliability play a vital role in the smooth operations of IoT devices (Siddiqi *et al*. 2019).

3. Data and method

Investment in ICT can affect productivity directly through the capital accumulation (Jorgenson *et al*. 2008) i.e. the neoclassical view. Based on this view the rapid decline in quality adjusted prices of ICT leads to increased investment which drives labor productivity. However, this has no effect on total factor productivity (TFP) growth that is measured as a residual after accounting for inputs such as capital and labor. Some economists would even

argue that ICT-use would not cause TFP growth (Stiroh 2002a). However, it is possible that ICT would also affect productivity through an indirect effect due to reorganizations and rationalizations based on ICT. In this case the productivity growth contribution would be pushed beyond the neoclassical baseline and thus also affect TFP growth (Stiroh 2002a).

As described in section 2.4, latency appears to primarily affect productivity through cloud and IoT applications that leads to reorganization and rationalization. Thus, it is likely that latency would be affecting TFP growth. These productivity enhancing applications can first be fully acknowledged once the latency has been reduced to a certain level. Moreover, the GPT literature suggest that this would take time due to reorganizations of production.

3.1 Method

The method used in this paper is based on the production function that relates output to labor, capital and TFP. Assuming an augmented Cobb-Douglas production function (Cobb and Douglas 1928), we have the following equation:

$$V_{i,t} = TFP_{i,t} K_{i,t}^{S_K} L_{i,t}^{S_L} \quad (1)$$

where $V_{i,t}$ is real value added, $K_{i,t}$ is capital, $L_{i,t}$ is labor input and $TFP_{i,t}$ is Hicks-neutral TFP all for country i at time t.

By taking natural logarithms of and first differencing equation (1):

$$\Delta \ln V_{i,t} = s_K \Delta \ln K_{i,t} + s_L \Delta \ln L_{i,t} + \Delta \ln TFP_{i,t} \quad (2)$$

Based on the growth accounting framework it is assumed that markets are competitive and there is constant returns to scale, which implies that the elasticities S_K and S_L are equal to each factor's income share. Thus, by transforming equation (2), TFP can be estimated as follows:

$$\Delta \ln TFP_{i,t} = \Delta \ln V_{i,t} - s_K \Delta \ln K_{i,t} - s_L \Delta \ln L_{i,t} \quad (3)$$

Equation (3) shows that ΔTFP is measured as a residual, which implies that there might be measurement errors in capital and labor inputs. Moreover, there might also be unmeasured

intangible capital (Corrado *et al*. 2009; Marrano *et al*. 2009). However, TFP could also be caused by organizing production processes in a smarter (more productive) way.

Lower latency improves the quality of a network and primarily affect cloud and IoT applications which in the longer run leads to reorganization. It would therefore be of interest to estimate an equation that tests whether latency is correlated with TFP growth. The econometric specification is based on first differences in order to control for country fixed effects.

$$\Delta \ln TFP_{i,t} = \beta_1 + \beta_2 \Delta \ln Latency_{i,t} + \beta_3 \Delta \ln K_{i,t} + \beta_4 \Delta \ln LS_{i,t} + \beta_5 \Delta \ln X_{i,t} + \delta_t + v_{i,t} \quad (4)$$

Where $\Delta \ln TFP_{i,t}$ is the change in log TFP in country i, $\Delta \ln Latency_{i,t}$ is the change in log latency, $\Delta \ln K_{i,t}$ is the change in log capital services, $\Delta \ln LS_{i,t}$ is the change in log labor services, $\Delta \ln X_{i,t}$ is the change in any additional control variables, δ_t are year dummies which capture common economic shocks and $v_{i,t}$ is the differenced residual.

3.2 Data

The data of the growth of capital and labor services and TFP are based on the Total Economy Database (Conference Board 2022). The dependent variable TFP growth is measured as a residual and accounts for the changes in output not caused directly by change in capital and labor services. Thus, it represents the effect of technological change, efficiency improvements, innovation and inability to measure the contribution of all other inputs (de Vries and Erumban 2022).

Capital services growth refers to the change in the flow of productive services provided by capital assets, such as buildings, transport equipment and machines. The underlying capital stock is based on six different asset types that are calculated from national accounts investment data using the perpetual inventory method. The aggregation of the growth in capital over the different types is based on user cost approach (see de Vries and Erumban 2022). Labor services have been constructed by aggregating the change in labor quantity and quality. Labor quantity is based on total hours worked or total persons engaged, while labor quality is based on a measure in the changes of the composition of the workforce, which is based on data on employment and wages by educational attainment.

Latency data and download speed data is based on analysis by Ericsson of Ookla® Speedtest Intelligence® data for 2014–2021 (see Ookla 2022). The database presents data from millions of tests and readings collected via Speedtest, which is an app service used to test the speed and latency of a particular mobile device. Latency is measured as round trip time (RTT) in milliseconds, while download speed is measured in kilo bits per second (kbps).

