The Effect of Internet Use on Total Factor Productivity: Evidence from OECD Countries

Yujie Ouyang*

Oklahoma State University, Stillwater, 74075, The United States

*yujie.ouyang@okstate.edu

Abstract. This study explores the positive impact and mechanism of Internet on productivity through empirical analysis. The findings highlight the role of internet-driven automation, information access, and innovation in economic growth. It examines the impact of internet use on total factor productivity (TFP) in 38 OECD countries from 2000 to 2019. Using panel data and fixed-effects regression models, the analysis finds a positive relationship between internet use and productivity with a notable lag effect. While increased internet adoption initially lowers productivity, its increases productivity in the long run. These findings reinforce the crucial role of digital connectivity in economic development and provide valuable insights for policymakers and business leaders.

Keywords: Internet use, Total factor productivity, OECD

1 Introduction

Internet use is a pivotal driver of modern economic growth and productivity because it lowers consumer costs, expands choices, boosts productivity and creativity for producers, and reduces information exchange costs, leading to greater overall output [1]. In particular, the widespread use of the Internet has had a profound impact on productivity at the individual, organizational, and national levels. It can boost TFP through increasing labor productivity [1]. In the current economic environment, how to use disruptive technologies such as Internet to promote enterprise growth and economic development is a question worthy of in-depth discussion. The rapid expansion of wireless Internet connections, especially since 2001, has been a primary driver of Internet growth [2], significantly altering daily life and influencing business operations and global economies. Since the advent of wireless Internet, people can access online resources more conveniently and efficiently, enabling real-time communication, remote work, and instant access to information. This has driven e-commerce growth [3], expanded educational access, and promoted flexible work styles like remote collaboration. García and Shafiq [4] show that Internet access has a positive impact on students' academic achievement and cognitive skills, supporting the role of wireless Internet in expanding educational opportunities.

© The Author(s) 2025
B. Siuta-Tokarska et al. (eds.), *Proceedings of the 2025 3rd International Academic Conference on Management Innovation and Economic Development (MIED 2025)*, Advances in Economics, Business and Management Research 348,
https://doi.org/10.2991/978-94-6463-835-6_63

Existing literature generally shows a strong positive correlation between Internet use and productivity. Studies have demonstrated that the widespread use of mobile Internet, referring to accessing the Internet via wireless networks on mobile devices, significantly enhances labor productivity within firms [5]. Moreover, broadband Internet adoption has been shown to drive economic growth and productivity in various countries and regions [6-8]. However, the data in these papers mainly captures the early expansion and growth of broadband, roughly between 2000 and 2011, and does not cover the adoption and maturity of the Internet at a later stage. The indicators used in these papers focus on "physical infrastructure construction" or "amount of investment in technology," but do not directly reflect the actual use of the Internet in society. For example, the fact that a country may have high broadband coverage does not mean that people use the Internet widely. Much of the existing research focuses on direct input-output relationships (for example, between Internet investment and GDP growth). However, by focusing predominantly on GDP, these studies do not capture the distinct role of productivity—shaped by technological progress, efficiency gains, and innovation—in driving economic outcomes such as GDP. This work addresses this gap by examining the effect of internet adoption on productivity, rather than on GDP.

Total factor productivity (TFP) is a comprehensive measure of economic productivity because it captures the efficiency with which all inputs—such as labor, capital, and technology—are utilized to produce output. This study aims to examine the impact of personal Internet use on TFP. To explore the relationship between Internet use and productivity, I use productivity data from World Bank and personal Internet use data from Penn World Table from 2000 to 2019. To test the hypothesis that Internet use has a positive impact on productivity, I perform two fixed-effects regression using panel data. I find a positive correlation between Internet use and TFP, which aligns with the existing literature. While the magnitude of the correlation is modest, there still exists significant economic influence of Internet use on productivity. I also find a lag effect of Internet use on productivity. The study highlights the critical role of Internet use in boosting productivity. Potential mechanisms for this effect may be improvement in task efficiency, automation [9-11], enhanced access to information and improved quality of information [11, 12]. Together, understanding the positive effect of Internet use on productivity and these mechanisms is not only valuable to the academic community but also provides important empirical insights for policymakers and business leaders to make informed decisions in the digital economy.

