

# The Covid-19 Pandemic and the Productivity Paradox

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## Abstract

The Covid-19 pandemic has created dramatic changes in how organizations function and people work. The application of new technologies has been expedited by the crisis. This article explores what effects this may have on future productivity growth. The results of the transformation of work may provide some answers to “the productivity paradox” – that is, the slow growth of productivity in recent years despite the deployment of new information and communication technologies. A new approach to measuring productivity is proposed. Some behavioral effects of the pandemic on productivity are discussed. Policies to further the productivity benefits arising from the pandemic are suggested.

**JEL Classification:** D2; D8; D9; O4; O8

## Keywords

productivity paradox — X-efficiency — pandemic — technology change — information and communication technology

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## Introduction

The Covid-19 pandemic that engulfed the world in 2020 provides an interesting opportunity of a test of “the productivity paradox”. The paradox is the underwhelming influence of new technologies such as computers and the internet on productivity growth. Since the advent of the digital age several decades ago, productivity growth in the U.S. and other developed countries has stagnated. Many expected that these new technologies would spur an increase in the rate of productivity growth, but no such improvement has been noted in the statistics. Various explanations for this disappointing result will be explored in a subsequent section.

The global pandemic offers a unique opportunity to test the influence of information technologies on productivity growth. The rapid, forced deployment of these technologies, and the change in working habits and methods that accompanied them, condenses technology change into an abbreviated period of time. In this article I will explore some of the potential effects of the rapid deployment of digital technologies on productivity, both positive and negative. Although we will have to wait for a full recovery from the pandemic to assess the ultimate result, the effect of the pandemic on productivity growth, and thus the productivity paradox, could be significant.

One of the explanations for the productivity paradox is mismeasurement in productivity statistics. In this article a new approach to measuring productivity is proposed that incorporates potential missing variables that are intangible such as “free goods” for consumers, increased convenience and leisure for both consumers and workers, and additional profits for businesses that information and communication technologies provide.

In fact, there are hopeful indicators that the pandemic will increase investments. A survey by the World Economic Forum in 2020 found that more than 80% of global firms surveyed planned to increase digitalization of their activities and provide more opportunities for remote work to their employees. 43% of these firms expected to realize a net reduction in their workforces (The Economist, 2020), which, if the amount of output maintains steady or increases, would result in a productivity increase.

A McKinsey Global Institute study surveying European and American executives in December 2020 found that 75% expected to invest more in new technology in the next few years (McKinsey Global Institute, 2021). This could lead to more rapid productivity growth in the future.

In section 2, a brief history of productivity growth in the U.S. and other countries will be presented. Section 3 discusses the productivity paradox and some possible explanations for it. Section 4 will discuss potential effects of the Covid-19 pandemic on productivity in terms of the changes in technology deployment and work methods that it has initiated. Section 5 examines the implications of the pandemic-induced changes on human behavior and how that may affect productivity, as well as some policy implications. Section 6 summarizes and concludes.

## History of Productivity Growth

The most commonly used measure of productivity growth is labor productivity. This is a measure of output calculated at the national level by GDP divided by labor hours. U.S. Department of Labor statistics show that labor productivity rose at a 2.1% annual rate from the end of World War II

through 2018. However, this average masks a generally downward trend in productivity growth. Rapid productivity growth above 3% annually occurred from 1948 to 1973 when the rate dropped significantly to about 1.5% per year through 1995. It then picked up to about 3% annually from 1995 to 2007, and then decelerated again to a rate of only about 1% from 2008 to 2019. One explanation for the slow rate of productivity growth in the most recent decade was weak consumption and investment demand (Tyson and Mischke, 2021). There was an uptick in 2019, but short-lived as the pandemic stifled business activity. In the first quarter of 2021 it jumped to a 4% annualized rate as output increased more rapidly than labor hours. However, in 2021 and the first quarter of 2022, it fell to only 0.6% as labor hours caught up with hiring (Gordon & Sayed, 2022). What the future holds will depend on how firms and individuals recover from the pandemic. There is reason for optimism that the longer-term productivity growth rate may increase from the last decade as digitalization of the economy occurs (Byrne, 2022).