In total data for 130 countries are used in the regression analysis for the period 2014–2021. The analysis is based on a balanced panel for all variables included in the respective regressions. Thus, all countries with missing data for a specific variable that is included in the specific regression analysis, have been dropped. *Table 1* shows a list of the countries that have been included in the regressions divided into OECD and non-OECD countries. Moreover, *table 2* shows some descriptive statistics.

4. Results

Table 3 presents the aggregate result based on the total sample of 130 countries. It shows that there is no significant relationship between TFP growth and the change in log mobile broadband latency. Moreover, when three years differences are included, there is still no evidence of any significant relationship.

As pointed out in section 2.3, the GPT literature suggests that there might be a lagged effect from new technology. One explanation for a delayed effect might be that applications that need lower latency also require organizational restructuring (Helpman 1998). An additional explanation might be that innovational complementarities, such as new applications that require low latency, are necessary before productivity grains are achieved. This implies that there might be a lagged effect from latency.

Table 4 includes the change in log of latency that has been lagged by one year. However, there is still no significant correlation between the lagged latency variable and TFP growth. Moreover, when we include both the change in the log of latency and its lag, there is no significant correlation with TFP growth. Thus, there is little evidence of any association between TFP growth and the change in the log of latency for our total sample of 130 countries.

To further investigate the impact from latency we divide our sample into OECD and non-OECD countries. *Table 5* shows that there is still no significant relationship between the change in log latency and TFP growth in OECD and non-OECD countries, respectively. The same holds for three years differences.

In *table 6*, the lagged change in the log of latency is introduced for OECD and non-OECD countries. The lagged change in the log of latency is still insignificant for non-OECD countries, but highly significant for OECD countries at the one percent level. When both the change in the log of latency and its lag are introduced in the regression analysis, the results for the lagged variable remain highly significant for OECD countries. Moreover, based on an F-test it is possible to reject the hypothesis that both the first differences and the lagged differences are jointly equal to zero at the 1 percent level.

There are two important points to be made based on the findings. Firstly, the lagged specification implies that the change of the dependent variable between two points in time is a function of the specified difference of the independent variable between the preceding points in time (Leszczensky and Wolbring 2019). This implies that the model with a lagged change in the log of latency is only appropriate if the lags in the panel data match the real-world casual lags in the process under study (Vaisey and Miles 2017). However, according to the literature on General Purpose Technologies, there is reason to believe that latency would have a lagged effect on productivity as it takes time for new technology to affect productivity growth (David 1990; Brynjolfsson and Hitt 2003).

Secondly, the findings that the lagged variable is only significant for OECD countries is also of interest. It suggests that it is only OECD countries that are able to take advantage of the productivity benefits from lower latency. One possible explanation could be that OECD countries have reached a higher maturity in digitalization and automation in production processes and thus are able to take advantage of the benefits of lower latency.

5. Robustness

5.1 The impact of speed

Latency is not the only capability of a mobile broadband network that may be important for productivity in the economy. There is for example evidence that the speed in fixed broadband is important for economic development (Kongaut and Bohlin 2014; Briglauer and Gugler 2019). Moreover, there is also evidence of a lagged effect from mobile broadband speed on labor productivity (Edquist 2022).

In order to test the robustness of the results the change in log of speed is introduced as an independent control variable. *Figure 7* shows that the lagged latency variable remains robust for OECD countries once the change in the log of speed is included as a control variable. When we include both the change in log of latency and its lag, the lagged variable remains highly significant. Based on an F-test, it is possible to reject the hypothesis that both variables are jointly equal to zero at the 5 percent significance level.

5.2 Low- and high-income countries

So far countries have been divided into OECD and non-OECD countries, where OECD countries are based on the members of the OECD i.e. some of the most industrialized countries in the world. However, countries could also be grouped based on income level. The World Bank (2023b) provide a classification of different countries based on income. According to the World Bank (2023b) low-income countries can be defined as countries with an GNI below $4256 per capita, while countries with higher GNI per capita are defined as high-income countries.

Table 8 shows the results based on low-and high-income countries. The results show that there is no significant relationship between the log change of latency and TFP growth. Thus, it appears that it is particularly in OECD countries that there is a relationship between TFP growth and the log change of latency.

5.3 Simultaneity

One general problem with studies investigating the impact from ICT on productivity is simultaneity. Simultaneity implies that latency can be both a driver and a result from increased TFP growth. It is not unlikely that countries that achieve higher TFP growth also

are able to invest more in mobile broadband networks and thus reduce latency. One approach to deal with simultaneity is to use instrumental variables that are correlated with the explanatory variables but not with the error term (see Czernich *et al*. 2011). However, it has not been possible to find valid instruments for mobile broadband latency.

Another approach is to use lagged variables as instruments. However, this method has been criticized by Reed (2015) who finds that it is not possible to escape simultaneity bias. A third method would be to use lagged values in 2SLS and GMM estimations. According to Reed (2015) this would only work if the lagged variables used do not themselves belong to the respective estimation equation and if they are sufficiently correlated with the simultaneously determined explanatory variable i.e. latency. Based on earlier findings on the impact of ICT (Basu and Fernald 2007; Brynjolfsson and Hitt 2003), the lagged variable of latency belongs to the estimation equation. Thus, the method to correct for simultaneity is refrained.