2 Literature Review

This study relates to several strands of literature. First, it contributes to the literature examining the impact of Internet use on labor productivity and economic growth. Using a dynamic panel data approach to study the impact of the Internet on labor productivity, Najarzadeh et al. [1] find that a 1% increase in the number of Internet users would increase GDP per employed person by $14.6. Barrero et al. [13] find that improving home internet quality for all Americans would boost labor productivity by 1.1%, resulting in $160 billion in annual output gains, with even greater benefits in disaster

scenarios like the COVID-19 pandemic, while also enhancing subjective well-being. Similarly, Edquist [6], Hawash and Lang [7], and Gruber et al. [8] demonstrate that broadband Internet exerts a substantial and positive impact on productivity and economic growth at the macroeconomic level in EU and OECD countries. These studies directly explore how Internet access and usage influence labor productivity, showing that increased access or improved quality of Internet service can lead to measurable improvements in productivity.

Second, this paper speaks to the literature exploring the effect of Internet use on other factors driving productivity gains. The level of Internet use reflects how consumers and businesses are leveraging digital technologies to influence productivity through channels such as e-commerce and digital communications, education, and business applications [3, 14]. Zhang, et al. [15] show that broadband infrastructure significantly increases firm productivity through improved information access and operational efficiency. Rehman and Nunziante [16] find that digital infrastructure and internet use significantly increase total factor productivity across European regions. Zhang et al. [15] show that broadband infrastructure significantly improves firm productivity by supporting digital engagement, information flow, and remote work, highlighting the productivity benefits of widespread internet access. Furthermore, Yang et al. [14] highlight how broadband Internet fosters enterprise innovation, positioning it as a cornerstone of digital transformation. Similarly, García and Shafiq [4] find that internet access supports educational performance, which can translate into long-term productivity gains through human capital development and indirectly contribute to productivity growth by enhancing skills and knowledge dissemination. Both broadband and mobile Internet are key components of Internet use, and their impact on enterprise productivity, e-commerce, educational advancements is critical in understanding the broader influence of Internet use on productivity growth.

The impact of the Internet will change rapidly as new applications, services, and digital platforms emerge. Recent data reflect these changes, giving a more accurate picture of how the Internet is being used to boost productivity. The data in these papers mainly captures the early expansion and growth of broadband, roughly between 2000 and 2011, but does not cover the adoption and maturity of the Internet at a later stage. However, the Internet has grown especially fast in the years they haven't been exploring. I use more recent data of internet use and TFP up to 2019 in this paper to analyze the latest trends in the impact of Internet use on productivity. I use the percentage of the population using the Internet personally to measure Internet use.[1]The percentage of the population using the Internet clearly shows the proportion of society that can use and participate in online technology. If a significant portion of the population is online, it suggests that more people are likely to use digital tools, e-commerce platforms and online communication channels that help make the economy more productive.

[1] Internet users are individuals who have used the Internet (from any location) in the last 3 months. The Internet can be used via a computer, mobile phone, personal digital assistant, games machine, digital TV etc. Source: World Bank Group. Available at: https://data.worldbank.org/indicator/IT.NET.USER.ZS? [17]

3 Framework

Internet use can contribute to productivity by several different channels. First, it enables automation and enhance routine task efficiency. According to Chen et al. [9] and Morales-Piñero et al. [10], technology enables the automation of numerous operations. These automated features eliminate manual tasks, allowing individuals to focus on more complex activities and boosting productivity. The internet plays a crucial role in advancing automation by providing widespread access to information, supporting real-time communication between smart devices, and enabling the development of interconnected automated environments [11].

Second, it can promote access to information and enhance the quality of information available. Mobile internet significantly enhances firms' labor productivity by improving information flows and supporting flexible work organization [5]. Technology has enhanced access to information and facilitated easier communication through tools such as mobile phones and video conferencing [10, 12].

Additionally, Internet can speed up innovation and resulting in growth of productivity. According to findings of Xu et al. [19], increasing innovation in a county depends on access to the Internet, as it lowers the costs associated with information and knowledge collection while facilitating rapid diffusion and adoption through entertainment-oriented services and compatibility with users' lifestyles. Firms' internet usage positively impacts their performance, as the internet facilitates knowledge spillovers, helping companies that typically engage less in innovation to increase their innovative activities and improve overall performance [20]. Thus, by increasing innovation, which has a positive impact on TFP [21], the internet could increase productivity.

In summary, existing literature posits that Internet use positively impacts the automation of routine tasks, improve access to and the quality of information, and foster innovation by reducing information costs and enhancing knowledge diffusion. Therefore, the Internet can significantly improve work efficiency, which in turn drives productivity. It can be hypothesized that Internet use, has a positive relationship with productivity.