The productivity growth rates in Europe have followed similar trends to those in the U.S. over the long term. Different business cycles cause year-by-year differences with the U.S., but the long-term trend for labor productivity is similarly downward sloping. Developing countries have experienced consistently higher growth rates of productivity than developed countries since the 1990's, but their growth rates had slowed down even before the pandemic. The catch-up in productivity, due to the ability of developing countries to implement new technology and methods already developed in the advanced countries, seems to also have diminished in the years before the pandemic (The Economist, 2020).

The trend of decreasing productivity growth rates in most of the world is reason for concern as productivity growth is the path to higher per capita income and living standards. As the Nobel laureate Paul Krugman has stated, “productivity growth isn't everything, but, in the long run, it is almost everything.” (The Economist, 2020). This global slowdown in productivity growth is puzzling to many as they witness the rapid change in their lives due to new technology, primarily information and communication technologies (ICT), that affect several aspects of how they live and work. This dilemma has led to what is called “the productivity paradox” which will be explored in the next section.

## The Productivity Paradox

The slowdown in productivity growth that has occurred since the 1990's in the U.S., as well as in other countries, has concerned economists. It would seem – with the rapid expansion of computers, Information Technology (IT), the Internet, software applications, smart phones, the Cloud, and Artificial Intelligence (AI) – that productivity growth should be accelerating rather than decelerating as these applications become widely employed in business and all walks of life. However, the data suggests otherwise.

Several hypotheses have been proposed for the produc-

tivity slowdown in the recent decades. Gordon (2018) has suggested that the recent technological innovations are not as significant for general productivity growth as past advances such as the steam engine, the internal combustion engine, railroads, and electrification. Therefore, IT and digitalization should not be expected to have the same impact as previous technological progress embodied in General Purpose Technologies (GPTs) that instigate externalities and innovation.

However, other researchers disagree arguing that the ICT externalities, specifically network and spillover effects, have far-reaching productivity benefits that take time to be realized (Cardon et al., 2013). The time lag explanation has been developed by Brynjolfsson et al. (2021) as a “productivity J-curve”, where the advances in computerization have a delayed effect on productivity growth. This occurs because investments must be made in intangibles such as business process redesign, new product and services development, and worker training, which may actually lower productivity in the short run. These investments take time to reach fruition, and thus we should expect improvements in productivity to not appear until some years later.

Another possible explanation is that the slowdown in productivity growth is primarily a measurement problem resulting from improvements in product quality, consumer surplus, and deficient price indexes that mask the underlying productivity growth that is actually occurring (Syverson, 2017).

An additional explanation for the productivity growth slowdown is made by the Harvard economist Lawrence Summers. He argues that weak aggregate demand in recent years has discouraged business investment in productivity-enhancing improvements. He calls this phenomenon “secular stagnation” (Probst, 2019; Tyson and Mischke, 2021). These different theories of the productivity growth slowdown are outlined in Table 1 in the Appendix.

To build on the mismeasurement hypothesis, I would propose that there are three surpluses that are not measured that result in significant growth in productivity in recent years that the data do not capture. To see the results as productivity growth one must expand the definition of what this term means. If we include the increases in consumer and worker welfare, as well as increased corporate profits, as part of the productivity growth definition, then there have been, in fact, large increases in productivity in the last two decades. These surpluses can be considered as utility that is gained over and above the normal measures of input and output.