6. Conclusions

This paper has investigated the relationship the log change in mobile broadband latency and TFP growth based on data for 130 countries. It finds no correlation between the log change of mobile broadband latency and TFP growth for the total sample. However, there is a strong negative relationship (at the one percent level) between the log change in the one-year lag of latency and TFP growth in OECD countries. Thus, a 10 percentage points decrease in the growth of latency in period t-1 is associated with an increase of 0.3 percentage points in TFP growth in OECD countries

The lagged specification implies that the change of the dependent variable between two points in time is a function of the specified difference of the independent variable between the preceding points in time (Leszczensky and Wolbring 2019). This implies that the model with a lagged change in the log of latency is only appropriate if the lags in the panel data match the real-world casual lags in the process under study (Vaisey and Miles 2017). However, according to the literature on General Purpose Technologies, there is reason to believe that latency would have a lagged effect on productivity as it takes time for new technology to affect productivity growth (David 1990; Brynjolfsson and Hitt 2003).

The findings that the lagged variable is only significant for OECD countries is also of interest. It suggests that it is only OECD countries that are able to take advantage of the benefits of lower latency. One possible explanation could be that OECD countries have reached a higher maturity in digitalization and automation in production processes and thus are able to take advantage of the benefits of lower latency.

These findings also provide some hope for future productivity development in OECD countries. There appear to be continued possibilities of increased productivity by investing in cellular networks and ICT technology. It remains to be seen how continued investment will affect productivity growth as new use cases and technologies such as AI becomes available at a large scale.

6. References

Acemoglu, Daron, Autor, David, Dorn, David, Hanson, Gordon H. and Price Brendan (2014), "Return of the Solow Paradox? IT, productivity, and employment in US manufacturing", NBER Working Paper 19835, Cambridge, MA. https://www.nber.org/papers/w19837

Basu, Susanto, Fernald, John. G., Oulton, Nicholas and Srinivasan, Sylaja (2003), "The case of the missing productivity growth, or does information technology explain why productivity accelerated in the United States but not in the United Kingdom". Gertler, Mark, and Rogoff, Kenneth (eds.), *NBER Macroeconomics Annuals 2003*, vol. 18, MIT Press, Cambridge, MA. https://doi.org/10.1086/ma.18.3585244

Basu, Susanto and Fernald, John G. (2007), "Information and communications technology as a general-purpose technology: Evidence from US industry data", *German Economic Review*, vol. 8, pp. 79–93. https://doi.org/10.1111/j.1468-0475.2007.00402.x

Bertschek, Irene, Briglauer, Wolfgang, Hüschelrath, Kai, Kauf, Benedikt and Niebel, Thomas (2015), "The economic impacts of telecommunications networks and broadband internet: A survey", *Review of Network Economics*, vol. 14, pp. 201-227. https://doi.org/10.1515/rne-2016-0032

Bloom, Nicholas, Sadun, Raffaella and Van Reenen, John (2012), "Americans do IT better: US multinationals and the productivity miracle" *American Economic Review*, vol. 102, pp. 167–201. https://doi.org/10.1257/aer.102.1.167

Bresnahan, Timothy F. and Trajtenberg, Manuel (1995), "General purpose technologies 'engines of growth'?" *Journal of Econometrics*, vol. 65, pp. 83–108. https://doi.org/10.1016/0304-4076(94)01598-T

Briglauer Wolfgang and Gugler, Klaus (2019), "Go for gigabit? First evidence on economic benefits of high-speed broadband technologies in Europe", *Journal of Common Market Studies*, vol. 57, pp. 1071–1090. https://doi.org/10.1111/jcms.12872

Brynjolfsson, Erik and Hitt, Lorin, M. (2003), "Computing productivity: Firm level evidence", *Review of Economics and Statistics*, vol. 85, pp. 793–808. https://doi.org/10.1162/003465303772815736

Cobb, Charles W. and Douglas, Paul H. (1928), "A theory of production", American Economic Review, vol. 28, pp. 139–165. https://www.jstor.org/stable/1811556

Conference Board (2022), *Total Economy database*, April, https://www.conference-board.org/data/economydatabase/total-economy-database-productivity

Corrado, Carol, Hulten, Charles and Sichel, Daniel (2009), "Intangible capital and U.S. economic growth", *Review of Income and Wealth*, vol. 55, pp. 661–685. https://doi.org/10.1111/j.1475-4991.2009.00343.x

Czernich, Nina, Falck, Oliver, Kretschmer, Tobias and Woessman, Ludger (2011), "Broadband infrastructure and economic growth", *Economic Journal*, vol. 121, pp. 505–532. https://doi.org/10.1111/j.1468-0297.2011.02420.x

Dahl, Christian, Kongsted, Hans Christian, and Sørensen, Anders (2010), "ICT and productivity growth in the 1990s: Panel data evidence on Europe", *Empirical Economics*, vol. 40, pp. 141–164. https://doi.org/10.1007/s00181-010-0421-4