4 Data

To investigate the relationship between Internet and TFP for 38 OECD countries over the period 2000–2019, I use the percentage of the population using the Internet as the measure of ICT investment and TFP (at constant national prices, 2017=1) as the measure of productivity. Internet usage is chosen because it is readily available from reliable sources and directly reflects the internet adoption. TFP, which captures how efficiently labor and capital are used together, serves as a comprehensive measure that can indicate how increased Internet use contribute to productivity gains beyond mere input growth. We also include population (in millions) and human capital index (based on years of schooling and returns to education) as key control variables to address potential endogeneity concerns and avoid omitted variable bias. Because population size and human capital can influence productivity independently, controlling for these variables

helps to isolate the effect of ICT investment on productivity. All Internet usage data are obtained from the World Bank Group, while TFP, human capital, and population data come from the Penn World Table.

5 Empirical Specification

To test the hypothesis discussed in the framework section, we employ the following regression equation:

$$LTFP_{it} = \beta_0 + \beta_1 ICT_{it} + \beta_2 Population_{it} + \beta_3 HumanIndex_{it} + a_i + \epsilon_{it} \quad (1)$$

where $LTFP_{it}$ represents the total factor productivity of country i at time t. ICT_{it} measures the Internet usage for country i at time t. $Population_{it}$ and $HumanIndex_{it}$ represent population size and human capital index of country i at time t. a_i denotes the time-invariant country-level fixed effects and ϵ_{it} is the pure error term. Results are presented in Table 1.

Table 1. Results of regression (1).

Regression Results (1) N=757		
	Beta	Standard error
ICT	0.000986***	0.000180
Human Index	-0.0762*	0.0308
Population	-0.00167**	0.000583
Constant	1.223***	0.0888
Dependent variable: TFP		
* p < 0.05, ** p < 0.01, *** p < 0.001		

The lag effect may exist because firms and individuals need time to adapt processes, learn new technologies, and restructure workflows to fully harness the internet's benefits. Additionally, the diffusion of knowledge, innovation development, and necessary capital investments also take time to impact productivity.

To test possible lag effects, we use the following regression equation:

$$LTFP_{it} = \beta_0 + \beta_1 ICT_{it} + \boldsymbol{\beta_2 L.ICT_{it}} + \boldsymbol{\beta_3 L2.ICT_{it}} + \beta_4 Population_{it} + \beta_5 HumanIndex_{it} + a_i + \epsilon_{it} \quad (2)$$

where β_1 represents the immediate effect of Internet usage on productivity for country i at time t, β_2 represents the lagged effect of Internet usage by one year, β_3 represents the lagged effect of Internet usage by two years. Results are presented in Table 2.

Table 2. Results of regression (2).

Regression Results (i) N=679		
	Beta	Standard error
ICT	-0.00108*	0.000514
L.ICT	0.000515	0.000670
L2.ICT	0.00108*	0.000459
Human Index	-0.0811*	0.0335
Population	-0.225	0.000626
Constant	1.257	0.0967
Dependent variable: TFP		
* p < 0.05, ** p < 0.01, *** p < 0.001		

6 Results and Discussion

The dataset shows a positive regression result in the first regression, indicating that Internet use has a positive impact on TFP. Although I cannot directly compare the magnitude of the coefficient because the definition and scale of productivity used in the literature are different from that in this paper (they use GDP or whether the company has patents), the direction of the effect is all the same - positive and significant. Though the magnitude is not too big, the magnitude of the coefficient indicates a meaningful economic impact, where a 1 percentage point increase in Internet use leads to a 0.000986 increase in TFP. This means a 10-percentage point increase in Internet use leads to a 0.00986 (approximately equal to 0.01) increase in TFP.

Estimates from Eq. 2 show a lag effect. Specifically, a 1 percentage point increase in Internet use leads to a 0.001 decrease in TFP in the same year, but results in a 0.0005 increase in TFP one year later and a 0.001 increase two years later. This suggests that Internet use initially has a negative impact on productivity but contributes positively over time, with the effect becoming more pronounced in the second year. These results imply that the productivity benefits of Internet adoption are not immediate and instead take time to materialize. This lag can be attributed to the adjustment period required for individuals and firms—especially larger enterprises—to integrate new technologies into their operations. Learning to effectively use the Internet, adapt workflows, and restructure strategies all require time. In regions with lower Internet penetration, this process may take even longer due to limited access and exposure. As such, regressions focusing solely on the same-year relationship may capture only short-term disruptions rather than the long-term productivity gains, possibly explaining the negative coefficient in the immediate year.