The first surplus that has resulted from the deployment of ICT is a *consumer surplus*. This results from the increased quality and functionality of many products and services without increases in price, and often decreases in price. The smartphone is an example of this consumer surplus. Now it is possible to check email, order a meal or a ride, buy products on-line, find the fastest route to a destination, see how investments are doing, and myriad other functions with our smartphones saving time each week to perform these activities. Apart from the convenience, the smartphone apps result

in greater leisure time from the efficiency of performing these tasks via the phone. Many of the apps providing this utility are “free goods” and thus do not get measured as output (Syverson, 2017; Byrne, 2022). A consumer surplus of increased capabilities and time savings is difficult to quantify and measure, but is certainly real.

There is also a *worker surplus* as the ICT technologies are applied. Most jobs now employ some type of computer technology; for example, to source information (e.g., a pharmacy finding patient prescription information), perform office tasks (e.g., doing the payroll), billing (e.g., supermarket scanners), writing (e.g., screenplays and books), and countless other tasks. These technologies may not result in a reduction of hours worked, but they expand the sophistication and accuracy of the tasks being performed and may result in increased efficiency, ease, and/or more leisure time on the job for the employee. Again, it is hard to quantify and measure the worker surplus from new technology.

A third surplus that results from the digitalization of the economy is a *profit surplus for businesses*. The record profits of U.S. firms in recent years would seem inconsistent with slow productivity growth. After-tax corporate profits rose to 12.7% of GDP in 2021 versus an average of less than 10% until 2010 when the profit share began to rise (Fox, 2021). This suggests that much of the hidden productivity growth is accruing to corporations, which are distributing much of it to shareholders through dividends and share buybacks, as well as share price appreciation. Wages have risen more slowly than corporate profits in the last few decades. The resulting redistribution of wealth has benefited primarily the wealthier segments of society resulting in increasing inequality in the U.S. Those that have benefited the most from the hidden productivity growth – the educated, skilled, and professional workers (Greenwald et al., 2019) – have also likely experienced the highest increase in their own productivity and/or leisure along with their incomes. These are the people who are most willing and able to use ICT to improve the performance of their work. In addition, they are the ones populating entirely new types of high-productivity work such as software engineers and programmers, data scientists, and AI experts.

When one assesses how much everyday life has changed to become easier and more convenient, it is hard to reconcile slow productivity growth with this. Although this increase in convenience and leisure is difficult to quantify, it is very tangible to most people. The task that confronts us is to find ways to measure the improvement in quality of life resulting from technological change and incorporate it into productivity statistics to reflect it. The starting point would seem to be an expanded definition of productivity from the conventional output per worker. Adding the three surpluses or utilities generated by technological change to the definition of productivity should yield a more accurate picture of actual productivity change.

The traditional measure of productivity, specifically labor productivity, does not take account of the three surpluses

discussed above: the consumer, worker, and profit surpluses. Labor productivity is a measure of output over input ( $LP = O / I$ ). Output is usually units, sales revenue, or GDP. Input is typically either number of workers or labor hours.

These are all *explicit* measures where data is readily available. The data goes back many years allowing trends over time to be determined. In the previous century this measure of labor productivity was reasonably accurate. However, with the advent of ICT, the traditional measure is no longer adequate because it does not take account of the implicit factors now influencing productivity – specifically the three surpluses discussed above. They can significantly alter both the numerator and denominator of the productivity ratio.

The output measure does not incorporate the consumer surplus of increased quality, functionality, and convenience of the ICT technologies, nor the “free goods” that ICT provides, which if included would raise measured productivity. The measures of input of workers or hours do not take account of the increased ease and leisure time available in many jobs with the implementation of ICT – the worker surplus. If incorporated this would also increase productivity.

The profit surplus is a little more complicated in its influence on labor productivity. If output is measured as units, it would not be included. If measured as sales revenue or GDP it would be incorporated in the numerator. It could have an effect on the denominator by lessening the cost pressure on the firm to reduce the number of workers or hours; that is, since the margin between revenue and costs has increased, managers are not as likely to lay off workers or reduce hours. They also may feel less need to implement productivity-improving methods. This would result in the input measure being inflated through either the excess workers or reduced efforts to increase productivity. Productivity growth would then appear to be less than it actually is.

An adjusted labor productivity (ALP) measure incorporating these implicit factors can be expressed as follows:

$$ALP = (O + CS + PS) / (I - LS)$$

Where:

ALP = Adjusted Labor Productivity

O = Output

CS = Consumer Surplus

PS = Profit Surplus

I = Input

LS = Labor Surplus

Measuring the consumer and worker surpluses is difficult and incorporating the profit surplus is complicated since it can affect both the numerator and denominator, so this is just a conceptual approach at this stage.

In essence, the measurement issue distills to “explicit” versus “implicit” productivity. Explicit productivity is what we can measure such as units, GDP, labor hours, etc., but

implicit gains such as greater consumer or worker utility are difficult to measure. Surveys of consumers and workers to assess these intangible utilities might give some insight. However, currently such data is not being collected to the best of my knowledge, so this remains as a future endeavor. Some of the measurement issues in accounting for the digitalization of the economy are discussed in Byrne (2022). If these three surpluses/utilities are substantial, they could help explain the productivity paradox.

### Potential Pandemic Effects on Productivity

The Covid-19 pandemic suddenly and dramatically altered personal and business life in 2020 in most of the world. Demand for many products and services dropped precipitously and unemployment shot up. This forced all types of businesses to alter their normal operating methods and procedures. Of course, e-commerce was a major beneficiary of this, but many other industries benefited as well, especially technology-focused businesses that saw demand for their products and services skyrocket (e.g., Zoom and Netflix). Although the health crisis creating these shifts is unfortunate, it does provide some potential long-term benefits to productivity growth, as well as a few downsides. These potential productivity effects of the pandemic are presented in Table 2 in the Appendix.

The sudden shift to a Work-from-Home (WFH) environment for employees, caused many individuals and businesses to adopt new technology they had previously not used, or used sparingly. This included video conferencing, cloud computing, social media, software for sales and logistics, automation of processes, robotics, AI, and machine learning. All these technologies were being adopted by a wide range of businesses prior to the pandemic but the health crisis expedited greatly their deployment.

Preliminary data on the productivity of WFH is mixed. One study found people are working more hours in total per week (Gibbs et al., 2021), which would imply lower productivity per hour assuming the same amount of work is accomplished. However, if more or better work is done, productivity could be higher. Several studies have suggested that many people prefer to work at home, at least some of the time (Aksoy et al., 2022; Stamm, 2021), which could lead to better morale and motivation, which in turn could lead to higher productivity. In fact, 41% in one of these studies said they were more efficient working from home than in the office (Gibbs et al., 2021). Also, there is the gain of the time previously spent commuting to the office or other place of work, that if used for work-related tasks, could also lead to higher productivity of employees. If employees working from home are also less likely to take time off for sickness, this might also boost productivity. Aksoy et al. (2022) found in a survey of 27 countries that many employees were “surprised” at how productive they were at WFH.

Another dramatic shift in the nature of work has occurred in how people shop and eat. E-commerce has seen dramatic growth since 2020 as consumers shifted to ordering both

goods and services online. Distribution and delivery services have experienced rapid growth as a result. Many new types of jobs appeared while traditional retail and service jobs diminished. Some of these jobs may be easier to automate (e.g., warehouse work) than traditional service jobs while others may not (e.g., delivery services) so the potential effect on the overall growth of productivity is difficult to discern at this stage. However, ICT is critical to most of these new types of jobs so the effect could be substantial.

A possible negative effect of the pandemic on productivity is potential stagnation of worker skills due to either unemployment or lack of training and education activities, as these may have been scaled back by both firms and educational institutions. Online training using communication technology has increased, but the relative effectiveness of this compared to in-person instruction remains to be studied.

Another potential negative effect of remote work is the effect on communication and teamwork in organizations. Non-verbal communication is hindered by remote work as is the building of trust and confidence that fosters improved teamwork. Teamwork can be important to productivity improvement as has been demonstrated in lean system and Six-Sigma Quality programs (Mefford, 2010).

Businesses of all types have been forced to change many of their processes that required face to face interaction. These changes extend to video conferencing instead of meetings and sales calls, online ordering of a wide range of materials, digital communications within the supply chain, and automating of previously manual processes such as order-taking in restaurants. In addition, the use of machine learning, AI, and other data-mining techniques has also expanded.

The labor shortages, unionization pressures, and rising wages have put additional pressure on firms to increase productivity of their workforces. These pressures are unlikely to abate with the end of the pandemic due to the demographic shifts of an aging population and rising worker expectations. Automation and productivity improvements through improved work processes will be a likely long-term trend.

Two pertinent examples of the rapid deployment of new technology can be found in health care and education. Telemedicine has spread rapidly increasing the productivity of medical personnel. Video visits, instead of in person consultations, took only one third as long and were more likely to finish on time a study at Stanford Health Care found (The Wall Street Journal, 2021). This allowed doctors and other medical personnel to see more patients, increasing their productivity. In education, remote teaching has, of course, been the norm for the past several years, forcing both educators and students to adapt. Although most educational institutions are returning to primarily in-person instruction as the pandemic fades, some of the new technology adopted will likely continue to be used and may well expand to supplement, or in some cases replace, in-person learning. The productivity improvements potentially brought about in healthcare and education are significant as these are two of the industries with the slowest

rates of productivity increase in the last few decades.

The rapid deployment of new technology brought about by the Covid-19 pandemic may provide a good test of whether the productivity paradox still holds. If in future years productivity achieves a higher growth rate, this would tend to support the J-curve explanation of the paradox. As the new technologies are applied, improved, and spread, they should provide the means for organizations of all types to achieve higher productivity growth. The McKinsey Global Institute (2021) predicts yearly productivity growth will be 1% higher at least until 2024 due to these effects. But there is also the X-efficiency factor that will have a major bearing on whether, and to what extent, the productivity enhancement of technology deployment occurs. This topic is discussed in the next section.

### Behavioral Effects and Policy Implications

Leibenstein (1966) proposed that there is a missing factor in the analysis of productivity, the residual left when capital and labor are used in a production function approach to productivity analysis. He called this factor “X-efficiency” and attributed it to management and how effectively managers utilize their capital and labor resources and implement technological change. The measure of this is Total Factor Productivity (TFP) which represents capital and labor plus technological change as a residual. Many economists attribute the total residual to technology change, but Leibenstein (1966) argued that managers play a critical role in the implementation of technology. The X-efficiency theory provides another potential explanation of the productivity paradox. That is, managers may not have employed new technology effectively to increase productivity. Bloom et al. (2020) research using data on multinational firms supports this hypothesis attributing productivity differences to organizational factors and management quality. This is related to the J-curve explanation that it takes time to change processes and train people to make new technology effective, and managers play a critical role in this process.

Another explanation of how managers employ new technologies is that they choose to use them not to increase productivity, but rather to enhance the customer experience and/or to make jobs easier, safer, or less stressful for employees. This relates to the consumer and labor surpluses/utilities previously postulated in section 3. Conventional productivity measurement does not capture these utilities. The overall benefits of technology change would therefore be much larger than conventional measures of productivity suggest.

Managers, of course, have other objectives than simply lowering costs and increasing productivity. Often these other objectives will dominate the cost reduction goal. Such objectives include increasing sales and revenues, developing new products, expanding market share, increasing the morale and loyalty of their employees, and more personal goals such as expanding their areas of responsibility, getting promoted, or reducing their own workload. These other goals may not be congruent with cost reduction and may actually be contrary to

it. The adoption and deployment of new technology may be in pursuit of these other objectives, and therefore may not result in an increase in labor productivity. This does not mean it does not benefit the organization, however, as it may become more competitive because of the pursuit of the other goals. Alternatively, the manager may also benefit personally even though the organization does not – agency theory.

The pandemic has some potentially significant effects on both managers and workers that could affect future productivity growth. The pandemic could influence how people react to risk and uncertainty. Risk is associated with estimated probabilities while uncertainty deals with inestimable probabilities. Studies have shown that most individuals are typically both risk-averse (i.e., they prefer prospects with lower outcome variance) and ambiguity-averse (i.e., they prefer prospects with known to unknown probabilities) (Attanasi and Montesano, 2012). The pandemic certainly increased most people’s sense of uncertainty about the future in many different dimensions, also in terms of pessimism and underconfidence (Attanasi et al., 2014; Brodeur et al., 2021). This potentially could make them less likely to experiment with new methods and technologies which, in turn, might hinder the implementation of new productivity-enhancing efforts by businesses. People may overweight the likelihood of negative events making them more risk-averse (Alifano et al., 2020). Individuals might also react to uncertainty by saving more and consuming less, thereby slowing economic growth. Ambiguity-averse managers may react to pandemic-induced uncertainty by cutting back production and investment (Okamoto, 2020). This apparently was what occurred in the early stages of the pandemic, but when demand quickly recovered, firms found themselves understocked and understaffed for the subsequent surge in demand in late 2020 and 2021.

Another potential behavioral effect of the pandemic on productivity involves social distancing resulting from pandemic protocols and work-from-home (Van Bavel et al., 2020). Many productivity improvements result from team work in programs such as Six Sigma and lean production (Mefford, 2010). If remote work results in a permanent reduction in social interaction at work sites for some organizations, this might hinder future productivity growth. However, ICT has developed new and better methods of virtual interaction that may mitigate this problem (Askoy et al., 2022).

Several studies found that addictive behaviors increased during the lockdowns in the early stages of the pandemic (Attanasi et al., 2021). If these types of behaviors persist or work-from-home makes them more prevalent in the future, this could be a potential drag on future productivity growth. It is too early in the life of the Covid pandemic to assess if any of these behavioral effects will persist into the future, and how they may affect future productivity growth. They should, however, provide a rich field for future research.

There are several policy implications for firms and managers of the pandemic effects on behavior. If managers want to facilitate the implementation of new technology to fos-

ter productivity growth, they will have to overcome inherent resistance to change which may be fostered by increased pessimism and ambiguity-aversion induced by the pandemic. However, the rapid deployment of new information technology during the pandemic may have overcome some of the resistance, and perhaps even made people more inclined to use these technologies. Also, to facilitate productivity improvements that result from group effort, firms may have to devise new methods of collaborative work congruent with remote work (e.g., online meetings) as well as hybrid systems of work involving both onsite and work-from-home. There will likely be a period of experimentation as hybrid work arrangements are tested. Different combinations of remote and onsite work will be effective depending on the nature of the work and the skill levels of the employees. As the most efficient hybrid work designs are found, productivity should increase via the J-curve effect (Brynjolfsson et al., 2021).

A clear public policy implication of this research is that better measurement of productivity needs to be developed. The current measures of productivity do not account for intangibles such as “free goods” and the three productivity surplus utilities suggested in this article. Government agencies, which are primarily responsible for collecting and distributing such data, should develop new methods of presenting more comprehensive and relevant productivity data.

## Summary and Conclusions

The global pandemic of the Covid-19 has had an unexpected and unfortunate effect on life around the globe, causing millions of deaths, restrictions on travel and personal life, and a global recession. One of the few beneficial effects may be that it has accelerated the adoption of new technology by both individuals and businesses that may improve consumer and employee welfare in the future. It may also improve the rate of productivity growth, but this is not a given. It will depend on how effectively organizations deploy the new technologies and to what purposes. Moreover, it will provide a test of the productivity paradox that otherwise may not have occurred. The deployment of new technology on such a scale, and in such a short period of time, is unprecedented. A recent study by Bloom et al. (2022) found both measured and self-reported productivity increased at a Chinese travel agency with hybrid work, and these results may be generalized.

One contribution of this article is to develop a new conceptual model of how productivity growth may be mismeasured because of three missing factors: the consumer, labor, and profit surpluses. These are not measured in conventional productivity statistics and could potentially result in a significant underestimation of productivity growth. The rapid deployment of new information and communication technology contributes to these surpluses. The pandemic has turbocharged the implementation of ICT.

The conditions for the new technology to result in a sustained increase in productivity growth are several. First, the goal of implementing new technologies must be to improve

productivity, not consumer or employee welfare. If efficiency is a secondary goal of the technology deployment, it is unlikely to have a substantial and long-lasting effect. Second, managers must effectively adopt and deploy new technology to achieve the goal of higher productivity. Many managers may see this as a secondary goal and/or not be very effective in implementing the new technologies. This will involve redesigning processes in some cases and selecting, training, and motivating employees to work with these new processes and technologies. Also, it will require designing effective modalities for hybrid work. Many managers may not be very good at this – the X-efficiency factor.

The rate of growth of productivity will vary between industries and countries, as it always has. Some industries will more quickly adopt new technologies than others based on need, resources, and competitive factors. One encouraging sign for productivity growth is that traditionally low-productivity-growth service industries like health care and education have been among the fastest in uptake of technology adoption and deployment during the pandemic. This bodes well for overall productivity growth of the economy if it can be sustained. Of course, efficiency gains by competitors can be a spur for other firms to also focus on improving productivity. These are likely to be very industry-specific effects.

An important determinant of whether strong economic growth can be sustained is aggregate demand. The pandemic resulted in a less severe global recession than many had feared. This was due in large part to aggressive fiscal and monetary policies in countries around the world. If countries can sustain effective fiscal and monetary policies in the future, economic growth can remain strong, and with it, high rates of productivity growth (Tyson and Mischke, 2021). Another unknown is how consumers and businesses will react in the future to the high degree of uncertainty created by the pandemic (Okamoto, 2020). If consumers become more risk or ambiguity-averse and save more and consume less, then demand may be less than anticipated. In turn, if businesses become more pessimistic and/or ambiguity-averse due to the uncertainty about future demand and invest less, productivity may not grow as rapidly as hoped for.

Just as in different industries, different countries will experience different rates of post-pandemic productivity growth. The developed countries are likely to have faster rates of pickup of productivity since they have more technology available to adopt, as well as more resources to deploy it. Strong aggregate demand is essential to encourage companies to invest in general, and in particular in new technologies. Sustained strong economic growth will be a major determinant of the deployment of new technology and the resultant effect on productivity growth.

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## Appendix

Theory	Description
ICT not a GPT	Information and Communication Technologies (ICT) less significant than General Purpose Technologies (GPT) (Gordon, 2018)
J-Curve Effect	Takes time to implement new ICT (Brynjolfsson et al., 2021)
Secular Stagnation	Weak aggregate demand and investment (Lawrence Summers) (Probst, 2019; Tyson and Mischke, 2021)
Mismeasurement	Productivity measures underestimate productivity growth (Syverson, 2017)

**Table 1.** Explanations for the productivity paradox

Potential positive effects	
Hybrid work:	<ul style="list-style-type: none"> <li>Commuter time saving = more work hours</li> <li>Employees work when most productive</li> <li>Higher motivation</li> <li>Less sick leave taken</li> <li>Less turnover</li> </ul>
Labor shortages and higher wages pressure employers to be more efficient	
Potential negative effects	
Less communication and teamwork	
Less training and tutoring	
Increased addictive behavior from remote work	
Greater risk and ambiguity aversion:	
	<ul style="list-style-type: none"> <li>Less investment in new technology</li> <li>Less experimentation/innovation</li> <li>Lower consumption/more savings</li> </ul> = slowing economic growth

**Table 2.** Potential productivity effects of the Pandemic