Dar, Aejaz A. (2018), "Cloud computing-positive impacts and challenges in business perspective", *Journal of Computer Science and Systems Biology,* vol. 12, pp. 15–18, https://doi.org/10.4172/jcsb.1000294

David, Paul A. (1990), "The dynamo and the computer: an historical perspective on the modern productivity paradox", *American Economic Review*, vol. 80, 355–361. https://www.jstor.org/stable/2006600

Devine, Warren (1983), "From shaft to wires: Historical perspective on electrification", *Journal of Economic History*, vol. 43, pp. 347–372. https://doi.org/10.1017/S0022050700029673

De Vries, Klaas and Erumban Abdul Azeez (2022), "Total economy database: A detailed guide to its sources and method", April, https://www.conference-board.org/retrievefile.cfm?filename=TED_SMDetailed_apr2022.pdf&type=subsite

Edquist, Harald, and Henrekson, Magnus (2006), "Technological breakthroughs and productivity growth." *Research in Economic History*, vol. 24, pp. 1–53. https://doi.org/10.1016/S0363-3268(06)24001-1

Edquist, Harald and Henrekson, Magnus (2017), "Do R&D and ICT affect total factor productivity growth differently?", *Telecommunications Policy*, vol. 41, pp. 106–119. https://doi.org/10.1016/j.telpol.2016.11.010

Edquist, Harald, Goodridge, Peter, Haskel, Jonathan, Lee, Xuan, Linquist, Edward (2018), "How important are mobile broadband networks for the global economic development?", *Information, Economics and Policy*, vol. 45, pp. 16–29. https://doi.org/10.1016/j.infoecopol.2018.10.001

Edquist, Harald, Goodridge, Peter and Haskel, Jonathan (2021), "The internet of things and economic growth in a panel of countries", *Economics of Innovation and New Technology*, vol. 30, pp. 262–283. https://doi.org/10.1080/10438599.2019.1695941

Edquist, Harald (2022), "The economic impact of mobile broadband speed", *Telecommunications Policy*, vol. 46, Article 102351. https://doi.org/10.1016/j.telpol.2022.102351

Greenwood, Jeromy (1999), "The third industrial revolution: Technology productivity and income inequality", *Economic Review*, vol. 35, pp. 2–12, Federal Reserve Bank of Cleveland.

https://fraser.stlouisfed.org/files/docs/publications/frbclevreview/rev_frbclev_1999q2.pdf?utm_source=direct_download

Goodridge, Peter, Haskel, Jonathan and Edquist, Harald (2019), "The economic contribution of the "C" in ICT: Evidence from OECD countries", *Journal of Comparative Economics*, vol. 47, pp. 867–880. https://doi.org/10.1016/j.jce.2019.07.001

Gordon, Robert J. (2000), "Does the 'new economy' measure up to the great inventions of the past?", *Journal of Economic Perspectives*, vol. 14, pp. 49–74. https://doi.org/10.1257/jep.14.4.49

Gruber, Harald and Koutroumpis, Pantelis (2011), "Mobile telecommunications and the impact on economic development", *Economic Policy*, vol. 26, pp. 387–426. https://doi.org/10.1111/j.1468-0327.2011.00266.x

Gruber, Harald, Hätönen, Jussi and Koutroumpis, Pantelis (2014), "Broadband access in the EU: An assessment of future economic benefits", *Telecommunications Policy*, vol. 38, pp. 1046–1058. https://doi.org/10.1016/j.telpol.2014.06.007

Helpman, Elhanan, ed. (1998), *General Purpose Technologies and Economic Growth*, MIT Press, Cambridge, MA.

ITU (2021), The economic impact of broadband and digitization through the COVID-19 pandemic: Econometric modelling, June, Geneva. https://www.itu.int/dms_pub/itu-d/opb/pref/D-PREF-EF.COV_ECO_IMPACT_B-2021-PDF-E.pdf

Jorgenson, Dale. W., Ho, Mun S., & Stiroh, Kevin J. (2008), A retrospective look at the U.S. productivity resurgence. *Journal of Economic Perspectives*, vol. 22, pp. 3–24. https://doi.org/10.1257/jep.22.1.3

Kongaut, Chatchai and Bohlin, Erik (2014), "Impact of broadband speeds and economic outputs: An empirical study of OECD countries", 25th European Regional Conference of the International Telecommunications Society (ITS), Brussels, June 22–25. https://www.econstor.eu/bitstream/10419/101415/1/795234465.pdf

Leszczensky, Lars and Wolbring, Tobias (2022), "How to deal with reverse causality using panel data? Recommendations for researchers based on a simulation study", *Sociological Methods & Research*, vol. 5, pp. 837–865. https://doi.org/10.1177/0049124119882473

Marrano, Mauro, Haskel, Jonathan and Wallis, Gavin (2009), "What happened to the knowledge economy? ICT, intangible investment and Britain's productivity record revisited", *Review of Income and Wealth*, vol. 55, pp. 686–716. https://doi.org/10.1111/j.1475-4991.2009.00344.x

NGNM (2015), "NGNM 5G white paper", Next Generation Mobile Networks (NGNM), February 17. https://ngmn.org/wp-content/uploads/NGMN_5G_White_Paper_V1_0.pdf

Niebel, Thomas (2018), "ICT and economic growth – Comparing developing, emerging and developed countries", *World Development*, vol. 104, pp. 197–211. https://doi.org/10.1016/j.worlddev.2017.11.024

OECD (2023), *Going digital toolkit indicator 15*, https://goingdigital.oecd.org/indicator/15

Oliner, Stephen D. and Sichel, Daniel (2000). The resurgence of growth in the late 1990s: Is Information technology the story?. *Journal of Economic Perspectives*, vol. 14, pp. 3–22. https://doi.org/10.1257/jep.14.4.3

O'Mahony, Mary and Vecchi, Michaela (2005), "Quantifying the impact of ICT capital on output growth: A heterogeneous dynamic panel approach", *Economica*, vol. 91, pp. 909–923. https://doi.org/10.1111/j.1468-0335.2005.0435.x

Ookla (2022), *Speedtest Intelligence database*, October. www.ookla.com

Reed, Robert W. (2015), "On the practice to lag variables to avoid simultaneity", *Oxford Bulletin on Statistics*, vol. 77, pp. 897–905. https://doi.org/10.1111/obes.12088

Rohman, Ibrahim K. and Bohlin, Erik (2012), "Does broadband speed really matter for driving economic growth? Investing OECD countries", *International Journal of Management and Network Economics*, vol. 2, pp. 336–356. https://doi.org/10.1504/IJMNE.2012.051888

Röller, Lars-Hendrik, and Waverman, Leonard (2001), "Telecommunications infrastructure and economic development: A simultaneous approach", *American Economic Review*, vol. 91, pp. 909–923. https://doi.org/10.1257/aer.91.4.909

Siddiqi, Murtaza A., Yu, Heejung and Joung, Jingon (2019), "5G ultra-reliable low-latency communication implementation and operational issues with IoT devices", *Electronics*, vol. 8, 981. https://doi.org/10.3390/electronics8090981

Solow, Robert (1987), "We'd Better Watch Out", *New York Times Book Review*, July 12, p. 36.

Stiroh, Kevin J. (2002a), "Are ICT spillovers driving the new economy?", *Review of Income and Wealth*, vol. 48, pp. 33–57. http://doi.org/10.1111/1475-4991.00039

Stiroh, Kevin. J. (2002b), "Information technology and the U.S. productivity revival: what do the industry data say?" *American Economic Review*, vol. 92, pp. 1559–1576. https://doi.org/10.1257/000282802762024638

Stiroh, Kevin J. (2005), "Reassessing the impact of IT in the production function: A meta-analysis and sensitivity tests", *Annales d'Éconmie et de Statistique*, no. 79/80, pp. 529–561. https://doi.org/10.2307/20777587

Sundaresan, Karthik, White, Greg and Glennon, Steve (2020), "Latency measurement: What is latency and how is it measured", SCTE and ISBE Technical Paper. https://www.nctatechnicalpapers.com/Paper/2020/2020-latency-measurement

Thompson, Herbert G. and Garbacz, Christopher (2011), "Economic impacts of mobile versus fixed broadband", *Telecommunications Policy*, vol. 35, pp. 999–1009. https://doi.org/10.1016/j.telpol.2011.07.004

Vaisey, Stephen and Miles, Andrew (2017), "What you can–and can't–do with three-wave panel data", Sociological Methods & Research, vol. 46, pp. 44–67. https://doi.org/10.1177/0049124114547769

Van Ark, B., O'Mahony, M., & Timmer, M. (2008). The productivity gap between Europe and the United States: Trends and causes. *Journal of Economic Perspectives*, vol. 22, pp. 25–44. https://doi.org/10.1257/jep.22.1.25

van Leeuwen, George, and van der Wiel, Henry (2003), "Do ICT Spillover Matter: Evidence from Dutch Firm-Level Data." CPB Discussion Paper No. 26. CPB Netherlands Bureau for Economic Policy Analysis. The Hague. https://www.cpb.nl/sites/default/files/publicaties/download/do-ict-spillovers-matter-evidence-dutch-firm-level-data.pdf

Van Reenen, John, Bloom, Nicholas, Draca, Mirko, Kretschmer, Tobias, Sadun, Raffaella, Overman, Henry and Schankerman, Mark (2010), "The economic impact of ICT", Centre for Economic Performance, London. https://warwick.ac.uk/fac/soc/economics/staff/mdraca/cstudytheeconomicimpactofictlondonschoolofeconomics.pdf

Vu, Khuong, Hanafizadeh, Payam and Bohlin, Erik (2020), "ICT as a driver of economic growth: A survey of the literature and directions for future work", *Telecommunication Policy*, vol. 44, Article 101922. https://doi.org/10.1016/j.telpol.2020.101922

World Bank (2023a), *World development indicators*, https://data.worldbank.org/indicator/SL.GDP.PCAP.EM.KD

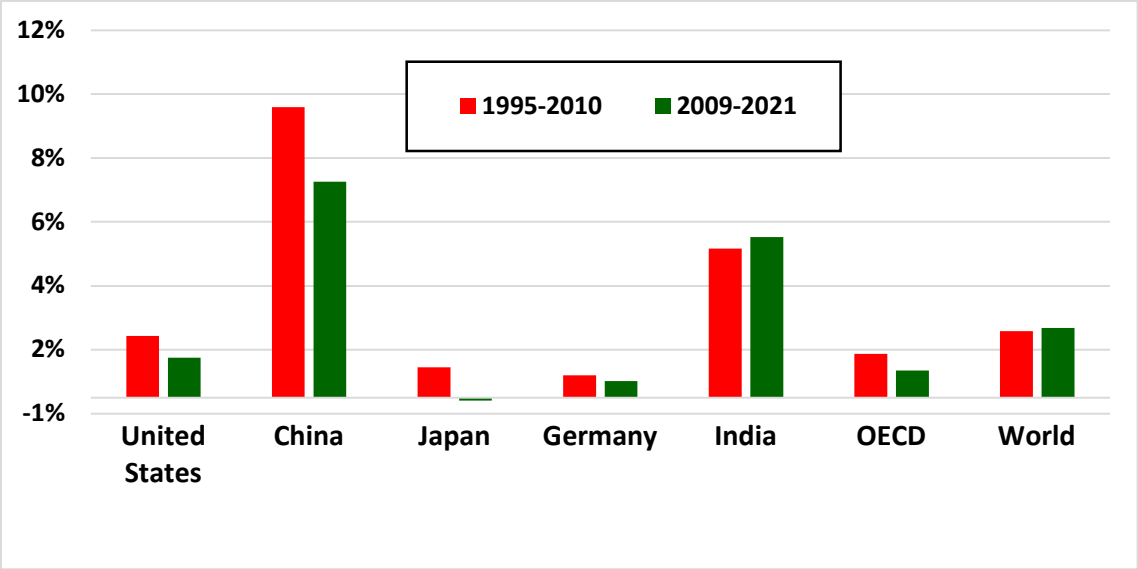
World Bank (2023b), *World Bank Country and Lending Groups*, https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups

Zhang, Liangliang, Tao, Yunquing and Nie, Cong (2022), "Does broadband infrastructure boost firm productivity? Evidence from a quasi-natural experiment in China", *Finance Research Letters*, vol. 48, 102886. https://doi.org/10.1016/j.frl.2022.102886

7. Tables and figures

7.1 Figures

Figure 1 **Annual labor productivity growth measured as GDP per person employed (constant 2017 PPP $) in the five largest economies of the world 1995–2021**



Source: World Bank (2023a).

7.2. Tables

Table 1 Countries included in the regressions divided into OECD and non-OECD countries

OECD countries (38)	Australia, Austria, Belgium, Canada, Chile, Colombia, Costa Rica, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Latvia, Lithuania, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Slovakia, Slovenia, South Korea, Spain, Sweden, Switzerland, Turkey, United Kingdom, United States
Non-OECD countries (92)	Albania, Algeria*, Angola*, Argentina, Armenia, Azerbaijan, Bahrain, Bangladesh*, Belarus, Bolivia*, Bosnia and Herzegovina, Botswana, Brazil, Bulgaria, Burkina Faso*, Cambodia*, Cameroon*, Chad*, China, Congo*, Croatia, Cyprus, Côte d'Ivoire*, DR Congo*, Dominican Republic, Ecuador, Egypt*, Ethiopia*, Gabon, Georgia, Ghana*, Guatemala, Hong Kong, India*, Indonesia*, Iran*, Iraq, Jamaica, Jordan, Kazakhstan, Kenya*, Kuwait, Kyrgyzstan*, Lebanon*, Libya, Madagascar*, Malawi*, Malaysia, Mali*, Malta, Mauritius, Moldova, Morocco*, Mozambique*, Myanmar*, Namibia, Niger*, Nigeria*, North Macedonia, Oman, Pakistan*, Paraguay, Peru, Philippines*, Qatar, Romania, Russia, Rwanda*, Saudi Arabia, Senegal*, Serbia, Singapore, South Africa, Sri Lanka*, Sudan*, Syria*, Taiwan, Tanzania*, Thailand, Trinidad and Tobago, Tunisia*, Turkmenistan, Uganda*, Ukraine*, United Arab Emirates, Uruguay, Uzbekistan*, Venezuela, Vietnam*, Yemen*, Zambia*, Zimbabwe*

Note: *indicates that the country is defined as a low-income country i.e. has GNI per capita below $4256.

Table 2 Descriptive statistics (2014–2021)

Variables	Mean	St. Dev.	Min	Max	No. obs
All countries					
Log change in total factor productivity (ΔlnTFP)	–0.008	0.05	–0.85	0.50	910
Log change in median latency (ΔlnLatency)	–0.19	0.26	–1.76	1.06	910
Log change in labor services (ΔlnLS)	0.006	0.01	–0.05	0.16	910
Log change in capital services (ΔlnK)	0.04	0.03	–0.08	0.19	910
Log change in download speed ((ΔlnSpeed)	0.3	0.34	–0.83	2.93	910
OECD countries					
Log change in total factor productivity (ΔlnTFP)	0.0006	0.021	–0.14	0.07	266
Log change in median latency (ΔlnLatency)	–0.13	0.13	–0.78	0.09	266
Log change in labor services (ΔlnLS)	0.005	0.007	–0.04	0.04	266
Log change in capital services (ΔlnK)	0.03	0.02	–0.01	0.19	266
Log change in download speed ((ΔlnSpeed)	0.25	0.20	–0.37	1.07	266
Non-OECD countries					
Log change in total factor productivity (ΔlnTFP)	–0.01	0.06	–0.85	0.50	644
Log change in median latency (ΔlnLatency)	–0.21	0.29	–1.76	1.05	644
Log change in labor services (ΔlnLS)	0.006	0.01	–0.05	0.17	644
Log change in capital services (ΔlnK)	0.04	0.04	–0.08	0.18	644
Log change in download speed ((ΔlnSpeed)	0.32	0.38	–0.83	2.93	644

Note: Latency and download speed data based on analysis by Ericsson of Ookla® Speedtest Intelligence® data for 2014–2021.

Table 3 Regressions of the relationship between TFP growth and the change in the log of latency

	Dependent variable: TFP growth (ΔlnTFP)	
	First differences	Three years differences
ΔLog of latency (ΔlnLatency)	–0.002 (0.008)	–0.02 (0.020)
ΔLog of labor services (ΔlnLS)	–0.33*** (0.099)	–0.23 (0.308)
ΔLog of capital services (ΔlnK)	0.01 (0.141)	0.04 (0.176)
Constant	–0.007 (0.009)	–0.03 (0.032)
Year dummies	Yes	Yes
R^2	0.06	0.04
Number of observations	910	650

Note: The estimates are based on pooled Ordinary Least Squares (OLS). Cluster robust standard errors are presented in parenthesis. ***, **, * indicate statistical significance at the 1%, 5% and 10% levels, respectively. Latency data based on analysis by Ericsson of Ookla® Speedtest Intelligence® data for 2014–2021.

Table 4 Regressions of the relationship between TFP growth and the change in the log and lagged log of latency

	Dependent variable: TFP growth (ΔlnTFP)		
	First differences	Lagged differences	First + lagged differences
ΔLog of latency (ΔlnLatency)	–0.002 (0.008)		–0.009 (0.011)
ΔLog of latency (ΔlnLatency) (t–1)		–0.005 (0.006)	–0.005 (0.006)
ΔLog of labor services (ΔlnLS)	–0.33*** (0.099)	–0.28** (0.119)	–0.29** (0.118)
ΔLog of capital services (ΔlnK)	0.01 (0.141)	–0.003 (0.159)	–0.005 (0.160)
Constant	–0.007 (0.009)	–0.009 (0.010)	–0.01 (0.010)
Year dummies	Yes	Yes	Yes
R^2	0.06	0.06	0.07
Number of observations	910	780	780

Note: The estimates are based on pooled Ordinary Least Squares (OLS). Cluster robust standard errors are presented in parenthesis. ***, **, * indicate statistical significance at the 1%, 5% and 10% levels, respectively. Latency data based on analysis by Ericsson of Ookla® Speedtest Intelligence® data for 2014–2021.

Table 5 Regressions of the relationship between TFP growth and the change in the log of latency for OECD and non-OECD countries

	Dependent variable: TFP growth (ΔlnTFP)			
	First differences		Three years differences	
	OECD	Non-OECD	OECD	Non-OECD
ΔLog of latency (ΔlnLatency)	0.004 (0.012)	–0.007 (0.009)	–0.012 (0.021)	–0.03 (0.023)
ΔLog of labor services (ΔlnLS)	–0.14 (0.230)	–0.32*** (0.119)	–0.03 (0.373)	–0.10 (0.395)
ΔLog of capital services (ΔlnK)	–0.29 (0.233)	0.08 (0.158)	–0.25 (0.239)	0.11 (0.200)
Constant	0.01* (0.008)	–0.018 (0.012)	0.03 (0.021)	–0.07 (0.049)
Year dummies	Yes	Yes	Yes	Yes
R^2	0.31	0.05	0.20	0.05
Number of observations	266	644	190	460

Note: The estimates are based on pooled Ordinary Least Squares (OLS). Cluster robust standard errors are presented in parenthesis. ***, **, * indicate statistical significance at the 1%, 5% and 10% levels, respectively. Latency data based on analysis by Ericsson of Ookla® Speedtest Intelligence® data for 2014–2021.

Table 6 Regressions of the relationship between TFP growth and the change in the log and lagged log of latency

	Dependent variable: TFP growth (ΔlnTFP)					
	First differences		Lagged differences		First + lagged differences	
	OECD	Non-OECD	OECD	Non-OECD	OECD	Non-OECD
ΔLog of latency (ΔlnLatency)	0.004 (0.012)	–0.007 (0.009)			0.02 (0.016)	–0.01 (0.011)
ΔLog of latency (ΔlnLatency) (t–1)			–0.03*** (0.010)	–0.009 (0.008)	–0.03*** (0.010)	–0.01 (0.008)
ΔLog of labor services (ΔlnLS)	–0.14 (0.230)	–0.32** (0.119)	–0.14 (0.274)	–0.28** (0.134)	–0.12 (0.281)	–0.28** (0.134)
ΔLog of capital services (ΔlnK)	–0.29 (0.233)	0.08 (0.158)	–0.31 (0.250)	0.07 (0.181)	–0.31 (0.251)	0.07 (0.181)
Constant	0.014 (0.008)	–0.018 (0.012)	0.0006 (0.006)	–0.02 (0.014)	0.005 (0.008)	–0.025 (0.015)
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.31	0.05	0.33	0.06	0.33	0.06
Number of observations	266	644	228	552	228	552

Note: The estimates are based on pooled Ordinary Least Squares (OLS). Cluster robust standard errors are presented in parenthesis. ***, **, * indicate statistical significance at the 1%, 5% and 10% levels, respectively. Latency data based on analysis by Ericsson of Ookla® Speedtest Intelligence® data for 2014–2021.

Table 7 Regressions of the relationship between TFP growth and the change in the log and lagged log of latency

	Dependent variable: TFP growth (ΔlnTFP)					
	First differences		Lagged differences		First + lagged differences	
	OECD	Non-OECD	OECD	Non-OECD	OECD	Non-OECD
ΔLog of latency (ΔlnLatency)	0.0006 (0.014)	0.003 (0.007)			0.01 (0.019)	–0.003 (0.008)
ΔLog of latency (ΔlnLatency) (t–1)			–0.03*** (0.010)	–0.009 (0.008)	–0.03*** (0.010)	–0.009 (0.008)
ΔLog of labor services (ΔlnLS)	–0.15 (0.229)	–0.36*** (0.106)	–0.14 (0.273)	–0.34*** (0.117)	–0.12 (0.279)	–0.34*** (0.116)
ΔLog of capital services (ΔlnK)	–0.29 (0.234)	0.09 (0.154)	–0.31 (0.254)	0.07 (0.174)	–0.31 (0.254)	0.07 (0.175)
ΔLog of download speed (ΔlnSpeed)	–0.004 (0.006)	0.02 (0.020)	–0.005 (0.008)	0.03 (0.025)	–0.003 (0.009)	0.02 (0.026)
Constant	0.015* (0.008)	–0.02 (0.017)	0.002 (0.007)	–0.029 (0.018)	0.005 (0.008)	–0.03 (0.017)
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.31	0.07	0.33	0.07	0.33	0.07
Number of observations	266	644	228	552	228	552

Note: The estimates are based on pooled Ordinary Least Squares (OLS). Cluster robust standard errors are presented in parenthesis. ***, **, * indicate statistical significance at the 1%, 5% and 10% levels, respectively. Latency and download speed data based on analysis by Ericsson of Ookla® Speedtest Intelligence® data for 2014–2021.

Table 8 Regressions of the relationship between TFP growth and the change in the log and lagged log of latency

	Dependent variable: TFP growth (ΔlnTFP)					
	First differences		Lagged differences		First + lagged differences	
	Low-income	High-income	Low-income	High-income	Low-income	High-income
ΔLog of latency (ΔlnLatency)	–0.007 (0.006)	0.02 (0.018)			–0.009 (0.007)	0.007 (0.016)
ΔLog of latency (ΔlnLatency) (t–1)			–0.006 (0.005)	0.003 (0.012)	–0.007 (0.005)	0.003 (0.012)
ΔLog of labor services (ΔlnLS)	–0.44 (0.318)	–0.36*** (0.072)	–0.53 (0.336)	–0.35*** (0.071)	–0.54 (0.332)	–0.35*** (0.072)
ΔLog of capital services (ΔlnK)	0.12 (0.118)	–0.40*** (0.125)	0.06 (0.094)	–0.45*** (0.124)	0.06 (0.095)	–0.45*** (0.124)
ΔLog of download speed (ΔlnSpeed)	0.009 (0.008)	0.02 (0.033)	0.008 (0.005)	0.02 (0.039)	0.004 (0.006)	0.02 (0.038)
Constant	–0.023 (0.019)	0.012 (0.017)	–0.018 (0.011)	0.005 (0.013)	–0.022* (0.011)	0.007 (0.016)
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.06	0.13	0.06	0.14	0.06	0.14
Number of observations	308	595	264	510	264	510

Note: The estimates are based on pooled Ordinary Least Squares (OLS). Cluster robust standard errors are presented in parenthesis. ***, **, * indicate statistical significance at the 1%, 5% and 10% levels, respectively. Venezuela is included in the total sample, but it has been excluded when the sample is divided into high- and low-income countries. The reason is that it is not classified as a high- or low-income country by the World Bank (2023b). Latency and download speed data based on analysis by Ericsson of Ookla® Speedtest Intelligence® data for 2014–2021.