The advancement of Internet is significant for economic growth in OECD countries. The positive correlation between internet use and TFP highlights the essential role of Internet use in boosting productivity in these nations. This result supports previous literature that internet use increases productivity. Previous literature suggests several key mechanisms, including impacting the automation of routine tasks, improving access to and the quality of information, and fostering innovation by reducing information costs

and enhancing knowledge diffusion. With the development of the Internet, the accuracy, timeliness and relevance of data have also been correspondingly improved. This provides a reliable information base for enterprises to make innovation, timely and correct changes and strategic planning. Overall, increased internet use significantly enhances productivity. By these mechanisms discussed, the Internet creates a more productive and competitive business environment and contribute to sustained economic growth and development. The lag effect found in the second regression analysis also has some meaningful implications for productivity development. The negative impact in the immediate term may stem from individuals or businesses struggling to effectively use information from the Internet. While the Internet provides easy access to external information, tasks like verifying, translating, and internalizing it require specialized expertise, typically held by only a few within the R&D team [18]. The speed of talent discovery often cannot keep up with Internet development. In businesses, certain employees are responsible for sourcing and filtering valuable technological information, which is then shared with others through face-to-face discussions for dissemination [18]. This process takes time, and failure by management to recognize these roles may hinder effective information flow [18]. Enterprises usually require training, process adjustment and system integration to achieve better efficiency and management, which may temporarily reduce productivity in the initial stage of adjustment. Internet has a positive impact on productivity both one year and two years later, with the effect being more pronounced in the second year than in the first. This suggests that as individuals and businesses gradually adapt to the new developments brought by the Internet, they can leverage these technologies and channels to access more effective information more quickly and achieve more efficient communication, ultimately enhancing productivity. Therefore, Internet use plays an important role in long-term planning. Businesses need to fully consider the short-term challenges brought by Internet to navigate the initial phase while also planning for the long-term benefits of Internet.

In addition to the Internet, the regression analysis reveals negative relationships between human capital and TFP, as well as between population and TFP: A 1 percentage point higher human capital index leads are associated with 0.44 lower TFP, and a 1 percentage point higher population is associated with 0.38 lower in TFP.

According to Kraay [22], effective investment in human capital is essential for development, offering substantial economic benefits in the long run. However, the negative relationship between human capital and TFP in the short term may be explained by the time lag between investments in human capital and their observable effects on productivity. As noted by Kraay [22], while effective human capital investments are crucial for long-term economic development, their benefits may not be immediately reflected in current productivity metrics. Similarly, the contribution of newborns to population growth doesn't translate into higher productivity until well into the future, which could explain the short-term negative relationship. Additionally, differences in the quality of human capital and population across countries may also influence these results.

7 Conclusions

The analysis shows that increased Internet use has a positive impact on TFP. The finding is consistent with existing literature. Specifically, the data show that a 1 percentage point higher Internet use is associated with 0.0009 higher TFP. The results are significant in underscoring the important role of ICTs in boosting productivity and supporting economic growth in OECD countries.

There are some limitations in current research and areas can be explored further. A notable finding is the time lag in the effect of Internet use on productivity. An increase in Internet use has long-term benefits on productivity while leads to a decline in productivity in the current period. The lag effect found in this study is conducive to long-term planning and strategy formulation for businesses, which contributes to sustained productivity improvement. Future research could consider further exploring the temporal dynamics of Internet use's impact on productivity, including potential regional or industrial variations. Further examination of how digital skills, infrastructure construction, and regulatory environments influence these dynamics would also be beneficial. This would help policymakers and businesses better anticipate and manage the transition period during which initial internet adoption may not immediately lead to productivity gains. Additionally, exploring the role of complementary factors such as innovation, digital skills, and ICT investment could refine our understanding of internet-driven productivity growth. Lastly, as the development of artificial intelligence (AI) and 5G networks, future research should assess their interaction with internet use and their combined effects on productivity. These advancements could significantly enhance efficiency, automation, and information processing, further amplifying the long-term benefits of internet adoption.

References

1. Najarzadeh, R., Rahimzadeh, F., & Reed, M. (2014). Does the Internet increase labor productivity? Evidence from a cross-country dynamic panel. *Journal of Policy Modeling*, *36*(6), 986-993, https://doi.org/10.1016/j.jpolmod.2014.10.003
2. OECD. (2012). OECD Internet Economy Outlook 2012. OECD Publishing.
3. Zhang, X. (2021). Broadband and economic growth in China: An empirical study during the COVID-19 pandemic period. Telematics and Informatics, 58, 101533.
4. García, E., & Shafiq, M. N. (2024). Do home computers and Internet access harm academic and psychological outcomes? Statistical evidence from Brazil, Mexico, Morocco, Thailand, and Turkey. *Prospects,* 54(1), 137–153. https://doi.org/10.1007/s11125-023-09669-2
5. Bertschek, I., & Niebel, T. (2016). Mobile and more productive? Firm-level evidence on the productivity effects of mobile internet use. *Telecommunications Policy*, *40*(9), 888–898. https://doi.org/10.1016/j.telpol.2016.05.007
6. Edquist, H. (2024). How important is mobile broadband latency for total factor productivity growth? Journal of Telecommunications and the Digital Economy, 12(1), 305–327. https://doi.org/10.18080/jtde.v12n1.824
7. Hawash, R., & Lang, G. (2020). Does the digital gap matter? Estimating the impact of ICT on productivity in developing countries. Eurasian Economic Review, 10, 189–209. https://doi.org/10.1007/s40822-019-00133-1

8. Gruber, H., Hätönen, J., & Koutroumpis, P. (2014). Broadband access in the EU: An assessment of future economic benefits. *Telecommunications Policy,* 38(11), 1046-1058.
9. Chen, S., Liu, W., & Song, H. (2020). Broadband internet, firm performance, and worker welfare: Evidence and mechanism. Economic Inquiry, 58, 1146–1166. https://doi.org/10.1111/ecin.12854
10. Morales-Piñero, J., Morales-Piñero, J., & Morales-Rubiano, M. (2024). Technological development and eco-efficiency: Drivers of total factor productivity in OECD countries. Problems and Perspectives in Management, 22(4), 174–188. https://doi.org/10.21511/ppm.22(4).2024.14
11. Ahuja, V. and Shankar, J. (2009), ''Benefits of collaborative ICT adoption for building project management'', Construction Innovation: Information, Process, Management, Vol. 9 No. 3, pp. 323-340.
12. Banday, T. P., & Erdem, E. (2024). ICT and declining labor productivity in OECD. SN Business & Economics, 4(3), 1–19. https://doi.org/10.1007/s43546-024-00626-5
13. Barrero, J. M., Bloom, N., & Davis, S. J. (2021). *Internet access and its implications for productivity, inequality, and resilience* (No. w29102). National Bureau of Economic Research.
14. Yang, M. J., Zheng, S., & Zhou, L. (2022). Broadband Internet and enterprise innovation. China Economic Review, 74, 101802. DOI: 10.1016/j.chieco.2022.101802
15. Zhang, L., Tao, Y., & Nie, C. (2022). Does broadband infrastructure boost firm productivity? Evidence from a quasi-natural experiment in China. Finance Research Letters, 48, 102886. https://doi.org/10.1016/j.frl.2022.102886
16. Rehman, N. U., & Nunziante, G. (2023). The effect of the digital economy on total factor productivity in European regions. Telecommunications Policy, 47(10), 102650. https://doi.org/10.1016/j.telpol.2023.102650
17. The World Bank. *Individuals using the Internet (% of population)* [Data set]. https://data.worldbank.org/indicator/IT.NET.USER.ZS
18. Whelan, E., Teigland, R., Donnellan, B., & Golden, W. (2010). How internet technologies impact information flows in R&D: Reconsidering the technological gatekeeper. R&d Management, 40(4), 400-41
19. Xu, X., Watts, A., & Reed, M. (2019). Does access to internet promote innovation? A look at the US broadband industry. *Growth and Change*, *50*(4), 1423-1440.
20. Paunov, C., & Rollo, V. (2016). Has the internet fostered inclusive innovation in the developing world?. *World Development*, *78*, 587-609.
21. Kijek, T., & Matras-Bolibok, A. (2019). The relationship between TFP and innovation performance: Evidence from EU regions. *Equilibrium. Quarterly Journal of Economics and Economic Policy*, *14*(4), 695-709.
22. Kraay, A. (2018). Methodology for a World Bank Human Capital Index. In World Bank, Washington, DC eBooks. https://doi.org/10.1596/1813-9450-8593

Open Access This chapter is licensed under the terms of the Creative Commons Attribution-NonCommercial 4.0 International License (http://creativecommons.org/licenses/by-nc/4.0/), which permits any noncommercial use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons license and indicate if changes were made.

The images or other third party material in this chapter are included in the chapter's Creative Commons license, unless indicated otherwise in a credit line to the material. If material is not included in the chapter's Creative Commons license and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder.