Asia-Pacific
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A Study on APEC Cooperation for Digital Economic Utilization in GVC in the COVID-19 Era

APEC Committee on Trade and Investment

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I. Introduction

1.1 Background

The spread of the digital economy represented by the emergence of advanced new technologies alters market participants' existing production and consumption activities. The digital economy encompasses various economic activities based on numerous digital connections between people and businesses in markets. Following the emergence of advanced Fourth Industrial Revolution (4IR) technologies such as artificial intelligence (AI), 5G, the Internet of Things (IoT), cloud computing, blockchain and others, the digital transformation is dramatically shifting existing avenues of economic participation and promoting the transformation of the digital economy.[1] The shift to a digital economy is producing changes in how businesses and consumers produce, sell, and consume existing and new products in the market.

The global economy's digital transformation is also rapidly spreading through global value chains (GVC). As GVCs spread among economies and mature, connections between economies and regions have deepened. The maturation of GVCs has inevitably lent the digital transformation a global perspective. In particular, new international businesses with advanced technologies are leading qualitative changes in GVCs through the digital transformation of manufacturing-oriented GVCs. Boundaries between the manufacturing and service industries are crumbling amid this shift.

The COVID-19 crisis is expected to accelerate the pace of the digital transformation. Governments have implemented measures such as cross-border movement controls and social distancing in response to COVID-19. These quarantine measures restrict the movement of people between economies and regions and constrain many forms of economic activity, but have led to a boom in non-face-to-face economic activity. Accordingly, companies are expected to update existing distribution methods and accelerate the spread of the so-called "untact" economy through the digitalization of production and consumption as a whole. This change marks a shift in the new global business environment, especially since the COVID-19 pandemic is not a temporary shock.

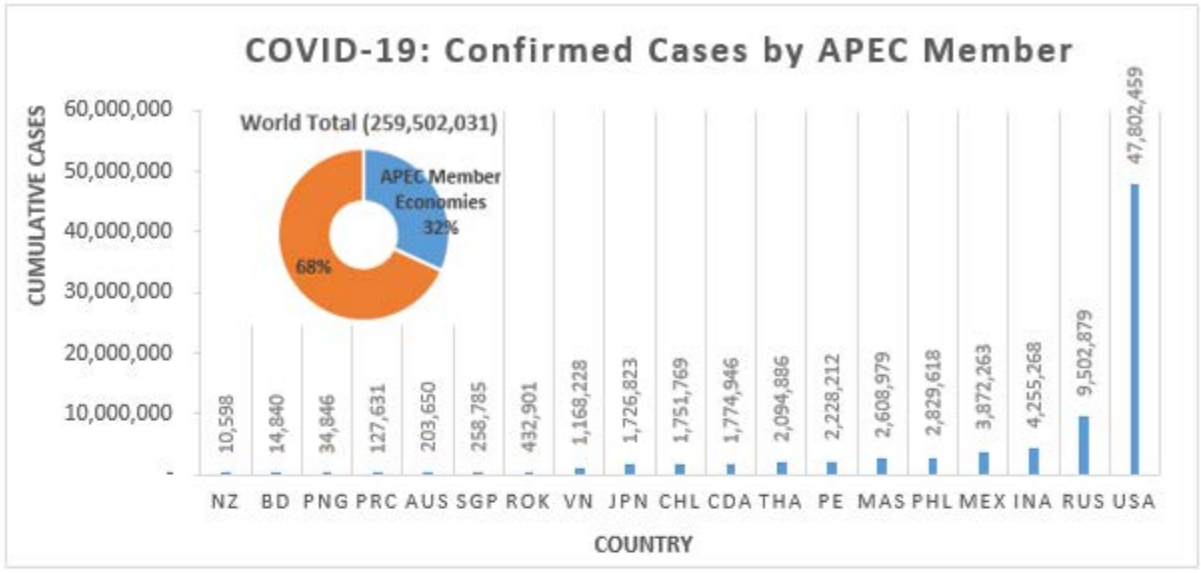
APEC economies are also undergoing a wide range of changes amid the ongoing COVID-19 pandemic. In early November 2021, the number of confirmed COVID-19 cases in the APEC members exceeded 80 million, or about one-third of the world's estimated 250 million confirmed COVID-19 cases.[2] The cumulative number of confirmed cases per 100,000 persons in the United States exceeds 14,441, nearly two-

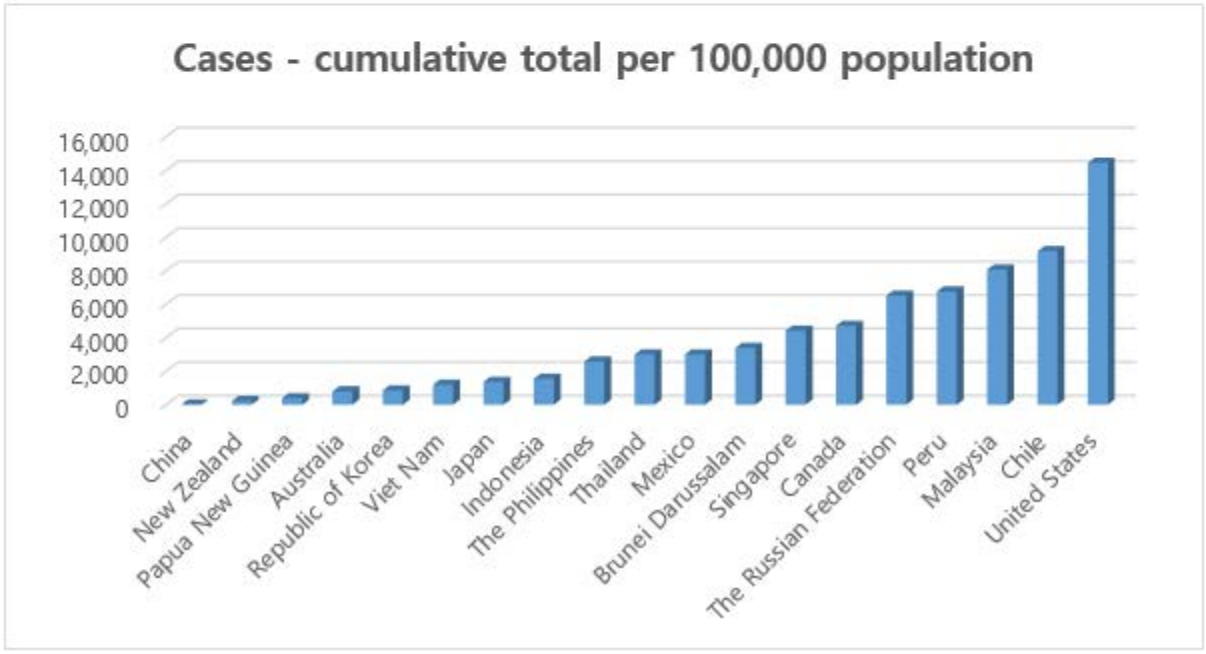
[1] WEF (2016) refers to artificial intelligence, robots, IoT, autonomous vehicles, 3D printing, nanotechnology, biotechnology, material science, energy storage, and quantum computing as key technologies in the 4IR era

[2] As of November 26, 2021 (WHO Coronavirus Disease (COVID-19) Dashboard).

thirds the figure of APEC member economies as a whole. Despite relatively smaller numbers, Chile; Malaysia; Peru and Russia have the largest number of cumulative confirmed cases per 100,000 after the United States. This illustrates the vulnerability of APEC member economies to the COVID-19 crisis.

Figure 1: COVID-19 cases — APEC member economies



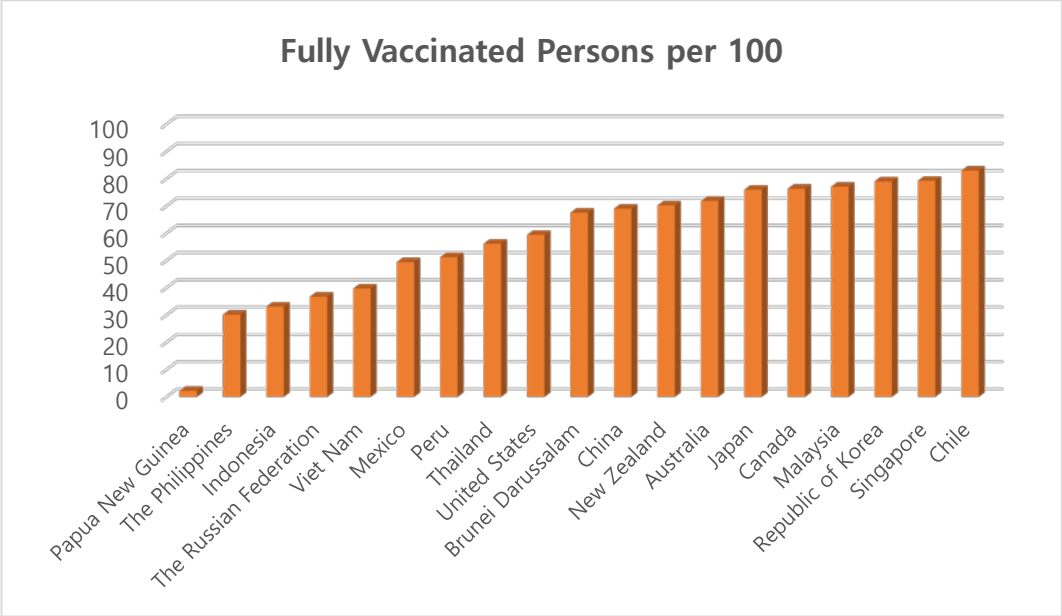


Source: WHO Coronavirus Disease (COVID-19) Dashboard.

Note: Data as of November 26, 2021. Data for Hong Kong, China and Chinese Taipei are unavailable.

Widespread vaccination of the public is critical to bringing an end to this crisis, and doing so could also shorten the length of the economic downturn, as people become more resistant to the coronavirus. Among APEC members, more than 50 percent of the population is fully vaccinated in 13 economies. Chile shows the highest rate of vaccination, at 82 percent. Singapore; the Republic of Korea, and Malaysia follow Chile. The speed at which the governments and related medical institutions of APEC member economies have vaccinated their populations varies, and there are gaps among members. In Papua New Guinea, only two percent of the total population is fully vaccinated. Despite vaccination programs being underway, gaps among members and non-member economies alike give rise uncertainties in the global economy, and these uncertainties could impede a more rapid recovery across APEC.

Figure 2: Vaccination Rates - APEC member economies

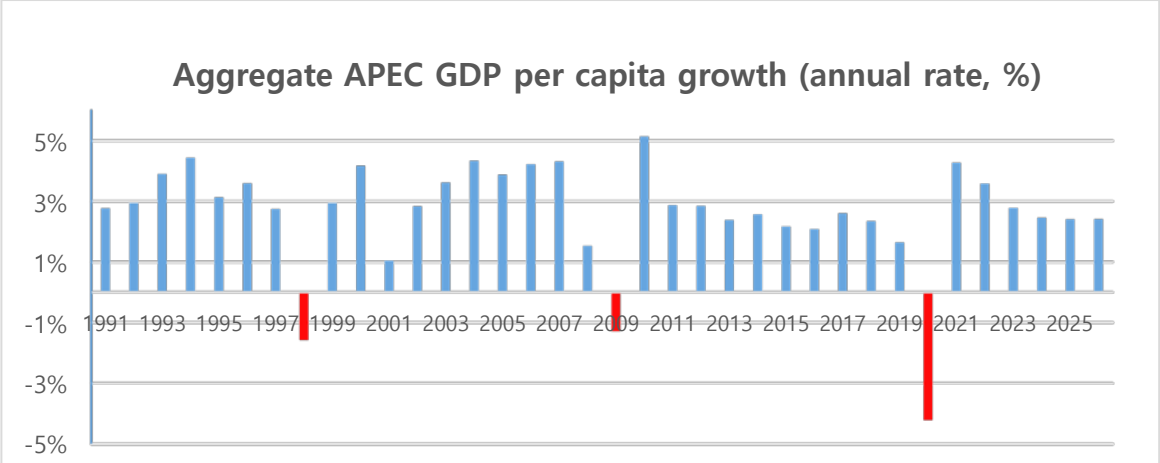


Source: WHO Coronavirus Disease (COVID-19) Dashboard.

Note: The latest data as of November 2021(accessed November 27, 2021). Hong Kong, China and Chinese Taipei are unavailable.

Shocks in APEC economies are radiating with the spread the COVID-19 pandemic. According to the IMF, APEC member economies recorded negative per capita GDP growth in 2020, at minus 4.2 percent on average. This represents the lowest aggregate growth rate of APEC member economies since 1990. Compared to the past Asian Financial Crisis of 1997 to 1998, in which APEC member economies as a whole saw their economies contract 1.6 percent, and the far-reaching impacts of the Global Financial Crisis of 2008 to 2009, the economic impacts of the coronavirus pandemic are starker yet.

Figure 3: APEC member economies' per capita GDP growth (rate, %)



Source: The authors, compiled using data from October 2021 IMF World Economic Outlook Database

Note: Rates based on constant PPP 2017 in international dollars. The per capita GDP growth is the average of each APEC members.

The pandemic has had sweeping negative impacts across most APEC member economies in a way measurably different from prior economic shocks. The Asian Financial Crisis saw many economies shrink, but the damage was concentrated in East Asia. The shocks of the Global Financial Crisis that originated in developed economies were more severe, leading to widespread negative growth in both developed and developing economies. However, neither crisis compares to the fallout from the COVID-19 pandemic: all APEC member economies save only for China; Chinese Taipei and Viet Nam are expected to contract due to the COVID-19 pandemic.

Table 1: Per capita GDP growth in APEC member economies during crises

Member economies	Economic Crisis	GDP per capita
Australia	Asian Financial Crisis	3.6%
	Global Financial Crisis	0.1%
	COVID-19 Pandemic	-2.9%
Brunei Darussalam	Asian Financial Crisis	-3.1%
	Global Financial Crisis	-3.2%
	COVID-19 Pandemic	0.9%
Canada	Asian Financial Crisis	3.0%
	Global Financial Crisis	-4.0%
	COVID-19 Pandemic	-6.4%
Chile	Asian Financial Crisis	3.0%
	Global Financial Crisis	-2.7%
	COVID-19 Pandemic	-7.5%
China	Asian Financial Crisis	6.9%
	Global Financial Crisis	8.9%
	COVID-19 Pandemic	2.0%
Hong Kong, China	Asian Financial Crisis	-6.8%
	Global Financial Crisis	-2.9%
	COVID-19 Pandemic	-4.9%
Indonesia	Asian Financial Crisis	-14.1%
	Global Financial Crisis	3.2%
	COVID-19 Pandemic	-3.3%
Japan	Asian Financial Crisis	-1.5%
	Global Financial Crisis	-5.6%
	COVID-19 Pandemic	-4.3%
Korea	Asian Financial Crisis	-5.8%
	Global Financial Crisis	0.3%
	COVID-19 Pandemic	-1.0%
Malaysia	Asian Financial Crisis	-9.7%
	Global Financial Crisis	-3.2%
	COVID-19 Pandemic	-6.8%
Mexico	Asian Financial Crisis	3.6%
	Global Financial Crisis	-6.7%
	COVID-19 Pandemic	-9.2%
New Zealand	Asian Financial Crisis	-0.6%
	Global Financial Crisis	-2.2%
	COVID-19 Pandemic	-4.0%
Papua New Guinea	Asian Financial Crisis	2.1%
	Global Financial Crisis	4.4%
	COVID-19 Pandemic	-5.9%
Peru	Asian Financial Crisis	-2.0%
	Global Financial Crisis	0%
	COVID-19 Pandemic	-11.9%
The Philippines	Asian Financial Crisis	-2.9%

	Global Financial Crisis	-0.3%
	COVID-19 Pandemic	-10.8%
The Russian Federation	Asian Financial Crisis	-5.2%
	Global Financial Crisis	-7.9%
	COVID-19 Pandemic	-2.6%
Singapore	Asian Financial Crisis	-5.5%
	Global Financial Crisis	-2.9%
	COVID-19 Pandemic	-5.1%
Chinese Taipei	Asian Financial Crisis	3.3%
	Global Financial Crisis	-2.0%
	COVID-19 Pandemic	3.3%
Thailand	Asian Financial Crisis	-8.7%
	Global Financial Crisis	-1.2%
	COVID-19 Pandemic	-6.3%
United States	Asian Financial Crisis	3.3%
	Global Financial Crisis	-3.4%
	COVID-19 Pandemic	-3.8%
Viet Nam	Asian Financial Crisis	4.2%
	Global Financial Crisis	4.4%
	COVID-19 Pandemic	2.0%

Source: The authors, compiled using the October 2021 IMF World Economic Outlook Database

Note: Rates based on constant PPP 2017 in international dollars

1.2 Research objectives

This report aims to investigate the digital transformation occurring within GVCs and describe the implications those changes carry for APEC cooperation. The COVID-19 pandemic is expected to accelerate the digital transformation and bolster the digital economy as work is underway to overcome this unprecedented crisis. Under these circumstances, understanding digital transformation within GVCs is critical to surmounting the COVID-19 crisis and preparing for a post-pandemic era.

The overall APEC economy is a mix of opportunities and challenges for the digital transformation, given that its members are of different levels of economic development. The opportunities and challenges that the digital transformation of GVCs creates for developed and developing economies are not uniform. Under these circumstances, it is urgent that we determine the implications carried by the digital transformation of GVCs and find ways to cooperate to ensure mutual prosperity among APEC member economies.

To this end, Chapter 2 of this report first reviews major contemporary issues in the digital transformation. It discusses the characteristics of significant changes in industries and economies led by the digital transformation and changes in GVCs. In particular, this study focuses on the structure of GVCs' digital transformation and on the digital enterprises that are driving this transition. Chapter 3 introduces new businesses and practices designed by digital companies to cope with COVID-19 and compares them to the limitations of ordinary companies' responses to the digital transformation during the pandemic. Chapter 4 of this study overviews the status of digital infrastructure, business conditions and the policies of digital enterprises operating in APEC economies. Finally, through these discussions, the final chapter of this study concludes with suggestions on how APEC member economies might overcome the impact of COVID-19 on GVCs in the midst of the digital transformation and prepare for the post-pandemic era.

II. The digital transformation and GVCs

2.1 Industrial and economic changes of the digital transformation

The digital transformation has undoubtedly imparted industrial and economic changes. Depending on the definition used, estimates of the size of the digital economy range from 4.5 to 15.5 percent of world GDP (UNCTAD, 2019). Its increasing relevance is evident in the emphasis placed on the topic by major international organizations. Such organizations include: UNCTAD, which has published relevant material on digital and information economies in various reports and technical notes, the OECD, which has published studies on the topic in its *Digital Economy Outlook Report* and other papers, the World Trade Organization (WTO), whose *World Trade Report 2018* focused on the digital economy, the International Trade Center and its focus on the digital transformation, the World Economic Forum and its focus on the future of the digital economy, and the U.S. Bureau of Economic Analysis and its reports on the digital economy, among many others. Research is in agreement that the COVID-19 pandemic has and will continue to accelerate the development and adoption of digital technologies (Fu, 2020; UNIDO, 2020).

It is important to note that there are few widely-accepted definitions for the terms “digital economy” or “digital transformation.” Measuring the size and value of the digital economy is difficult due to its intangible nature and rapid evolution. Even for agreed-upon elements, there is a lack of reliable data on key components and dimensions, especially in developing economies (UNCTAD, 2019). Efforts to collect data on digital trade remain in their infancy, particularly in developing economies and the world’s least-developed regions, where smaller transaction volumes and lower levels of ICT penetration call into question the value of dedicating limited resources to developing the relevant statistics (WTO, 2018). Nevertheless, efforts exist to create a common framework. For example, OECD recently proposed a definition for the digital economy and a set of existing indicators to measure related jobs, skills, and growth (OECD, 2020b). And a task force composed of IMF, WTO and OECD trade experts defined digital trade all trade ordered and/or delivered digitally (OECD, 2020). While opinions diverge on how to best measure the digital economy, there is widespread interest in and consensus regarding its potential.

Global production of ICT goods and services in 2014 amounted to an estimated 6.5 percent of global gross domestic product (GDP), representing value added of 5.1 trillion USD, of which 3.4 trillion was from services and 1.7 trillion from goods (UNCTAD, 2017a). Exports of ICT services grew by 40 percent between 2010 and 2015. Trade in ICT goods exceeded two trillion USD in 2015 (UNCTAD, 2017a). In 2018, digitally deliverable service exports amounted to 2.9 trillion USD, or 50 percent of global services exports. In underdeveloped economies, such services accounted for an estimated 16 percent of total services exports, more than tripling from 2005 to 2018 (UNCTAD, 2019). Digital-intensive industries account for about 44 percent of global

production (OECD, 2019).

Global employment in the ICT sector increased from 34 million in 2010 to 39 million in 2015, with computer services accounting for the largest share (38 percent). The share of the ICT sector of total employment rose over the same period, from 1.8 percent to two percent (UNCTAD, 2019).

Estimates of the size of the digital economy are often based on extrapolations of production and employment statistics or are derived from market reports based on technologies or concepts that enable the digital transformation. For example, concepts tend to include AI, IoT and the Industrial Internet of Things (IIOT) or more generally data collection and network connectivity, cloud computing, big data and analytics and blockchain technologies (Sturgeon, 2019; WTO, 2018). Other reports also include concepts related to advanced manufacturing, such as additive manufacturing or 3D printing, robotics and smart factory concepts.

AI patents issued by the leading five intellectual property offices around the world increased six percent per year from 2010 to 2015, which was more than twice the growth rate observed for all patents (OECD, 2017). Annual growth rate for individual areas related to the digital economy was projected to be close to 50 percent for AI, 34 percent for IoT and 15 percent for industrial robotics from 2018 to 2023 (BCC Research, 2018a, 2018b, 2018c). Estimates for the size of the IIOT market vary. Some estimates are as high as 800 billion USD as of 2020 (Columbus, 2018); conservative estimates are closer to 85 billion USD.

2.2 The digital economy: description and estimates

The digital economy can be broadly defined as the application of internet-based digital technologies to the production and trade of goods and services (UNCTAD, 2017) from (WTO, 2018).

The digital economy includes three main kinds of digital services: software, IT and internet software and services, which together comprise the IT GVC, in addition to servicification opportunities and uptake in industry-specific GVCs (Frederick et al., 2018).

Segment	Types/Examples	Revenue Source	Global Revenue (bln USD)	Companies
Software	Applications or operating software	Direct sales or licensing	$335.2, 2016	Microsoft, Oracle, SAP, Salesforce, Citrix, Red Hat, Kakao
IT Services	Operational consulting, business process outsourcing, data analysis (software users)	Service fees	$585.3, 2016	IBM, Accenture, Infosys, Wipro, Samsung SDS
Internet Software & Services	Search engines, E-commerce, Social networks ($33B), Cloud platforms ($28B), Mobile apps ($4B), Big data ($21.3B) & analytics ($5.2B)	Advertising, Commission	$91, 2015	Google, Naver, Baidu, Amazon, Alibaba, Facebook

Table 2: Digital economy market segments/final products, values, 2017-18

Sources: Frederick et al. (2018); "Sources for Global Revenue" from MarketLine and CFRA reports.

Software

The two main software categories are systems software and application software. Application software is fragmented and diverse, comprising over 35 different types. There are just two types of systems software, however: operating and database software, and the sector is driven by a small number of incumbent IT firms. The spread and uptake of internet use and access has enabled consumers to purchase, deliver and update software without the need for physical media. This allows software to disseminate rapidly (Frederick et al., 2018).

Companies with the largest software businesses, which include Microsoft, Oracle, IBM and SAP, accounted for 37 percent of worldwide commercial software revenue in 2014 according to IDC (CFRA, 2017c). The largest global software companies were established prior to 2000. These firms have been able to remain relevant and expand into new applications, often via acquisitions of tech firms in specific areas, and more recently through startup investments.

Application-specific software is the most relevant and growing segment. This includes software programs designed specifically for mobile devices, typically referred to as mobile apps, or just apps. Smartphone app developers create and publish applications for smartphones. The software segment also includes the growing Software as a Service (SaaS) market (MarketLine, 2017). In SaaS, software programs

are hosted and run on remote, offsite servers which are collectively referred to as the cloud. Salesforce, Microsoft and SAP are the three largest cloud software revenue earners (CFRA, 2017b).

Microsoft was established in 1975, and the company owns several well-known operating and application-specific properties, including the Windows operating system, Xbox, Office, Bing, as well as LinkedIn and Skype, both of which became part of Microsoft's portfolio via acquisitions. Over the last few years, the company's revenue has shifted increasingly into services; 19 percent of revenue was from services in 2015 but had climbed to 36 percent by 2017. The shift to services is also evident in changes in employment. Product support and consulting employment increased from 13,000 workers in 2007 to approximately 35,000 in 2017. Revenue from operating software (Windows) has steadily declined over the last two decades and been replaced with advertising revenue and revenue from the "intelligent cloud," which includes server products and cloud services for businesses, such as Microsoft Azure and SQL servers. The company is also earning more and more revenue from international sales; overseas revenues jumped from 29 to 41 percent of total revenues between 1997 and 2017.

IT Services

IT services is not a new industry, but one impacted by the advent of new digital technologies. Information technology and business service companies are users of software, particularly application-specific software (Frederick et al., 2018). The line between software and IT services is blurry as many companies often provide some application-specific software development in addition to managing data and providing data analytics and other business services. There is also overlap with IT platforms, as firms in this category may also provide infrastructure and platform services, which can include application hosting and data centers, desktop support and management, security and storage.

Notable global firms in this segment include IBM, Accenture, and three large Indian companies: Infosys, TCS, and Wipro. IBM, TCS and Wipro were all founded as hardware firms before shifting to their current, service-driven business models (Frederick et al., 2018). The Indian IT firms are particularly notable in this segment. In the 1990s and 2000s, they became key IT and business process (BP) outsourcing providers, having only recently moved into services-related to machine and equipment connectivity. They have been focused on systems integration, experimenting with the provision of services on existing IIoT platforms made by firms such as GE and Siemens. Infosys has focused on developing SaaS options for multiple IIoT platforms. However, their historical lines of business in back office IT has also positioned them as providers of data systems management for discrete equipment manufacturers. For example, Wipro provided mining and construction equipment manufacturer JCB with a turnkey IoT solution to connect sensors in their global fleets to the cloud (Wipro, 2018). TCS has provided data processing and engineering support for Rolls-Royce

since the 2000s, a role that has expanded as Rolls-Royce has sought to leverage big data across its supply chain and broaden its asset management services (Frederick et al., 2018). Infosys, Wipro, and TCS are all also investing in analytics firms to support their IIoT ambitions. Infosys launched a 500 million USD investment fund (2013); Wipro established a similar fund in 2014 valued at 100 million USD (Agarwal, 2017).

Internet platforms

This sector includes search engine providers (particularly Alphabet's core search product, Alphabet), social networking services, cloud storage and networking providers (IaaS and PaaS) and e-commerce firms. These are relatively newer companies, with well over half of them having been established between 1994 and 1999 (CFRA, 2017a).

The sector is diverse. One thread connecting the various firms in the industry is those firms' dependency on the Internet: they are entirely digital companies. Many of these are newer (founded after 1995) companies. In the WIR, these include the platform companies, digital content and e-commerce firms and some of the digital solutions providers (many of which are also in the software business). This segment is primarily active in the consumer market (B2C), save for cloud companies, the products of which are targeted at the industrial market (B2B). Companies in this segment earn revenue from advertising or from fees paid to access their platforms.

Alphabet was established in 1995 as Google, and is perhaps the most well-known digital company in the world. Alphabet is the global leader in internet search. The company once spent more on R&D than all other technology companies earned in revenue in a single fiscal year. As of 2018, Alphabet has been involved in 200 mergers and acquisitions, largely in Internet services and application software. Alphabet has an extensive history of acquisitions, and has used them to help expand the functionality of its existing products. Alphabet holds its own annual conference convening stakeholders in the United States, Japan and the UK. It is also active in setting up start-up innovation centers.

Digital Service Opportunities in Manufacturing

In manufacturing, there is a shift toward renting or leasing some types of capital equipment rather than purchasing outright. These contracts may include services related to equipment and system wide performance analytics, which enables improvements to operating parameters, maintenance and so on. Industrial OEMs are entering this space given they already have relationships with clients and have knowledge of the equipment and how to optimize operations (Frederick et al., 2018).

GE, a longstanding US-based industrial giant, is active in the aerospace, oil and gas, power generation, transportation and manufacturing sectors. As an OEM manufacturer, the company has access to equipment and the types of data needed to move into digital services. This move began by analyzing and utilizing sensor data to improve

user operations and optimize the maintenance of individual machines. While the company still sells physical equipment, it increasingly engages with clients through service level agreements (SLAs) in which GE maintains ownership of the equipment and essentially leases it to the client along with a contract to provide maintenance services, software, and analytics. From 2010 to 2017, services' share of revenue increased from one-quarter to one half of all revenues. In addition, the company began to internally develop proprietary software to support its equipment and systems. GE recognizes the importance of collaboration and was a founding member of the Industrial Internet Consortium and actively collaborates with IT services firms, telecommunications and network providers, IT hardware providers as well as consulting firms (Frederick et al., 2018).

2.3. Changes to GVCs in the digital transformation

Over the past thirty years, developed and developing economies alike have competed to participate in different industries, shaping a series of policies based on existing understandings of the distribution of value within links of the chain and the requirements to participate in each of those stages. The path followed by many developing economies has been to attract segments of GVCs that utilize their comparative advantage in labor, performing routine manual tasks and delivering services for global industries at a lower cost. Developed economies have focused on research, design, and technological development in addition to branding and marketing. They have also negotiated trade and investment policies to leverage the benefits of low-cost locations and to reduce barriers to entry for service providers seeking to do business in those markets.

Current trends are altering the dynamics of GVCs, affecting value distribution, governance, firm participation and geographic composition. The rise of the digital economy is influencing global value chains through several trends, a few of which are described below:

Changes to existing GVCs and the advent of new industries

1. New industries and stages creating new jobs and skill requirements
2. The emergence of new leading firms
3. The digital transformation and small and medium-sized enterprises (SMEs)
4. Changes in the geographic distribution of chain activities

Changes to existing GVCs and the advent of new industries

Changes to existing GVCs: The increasing importance of services has birthed new industries and stages — new links in the global value chain — in addition to altering the distribution of value in existing GVCs. Revenue firms from manufacturing-related services, particularly from "after-sales" services, is becoming just as important (if not more so) than the revenue from the manufacturing operations themselves (Low &

Pasadilla, 2015). In some capital equipment sectors, after-sales services already account for more than half of manufacturing firms' earnings. Furthermore, there is a shift to a pay-per-use model as opposed to outright ownership or fixed-price contracts across sectors (Cho et al., 2018).

Digitalization increases the value attributed to pre- and post-production services in GVCs and may comparatively lower the value of manufacturing (Rehnberg and Ponte, 2017). An expansion of digitized services exists in the pre-production stage as well, in areas that include a wider range of design software and data-driven services that inform new goods and services and in the post-production stage as services embedded in software and enhanced after-sales services (UNCTAD, 2019).

The adoption of digital consumer technology at the global level is reflected by the trend toward buying goods and services online, be them digital or physical, a trend itself enabled by the widespread use of internet-enabled devices such as smartphones and laptops (WTO, 2018). In 2016, the value of e-commerce transactions was 27.7 trillion USD (WTO, 2018). Most e-commerce sales are business-to-business transactions (B2B), estimated at 90 percent of sales in 2015, with 10 percent in the form of business-to-consumer (B2C) sales. UNCTAD estimated cross-border B2C e-commerce was worth 189 billion USD in 2015, which corresponds to seven percent of total B2C e-commerce (UNCTAD, 2017a). E-commerce retail sales more than doubled between 2012 and 2017, going from 1 trillion to 2.3 trillion USD in gross sales and representing approximately 11 percent of all retail sales in 2017 (eMarketer, 2014, 2018). Online platforms make it easier for more firms to market their products and services to a wider range of customers, and it creates the need for new businesses to develop the technology to run portals, process transactions, and analyze the data generated from the monitoring of shoppers' browsing and buying habits.

Digitalization impacts products, services and end markets differently. Sectors differ in their usage of digital technologies and in their receptiveness to digitization. The WTO (2018) report suggests that on average, service firms are more intensive users of digital technology than manufacturing firms, while high-tech firms are more intensive users of industrial robots than service or low-tech firms (WTO, 2018). The European Commission's 2017 *Digital Progress Report* proposed a digital intensity ranking of sectors based on the sectoral share of enterprises using at least seven out of 12 digital technologies. On average, service firms were found to be more intensive users of digital technology than manufacturing firms. The sectors with the highest digital intensity (greater than 50 percent) included the travel services, computer programming, and telecommunications sectors. Low-intensity industries (less than 10 percent) included the metal products, construction, textiles, food and beverage and tobacco sectors (WTO, 2018).

On the other hand, a recent UNCTAD paper discusses sectoral propensities with regards to digitization. For example, business services are more receptive to digitization (or digitizable), whereas beauty services are not. On average, manufacturing is more digitizable than services that require an in-person component.

Companies that are more digitized and automated have fewer workers and use more automated processes or artificial intelligence (Fu, 2020).

Differences also exist between consumer and industrial markets. Industrial markets are more varied as industries and firms have specific digital needs (Sturgeon, 2019). As such, the industrial side is more fragmented and will likely remain that way. The consumer side is likely to continue to be dominated by large-scale global platforms that benefit from the largest network effects and economies of scale.

New segments: Data is an increasingly valuable economic resource that can be transformed into so-called "digital intelligence" and monetized (UNCTAD, 2019). Data-related activities are no longer mere byproducts of the production of goods and services; instead, they have become a central feature of the production process and a key aspect of economic activity (UNCTAD, 2019). An entirely new industry has evolved around firms that support the generation of data-based insights, including data acquisition, storage and warehousing, modelling and analysis and visualization (UNCTAD, 2019). The ability to profit from data requires access to large amounts of relevant data, the ability to wield it, the ability to process and transform this information into digital intelligence and the ability to identify and access buyers and customers that would benefit from the insights gleaned from the data. In each of these activities is an opportunity for data monetization.

New industries and stages create new jobs and skill requirements

Regarding the labor market, the digital transformation is creating demand for new skills. The production of ICT products such as software, webpages, e-commerce, cloud-based computing, and data analytics requires ICT specialist skills to program, develop applications and manage networks. Demand for ICT skills is reflected in wages: all things being equal (including education and other skills), the higher the ICT task intensity of a job, the higher the hourly wage earned by workers (OECD, 2020b).[3] Demand for workers with programming and data analysis skills has increased significantly, with workers earning wages considerably greater than average in related occupations in the United States. Computer systems design and services and software publishers are among the industries with fast-growing employment and wages (Cho et al., 2018). One in four jobs in the G20 are in digital-intensive sectors and these sectors created 43 percent of all new jobs between 2006 and 2017 (OECD, 2020b).

The ability to find workers with digital skillsets and for workers to market their services is also facilitated by digital platforms through freelance marketplaces such as Upwork or FlexWork. Online labor platforms connect freelance service providers with clients worldwide, making trade in digitally-delivered services profitable even for small projects. These platforms also assist workers in developing economies by

[3] From OECD (2019), *Measuring the Digital Transformation: A Roadmap for the Future*, OECD Publishing, Paris, https://doi.org/10.1787/9789264311992-en

providing access to demand in developed economies. Demand for these services is largely in the United States and Europe, whereas the labor supply is concentrated in Asia and in South Asian economies in particular (WTO, 2018).[4]

Digital skills are becoming increasingly common across all occupations. It is necessary to expand the ICT curriculum across all educational levels, including among educational professionals themselves. Workers across a range of occupations would benefit from learning and employing generic ICT skills — searching out and accessing information online, using software, and so forth — in their jobs (OECD, 2020b). Efforts are needed to prepare everyday people for the digital transformation, and particular attention should be paid to the establishment of lifelong ICT training programs that can prepare employees in all fields and from all walks of life for the inevitable changes to come. In other words, upskilling and reskilling workers is critical to help them meet demand for digital skills. Adult learning systems that allow adults to maintain and upgrade skills throughout their careers are essential to harness the benefits of the digital transformation (OECD, 2020b).

The digital economy has led to growth in two new forms of education: certifications and online learning. All major software and service providers offer education and training for their products to enable workers to attain various levels of certification. This is both a means of revenue for the company and an alternative to more formal education. Alphabet, IBM, Oracle, Microsoft, Red Hat, Citrix, and Salesforce all offer training and certifications for their products (Cho et al., 2018).

Similarly, the digital economy has also expanded the ability for education and training programs to reach a larger audience. Alternative training channels such as massive open online courses (MOOCs) have become popular, especially among younger people (OECD, 2020a). Distance and online learning education platforms such as EdX and Coursera enable universities and training providers to offer courses internationally. The content of these programs is often free of charge, with participants paying a nominal fee to obtain a verified certificate of completion.

Emergence of new leading firms and their characteristics

Multiple sources attest to the increasing importance of digital firms and the digital economy. For example, in UNCTAD (2017b), the number of technology-related enterprises — as well as their share of assets and operating revenues — that rank among the top 100 multinational companies more than doubled from 2010 to 2015. The number of firms increased from four to ten, the share of digital firms' operating revenue increased from five to 12 percent and their share of assets from four to 11 percent. Among these tech multinationals, the emergence of firms whose main business lines revolve around the provision of digital services is especially prominent (Cho et al., 2018). Similarly, 15 of the top 20 companies in the world in 2018 based on market capitalization were technology, consumer services or financial companies. In 2009, only six companies of the top 20 firms globally hailed from these industries;

[4] WTO analysis of iLabour project data of the University of Oxford, p. 83-84.

seven were in extractive sectors. Based on market capitalization, the share of tech and financial companies among the top 20 went from 34 to 83 percent between 2009 and 2018 (UNCTAD, 2019).

Characteristics of leading global firms in the digital economy include a larger share of revenue from services rather than physical goods, a higher share of revenue from foreign sources (often greater than 50 percent) and extensive collaboration with other digital firms and key players in existing GVCs, particularly in data mining and analytics (Cho et al., 2018; Frederick et al., 2018). In the G20, over one-in-five jobs in digital-intensive sectors are sustained by foreign, rather than domestic, demand (OECD, 2020b).

A unique feature of companies in consumer markets is the difference between the products and services they provide and their sources of revenue. Many companies engaged in the platform segment earn most of their revenue from digital advertising, rather than selling their products or services. Companies such as Alphabet and Facebook offer end-users free accounts on various platforms and earn revenue from advertisements aired on those platforms that take advantage of user data. The growth of digital advertising is evident in the share of digital ad buys as a proportion of total media ad spending. Globally, 38 percent of global advertising revenue was from Internet advertising in 2017.

Companies build digital portfolios and domain expertise organically through human capital and R&D, M&A activity and joint innovation with partners to expand their reach (Cho et al, 2018, Frederick et al, 2018).

Digital firms often spend a significant share of revenue on R&D. In its 2018 *Global Innovation 1000* report, PricewaterhouseCoopers (PwC) identified 125 companies in the digital economy, representing 13 percent of all firms studied. Those digital firms spent an average of 12 percent of revenue on R&D, eight percent more than the typical firm (PwC, 2018). Strategic partnerships between digital firms in various sectors across the world are also common. Large multinationals build research, technology and innovation centers focused on digital technologies in key locations around the world to facilitate joint development.

Mergers and acquisitions (M&A) are common, and frequently employed by large companies to expand into new product lines, market segments or geographic areas (Cho et al., 2018; Frederick et al., 2018). Acquiring companies that exhibit expertise in desirable areas provides a quick way for firms to gain access to key knowledge, intellectual property, or new markets. It is also common for digital firms to establish venture capital arms to monitor and invest in promising start-ups. As such, SMEs often look to larger firms for start-up capital or develop products and services with the objective of being acquired by a large multinational enterprise.

Digital technologies and SMEs

Digital technologies reduce indirect costs associated with doing business. These technologies are comparatively more beneficial to SMEs than large firms because

indirect costs make up a larger share of expenses at smaller firms. They also facilitate access to customers and finance. For example, online marketing has also been shown to be important for SMEs, with digital access reducing estimated marketing costs by 57 percent (Ganne and Lundquist, 2019). Online and mobile banking services reduce transactions costs and new financing tools such as online crowdfunding also supplement traditional financing options available to SMEs.

E-commerce platforms provide a means for SMEs to reach customers without having to invest in physical retail establishments or access the supply networks of MNEs. These platforms enable SMEs to sell goods bearing their own designs and brands directly to consumers, which provides the opportunity for firms to increase profit margins and develop knowledge-intensive skills. For example, apparel manufacturers in China use online platforms to sell products featuring their own brands in the domestic market (Li et al., 2018).

These opportunities primarily exist in domestic market channels at present. However, as online shopping continues to account for a larger share of retail sales (particularly during the COVID-19 pandemic), so too will cross-border retail e-commerce. Cross-border online trade is expected to grow at twice the rate of domestic e-commerce (Ganne and Lundquist, 2019). E-commerce also enables SMEs to purchase inputs, particularly those needed in smaller quantities, more easily via B2B platforms.

Opportunities also exist for SMEs to develop new digital applications at the interregional and regional levels, where localized platforms that cater to local markets in terms of language and consumer preference are needed. These opportunities are most evident in consumer markets where local applications are necessary in areas ranging from banking to food delivery. However, digital platforms originating in developing economies are primarily transaction platforms rather than innovative or integrated platforms (UNCTAD, 2019). SMEs may find there are limited opportunities to expand beyond adopting the application to enter a new product category or to perhaps identify a niche area that is not currently dominated by a global platform.

On the other hand, the digital transformation may make it more difficult for SMEs to gainfully participate in the production networks of global MNEs. Major contracting firms will increasingly require suppliers to purchase and adopt specific preferred technologies, for example particular supply chain management or computer-aided design software. The cost of these software packages are not the only barrier, either; legislation pertaining to ICT and trade in services may restrict SMEs from digitally connecting to global value chains (Ganne and Lundquist, 2019).

Changes in the geographic distribution of chain activities and APEC members' participation

Easier separation of manufacturing and innovation: A fundamental characteristic of GVCs is how production and consumption activities in the links along the chain are not restricted in terms of geography. Digital technologies enable the granular division and reorganization of GVC activities.

Buyers and suppliers need to exchange information to produce products or services. The ease in which information can be codified and exchanged between firms and across borders impacts the ability to outsource and offshore activities along the chain. Modularity is enabled and accelerated by the technologies, tools, and platform ecosystems of the digital economy (Sturgeon, 2019). From a GVC perspective, the change with the greatest impact is the ability to further separate service and production activities. These trends influence the geographic distribution of GVC activities. Increased digitalization allows expanded globalization of services. Services such as data analysis for lifecycle management can be carried out anywhere in the world with the right mix of human capital availability and infrastructure. The distribution of GVC stages in APEC member economies reflects this: tech conglomerate Apple designs much of the software than runs on its hardware products in the US state of California, even as many components of the products themselves are manufactured in Chinese Taipei by supplier Foxconn. This illustrates how service links in GVCs in the digital economy (in this case, software design), face fewer geospatial restrictions than ever before. This relationship holds true between developing and developed economies as well. Korean electronics giant Samsung houses R&D centers across the globe, including many APEC member economies; Viet Nam is home to major links in the corporate supply chain.

On the other hand, advancements in automation and robotics may eventually lead to some reshoring of offshore production certain industries. The more immediate impact, however, is likely to be the continued consolidation of production in a handful of key economies that already produce large volumes of goods and can absorb the cost of investing in new technologies. A side effect of this is the difficulty faced by low-volume suppliers and firms in less-developed economies that struggle to compete. Furthermore, robots are mainly used in the automotive, electrical, electronics and metal industries (UNCTAD, 2019). Using data from the International Federation of Robotics, the WTO report estimated the use of industrial robots per employed worker. The automotive industry utilized far more robots than any other industry; it was followed, in order, by the electrical, electronics and metal products (non-automotive) sectors (WTO, 2018, p. 50). These are industries that already more capital-intensive than labor-intensive. Robotics in labor-intensive fields such as mass garment production do not yet exist due to the variety of products and materials used in the industry and difficulties in handling materials.

Concentration in key economies and inequalities: Because of differences between economies in digital skills, capabilities and infrastructure, as well as in heterogeneous abilities to invest in new technologies and digital infrastructure, it is likely that we will witness increasing inequality within and between economies (Fu, 2020).

2018 marked the year over half of the global population had gained access to the Internet. However the share of Internet users is not evenly allocated (UNCTAD, 2019).[5] In the world's least-developed economies, only one out of five people are

[5] Based on 2018 ITU data stating 51.2 percent, or 3.9 billion people went online.

online, compared with four out of five in developed economies. Limited Internet use is an impediment to scaling the market for value creation in the digital economy. Internet access is either cost-prohibitive or simply not available, particularly in rural locations, in these economies. Similarly, e-commerce is far less common in developing economies, with five percent or less of the population in lower-middle and low-income economies using the Internet to make online purchases, compared to the world average of 25 percent in 2017 (UNCTAD, 2019). Inequalities also exist within economies between urban and rural areas.

At the global level, the largest digital multinationals (by revenue) are primarily based in the United States, followed by China and Europe, with only a handful of concerns in other economies. As of 2015, two-thirds (67 percent) of digital MNEs were US-based firms. Twenty-three percent were European, four firms were Japanese, two were Chinese, and one each hailed from Korea, Canada, Mexico, and South Africa (UNCTAD, 2017b). Regarding value added in the ICT sector, the United States and China together accounted for almost 40 percent of the world total (UNCTAD, 2019). From 2013 to 16, five APEC member economies — China, Chinese Taipei, Japan, Korea and the United States — were responsible for developing between 72 percent and 98 percent of the top 25 cutting-edge digital technologies (OECD, 2019). One risk is that most economies, and particularly the world's least-developed economies, will become exporters of raw data and importers of value-added data products, with no ability to change this power dynamic domestically (UNCTAD, 2019).

Whereas China and the US may be the most well-known players in the digital economy, several other Asian economies play an important role in other parts of the digital economy. (Frederick et al., 2018).

China is home to several large domestic platform firms including Alibaba, Baidu and Tencent in addition to foreign-owned R&D centers and incubators owned by major international conglomerates that include including Bosch, Siemens, GE Digital, Microsoft, and Alphabet. The activities of both sets of firms are primarily aimed at the domestic Chinese market. Among other strategies, China has grown its footprint in the digital economy by aggressively engaging a large domestic market, offering corporate tax incentives for digital companies and implementing policies early on requiring foreign manufacturing investors to also engage in R&D activities. Korea's role in the digital economy is different, being primarily focused on manufacturing electronics and components that facilitate digital transactions. Well-known domestic MNEs include Samsung and LG. Korean firms also maintain a notable presence in gaming-related software and services.

Singapore plays an active role in the digital economy through its foreign investors and by attracting MNEs to set up Asia-Pacific regional headquarters or R&D innovation centers. Singapore's government has targeted the IIOT branches of key companies including ABB, Accenture, Bosch and Rolls-Royce. India plays an important role as well, focusing on IT services, software development, engineering and R&D. It is home to several large domestic IT service firms, some of them widely-

known, such as Infosys and Wipro. Most United States and European industrial and digital firms have maintained offices in India, some for over a decade. A significant portion of the global IT workforce is based in India, which possesses in-demand skills ranging from programming to analytics.

III. COVID-19 and the digital transformation in GVCs

Section 3 discusses how COVID-19 has accelerated the implementation of digital transformation strategies by firms in GVCs and describes the implications such strategies carry. It also deals with the ability (or lack thereof) of manufacturing firms to the digital transformation through an analysis of survey data on Korean firms' responses to COVID-19 and the digital transformation. Next, with regards to the COVID-19 situation, we document various cases of digital companies dealing with the pandemic through new lines of businesses that leverage new technologies. In this section, we emphasize the role digital companies in GVCs stand to play in the digital transformation through an examination of best practices.

3.1 COVID-19 and the digital transformation

Efforts made since the pandemic began in order to reduce face-to-face interaction and preserve the health and well-being of consumers and workers have been conspicuous in each business area. In this process, the use of new digital technologies, including digital delivery services, e-commerce and videoconferencing applications among others have collectively spawned a new non-contact model of doing business. Indeed, various research predicted that COVID-19 would rapidly accelerate the adoption of digital non-contact technologies.[6]

The COVID-19 pandemic is not only a health crisis caused by the transmission of a dangerous virus, but also an unexpected economic recession.[7] When economic shocks wield such outsize influence in the short term, haphazard or ad-hoc responses often fail to take into account inevitable mid- to long-term changes.

A recent survey conducted by KIET on 1,058 Korean companies in the manufacturing sector also shows that companies face short-term difficulties due to COVID-19 shocks and that these shocks have hampered their ability to prepare for future digital transitions.[8] It also revealed some of the inherent limitations to digitizing operations in the manufacturing sector, in which laborers typically perform manual tasks and operate capital equipment.

The number of non-face-to-face business activities of surveyed firms increased after the outbreak. The average percentage of telecommuters climbed from 0.1 percent of

[6] Following Kane et al (2020), searches for the term "contactless" increased sevenfold between November 2019 and late April 2020. Many companies have accelerated their digital transformation efforts

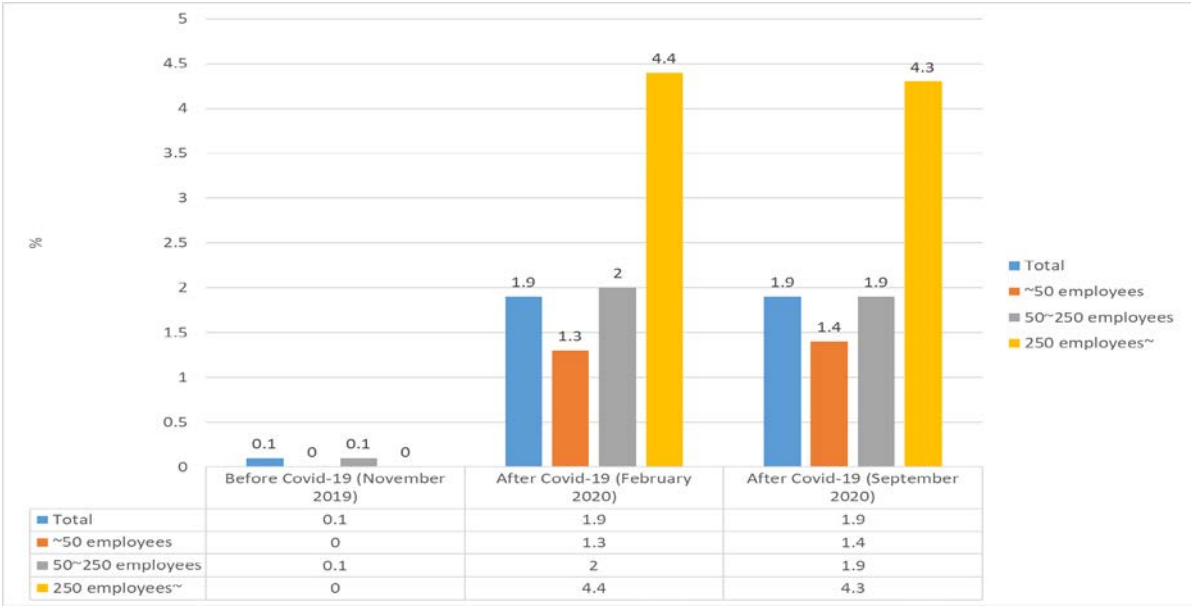
[7] OECD Economic Outlook (2020)

[8] The survey was conducted online from July to October 2020 on 1,058 Korean manufacturing businesses. See Kim et al. (forthcoming) for more specific details and results of the survey.

workers prior to the pandemic to 1.9 percent afterward. The use of videoconferencing services also increased; average daily hours spent videoconferencing before the COVID-19 outbreak was close to zero but had ticked up to 0.2 hours in the post-outbreak period.

The survey showed the scale and scope of the manufacturing firms' digital transformation activities to be limited. This reflects to some extent the inherently physical nature of manufacturing labor; office workers may be able to perform routine tasks working from home but workers contributing directly to production (as well as maintenance workers and others) must be physically present at the site of production. Despite this, considering how serious the ongoing COVID-19 pandemic has become in just over a year, the increased levels of digital activities at some firms is noteworthy.

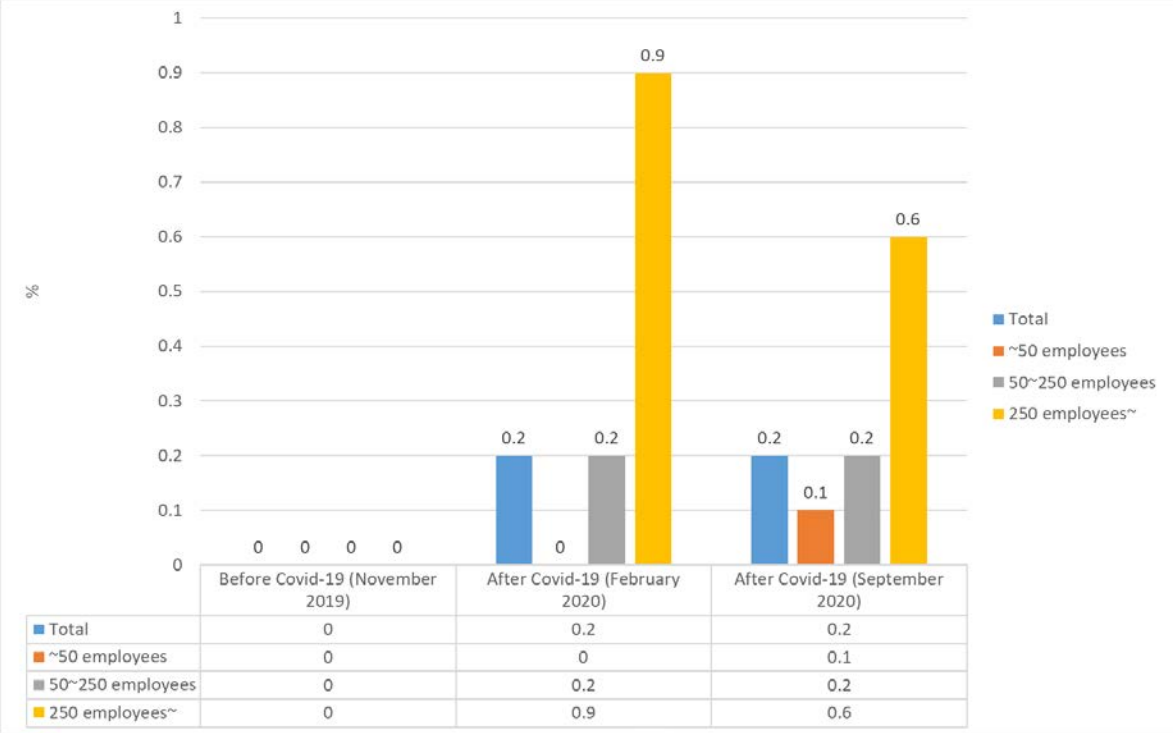
Figure 4: Average home worker ratio (%)



Source: KIET (forthcoming)

Note: February 2020 refers to the month after which the infectious disease risk alert was first raised to the level of "Warning" at the end of January. September 2020 refers to the period immediately following the promulgation of stricter social distancing guidance (Level 2) in August due to recurring outbreaks of COVID-19 in the Seoul metropolitan area and nationwide.

Figure 5: Utilization of video conferencing services (average daily utilization time)



	Before Covid-19 (November 2019)	After Covid-19 (February 2020)	After Covid-19 (September 2020)
Total	0	0.2	0.2
~50 employees	0	0	0.1
50~250 employees	0	0.2	0.2
250 employees~	0	0.9	0.6

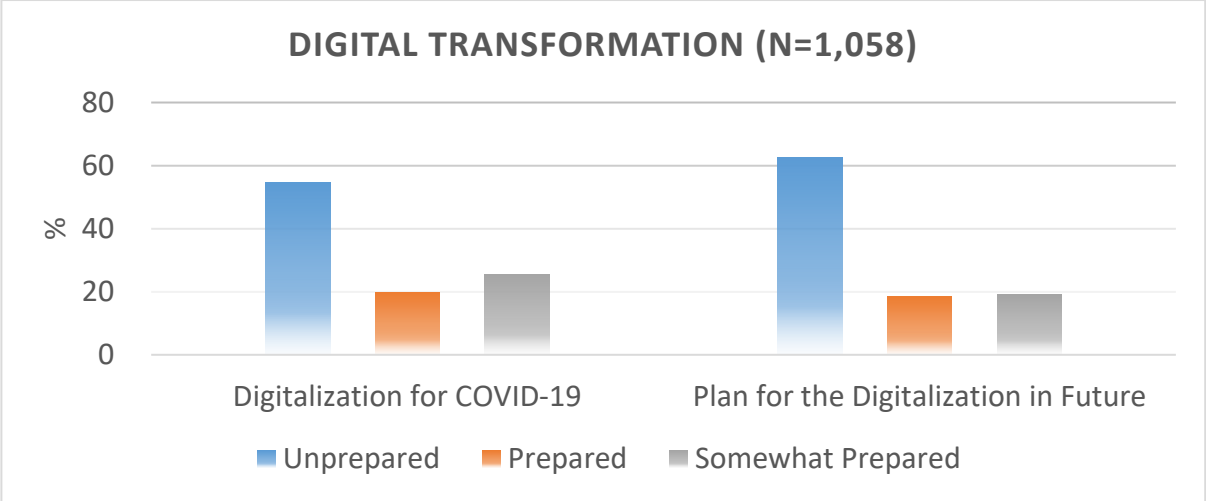
Source: KIET (forthcoming)

Note: See Figure 3.

The degree of corporate digital transition activities varies by enterprise scale. At small businesses, transition activities were sparse. The survey found similar rates of telecommuting hours at small and large companies prior to the COVID-19 pandemic. But ever since, the larger the company, the higher the rate of telecommuting. The use of video conferencing services reveals a similar pattern. These results suggest that the digital transformation in the wake of COVID-19 is closely tied to corporate scale.

Yet the level of digitalization at the majority of companies was not up to the task of dealing with the COVID-19 pandemic, and many companies remain unprepared for the digital transformation of the future. According to the survey, only 20 percent of respondent firms reported digitalization sufficient to cope with COVID-19. Most firms indicated that they were either entirely unprepared or poorly prepared, at rates of 55 and 22 percent of companies, respectively. And yet only 18 percent of companies surveyed replied that they had plans to expand and accelerate digitization as a result of the COVID-19 outbreak; 63 percent of firms had no digitalization plans in place. Piecemeal strategies were in place at 19 percent of firms.

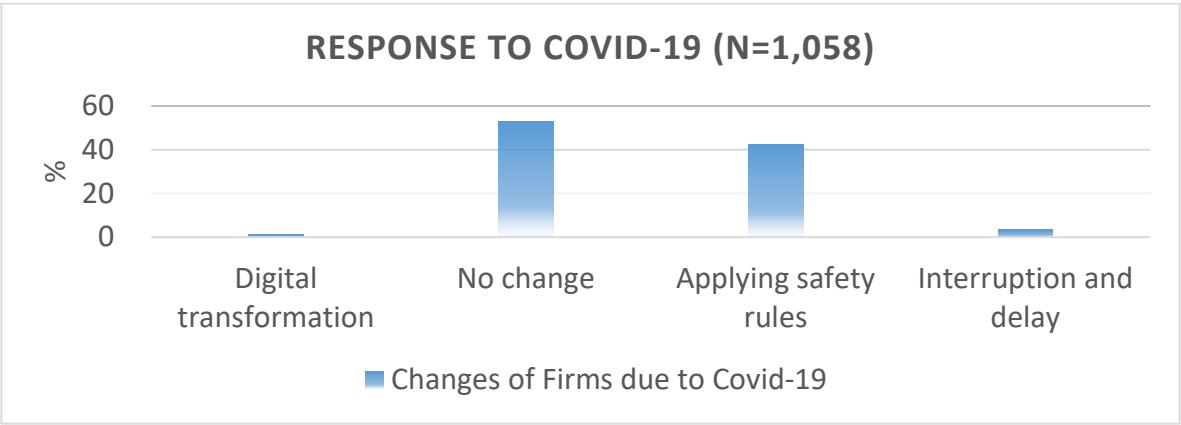
Figure 6: The digital transformation of Korean companies



Source: KIET (forthcoming)

The survey results showed that the pandemic has not accelerated the digital transformation at Korean SMEs. Most respondents indicated that COVID-19 would only lead to changes in the application of quarantine and safety regulations and not to any wide-ranging digital transformation. More than half of respondents (53 percent) reported no change in corporate practices. Just one percent of respondents said that COVID-19 resulted in a digital transformation, while 43 percent of companies reported some degree of change in the application of quarantine and safety procedures. These findings show that very few companies in the manufacturing sector are pursuing real digital transformations in the COVID-19 era.

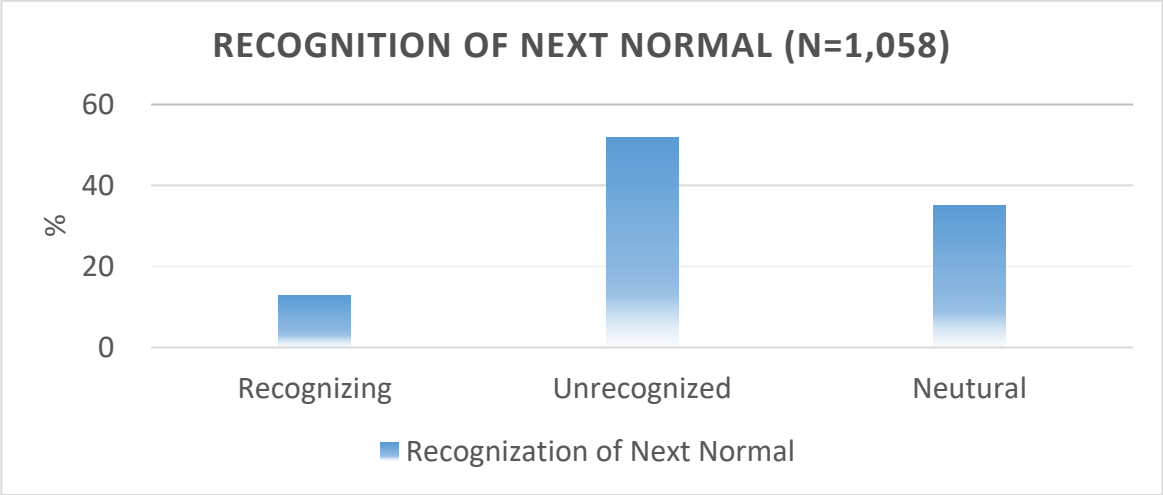
Figure 7: Changes at Korean companies due to COVID-19



Source: KIET (forthcoming)

Companies also demonstrated little awareness of the acceleration of the post-pandemic digital transformation referred to by economists and business scholars as the "Next Normal." According to the survey results, a majority (52) of companies do not recognize a new business environment in their perceptions of the post-COVID-19 era. Only 13 percent of firms acknowledged a unique post-pandemic business climate. These results suggest that corporate awareness of future changes to the business environment following the end of the pandemic is lacking.

Figure 8: Recognition of the Next Normal post-COVID-19



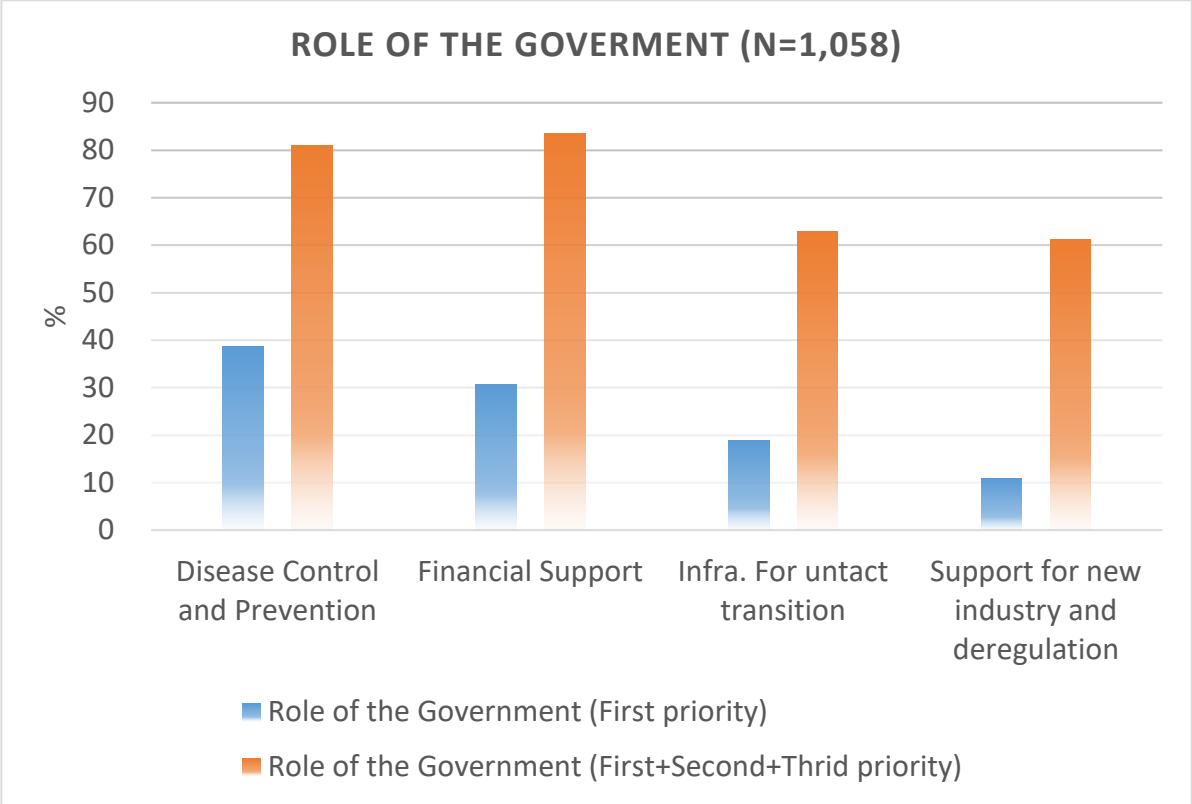
Source: KIET (forthcoming)

Regarding the role of the government in the COVID-19 situation, the surveyed firms indicated that they felt it was the responsibility of the government to control and prevent viral transmission as well as provide financial support. A bit less than half, or 39 percent of enterprises, said the government's main role in the pandemic was to manage the spread of the virus and treat those that had been infected. A further 31 percent of respondents said the government's principal responsibility was to support those financially affected by the pandemic. Just 19 percent of respondents said that the government should support the construction of non-contact infrastructure, which is essential to the digital transformation. Financial support was chosen most often, with 84 percent of respondents selecting it when given three government response measures to choose from. A significant 81 percent of firms surveyed chose disease control and prevention while a comparatively-low 63 percent of firms said the government should support building non-contact infrastructure. These responses indicate a relatively low level of interest in the role of the government with regards to infrastructure support, as financial difficulties and consequent risk of insolvency owing to the pandemic are issues of overwhelming urgency, leaving little room for consideration of the digital transformation.

There are limits to how this data should be interpreted, however. For one, these

conclusions are based on survey data from Korean firms and thus inevitably reflect the Korean experience with remote work, which is influenced by cultural and other factors that will vary across APEC member economies.

Figure 9: What companies expect from the government's COVID-19 response



Source: KIET (forthcoming)

3.2. Digital companies' responses to the COVID-19 crisis

The unprecedented COVID-19 crisis has led to rapid changes in and challenges to our social and economic lives. As many in-person activities are prohibited or limited to prevent viral transmission, firms began seeking novel new business strategies and identifying products and services made newly-essential in a world stricken by pandemic.

Two major changes in daily life brought about by COVID-19 include the shift to contactless work and play and digital technology-based shifts in business. Firms made new bets on the utilization of digital technologies that include digital health care, remote education and telecommuting that became suddenly popular owing to lifestyle changes brought about COVID-19. Firms are actively utilizing cutting-edge technologies such as AI and big data to bridge the offline and online worlds. In turn, digital technologies have been crucial factors improving the resilience of firms and

industries during the pandemic.

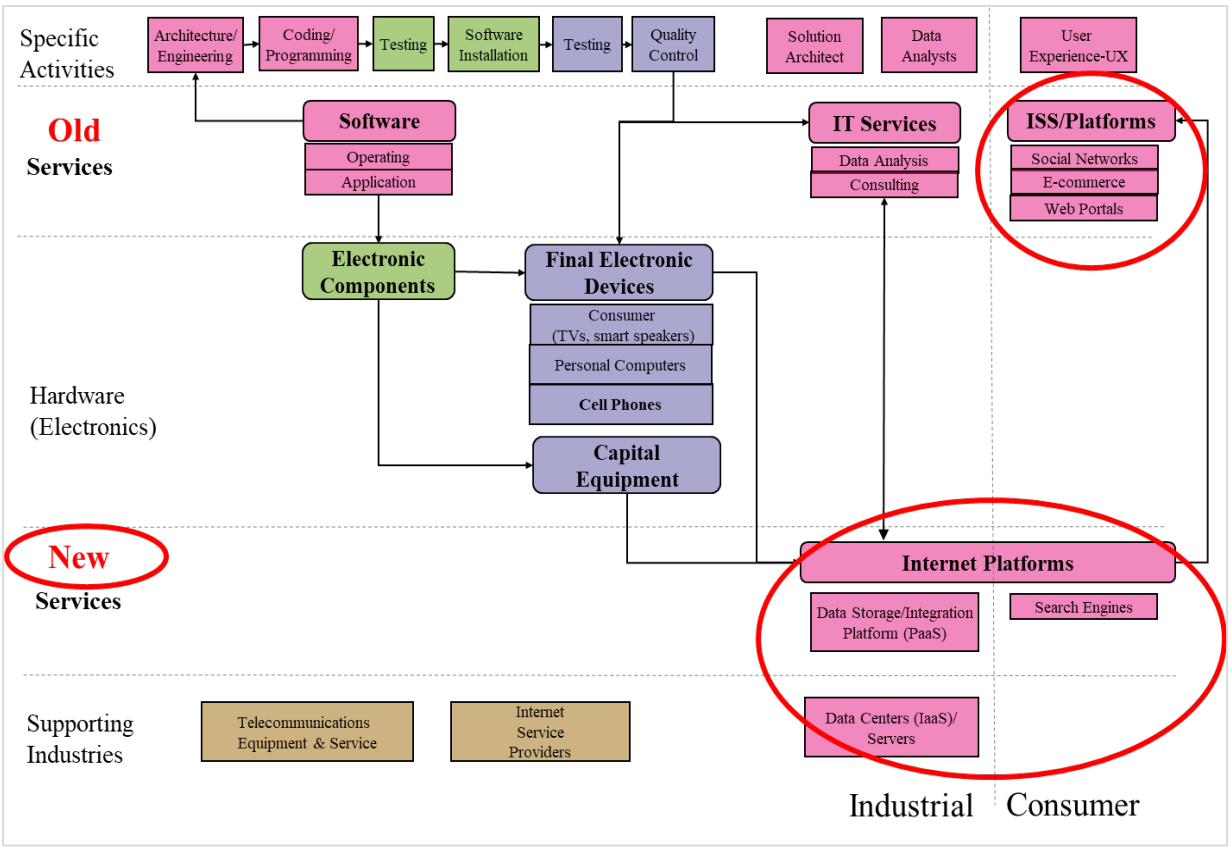
In this section, we will focus on how digital companies are responding to the COVID-19 outbreak. The case studies below illustrate effective corporate responses to the crisis based on their technological competencies. First, we explain how global leading digital companies are coping with COVID-19 and address the collaborative approach they are taking with the greater public. At the industrial level, key service sectors including logistics and distribution and health care (among others) will show how digital companies are engaging in COVID-19 crisis management and utilizing digital technologies and products. Lastly, we will emphasize the key messages and the importance of the role digital companies play in GVCs.

As the pandemic has required firms and industries to rapidly adapt to new ways of doing business in the COVID-19 era, corporate behavior during the crisis has exhibited a great degree of heterogeneity. As mentioned previously, Korean manufacturing firms are by and large not prepared for the paradigm shift brought about by COVID-19. Most firms are struggling to use or introduce digital technologies and the skills of their workforces remain underdeveloped.

The responses of digital companies have been demonstrably superior, owing to their extensive use of advanced technologies. Digital firms employed technologies to adjust their core strategies and daily business activities on the go and have developed and provided essential products and services in the COVID-19 era. Tech companies have supported explosive growth in telecommuting and teleconferencing while online retailers have made lockdown necessities safely available online. In the health care sector, firms deploying digital technologies including AI, telehealth, virtual collaboration and data tracking are stepping up to help mitigate the worst effects of the virus and flatten the curve. This has accompanied skyrocketing growth in the usage of online grocery shopping and communication tools.

The soaring demand for digital technologies and information technologies has led to some notable changes in the IT GVC. Internet platforms and IT-enabled services, including social networks, e-commerce, and web portals have assumed critical roles as new type of service) and are seizing the opportunities that have emerged in the global fight against COVID-19.

Figure 10: Information technology global value chain



Source: Gereffi, Frederick, Bamber & Cho. (2018), KIET-DUKE seminar (2018)

Amid an accelerating digital transformation, adjacent sectors are also seizing opportunities. The Financial Times noted in 2020 that digital-related sectors have exhibited rapid growth during the COVID-19 pandemic. In the midst of international market chaos, digital-related sectors have shown remarkable resilience in posting a net market cap gain of more than one billion USD in 2020. The information technology, communication services, consumer discretionary and healthcare sectors were particularly robust in the global stock market.

Among growth sectors, the IT sector is making the most of its opportunities and building resilience. Global tech giants such as Microsoft, Apple and PayPal have reaped gains alongside newer players such as Zoom Video that have also grown exponentially[9]. Microsoft achieved a 269.9 billion USD market cap in 2020 based on increased usage of its Teams communication app, as telecommuting became the norm. Use of its various cloud platform services also exploded. Apple also demonstrated remarkable sustainability despite severe limitations on offline sales in brick-and-mortar stores. Despite closing about 500 retail stores globally, Apple added 219.1 billion USD to its market cap in 2020, led by robust online sales and efforts to seize

9 *Financial Times* (2020), "Prospering in the pandemic: the top 100 companies," June 6, 2019, https://www.ft.com/content/844ed28c-8074-4856-bde0-20f3bf4cd8f0 (Accessed on: June 23, 2020)

new market opportunities in the expanding digital ecosystem through wearables and digital products. The California giant also released a new iPhone, iMac and MacBook in 2020.

Following the information technology sector, the consumer discretionary sector is another winner in the COVID-19 crisis. Amazon, Tesla, The Home Depot, Audi, and Alibaba have all sustained their positions[10]. Among them, Amazon yielded outstanding growth as a leading global e-commerce firm The Company also provides cloud-computing business essentials for the remote work era.

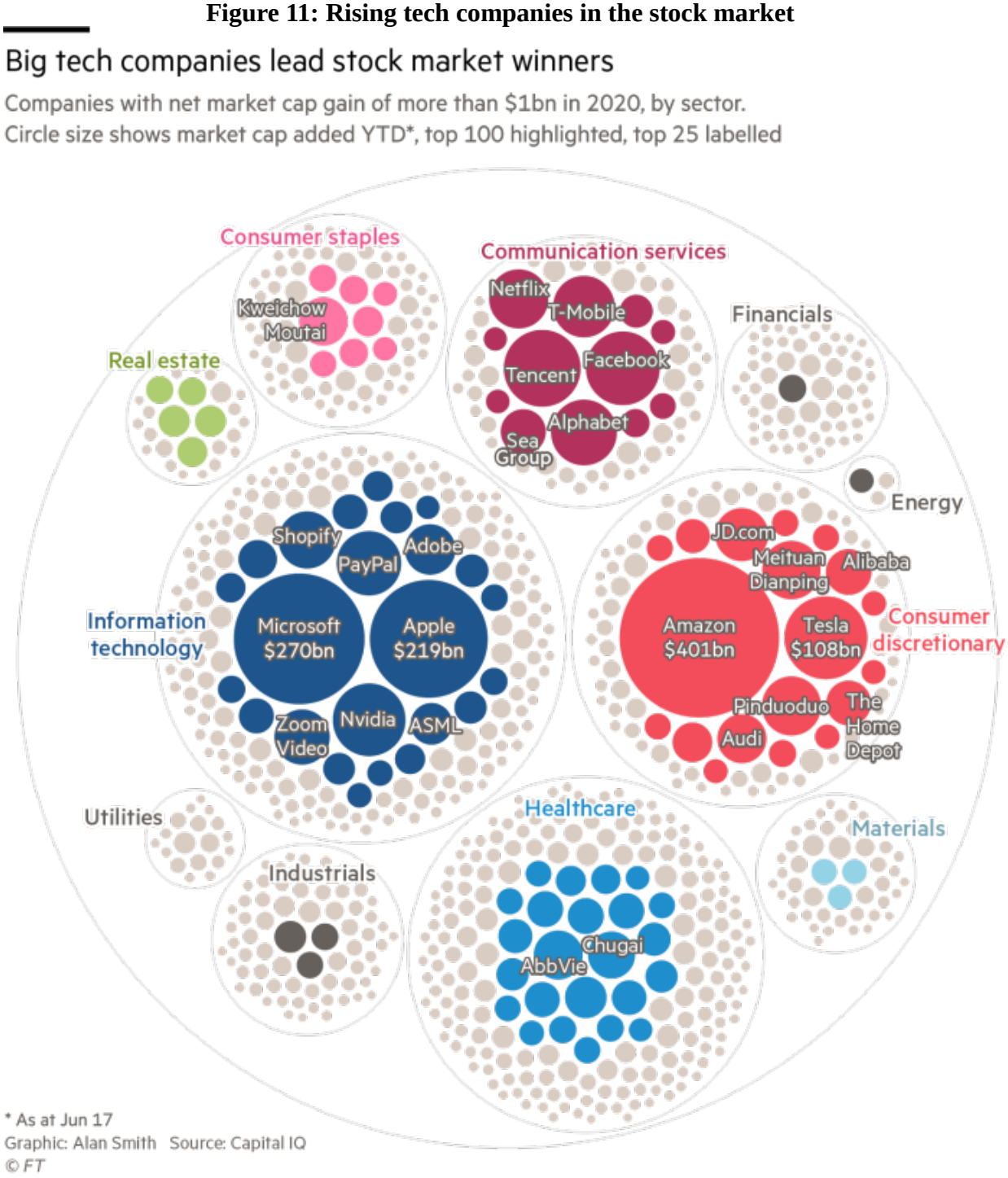
The communication service sectors are also seeing business growth due to changes in the way people spend their leisure time and conduct their daily lives. As people spend more time at home, demand for indoor activities including digital media (including games) is soaring. Firms such as Tencent, Netflix, Facebook, and Google parent company Alphabet are posting large profits by providing products and services supported by soaring ad revenues[11].

It is undeniable that digital technology-related sectors have shown resilience in the crisis. It reflects the crucial role of digital technology and the increasing speed of digitalization driven by COVID-19. In the post-COVID-19 era, both digital companies and the utilization of digital technologies they offer will be essential for adjusting and strengthening the resilience of and mitigating the vulnerability of the global socioeconomic order.

10 *Financial Times* (2020), "Prospering in the pandemic: the top 100 companies," June 6, 2019, https://www.ft.com/content/844ed28c-8074-4856-bde0-20f3bf4cd8f0 (Accessed on: June 23, 2020)

11 Ibid.

Figure 11: Rising tech companies in the stock market



Source: *Financial Times* (2020)

The response of global leading digital companies to the COVID-19 outbreak

Global digital companies are supporting the fight against COVID-19. Well-known firms including Alphabet, Apple, IBM, Amazon, Alibaba and Korean search giant Naver have effectively responded to the crisis, supporting the COVID-19 crisis response in various ways based on their technical strengths.

In a broad sense, they are expanding their domain within ICT GVCs and altering the structure of other sectors' GVCs by providing digitalization tools that are indispensable in the era of COVID-19. International experts, businesses, and governments are making active use of the services provided by these companies in their varied capacities in responding to the pandemic. The leading digital companies are expected to build upon the already-towering barriers to entry in the AI industry market with their ample reserves of capital, globally-competitive technology, human resources and sourcing capabilities and particularly the ease with which they are able to connect new products with those in existing service ecosystems (KISDI, 2020). We can see in this way how COVID-19 is fueling the expansion of existing AI platforms and cloud companies.

The below table summarizes digital companies' technologies used in the COVID-19 crisis response. All of them are digital technologies in active use and now-essential services in daily activities such as remote work, videoconferencing, online education and e-commerce.

Table 3: Global leading digital companies' responses to the COVID-19 outbreak

Company name	Key products and Services	Information
Alphabet	DeepMind	The 'alpha-fold' AI system used in the development of viral treatments
	Kaggle	Crowdsourcing platform
	Google Hangouts	Videoconferencing platform
	G Suite for Education	Online education platform
	Verily	Health care services, devices and R&D
	Exposure notification API (collab w/ Apple)	Base code that powers COVID-19 contact tracing applications using Bluetooth
Amazon	AWS Diagnostic Development Initiative	Initiative for accelerating the development and commercialization of COVID-19 diagnostic solutions
	Amazon Chime	Video conferencing platform
	Amazon Go	Fully-automated brick-and-mortar stores
	Amazon Pharmacy	Online store for purchasing prescription medications
Microsoft	Azure Machine Learning	An open data access portal to improve and update the accuracy of immune response features in real time
	Healthcare Bot service	Service systems for COVID-19 infections asking users health-related questions based on Azure
	MS Teams	Cloud storage, co-editing, chat, and video conferencing services
IBM	Rapid Supplier Connect	A blockchain network helping to address the shortage of PPE and other medical equipment
	IBM Watson and Cognos Analytics-based interactive dashboards	Interactive dashboards designed to analyze and filter local data in more depth
Alibaba	Smart Infectious Robot System	Outbound calls to investigate and prevent infectious diseases
	Alibaba Health	Free online telemedicine services for both citizens and Chinese expatriates living abroad
	Platform	Platform for predictive disease control solutions, CT analysis, COVID-19 genome sequencing, diagnostics, life sciences, high-performance elastic computing solutions and a global communication platform

Source: Author summary of website information

Note: For detailed references, refer to the individual citations below

Alphabet

Google parent company Alphabet provides various services that enable users to continue their daily lives as usual as well as conduct business activities. Among these digital services are DeepMind, Hangouts, and Kaggle. One of the AI systems of DeepMind was programmed to study "alpha-folding," helping researchers to predict the nature of protein structures. This knowledge can be applied in the development of coronavirus treatments. Hangouts is a videoconferencing platform with an intuitive graphical user interface. It is integrated with other core Google productivity software such as Gmail and Calendar.

Alphabet also has a presence in the remote education industry with its freely-distributed G Suite for Education platform. It supports both on-site, school-based learning and learning-from-home, which has helped schools and other educational institutes cope with closures due to COVID-19. Alphabet issues 10,000 user licenses per institution, providing storage capacity through its Drive and Photos cloud storage services with an additional one terabyte of storage per user for organizations with fewer than four members.[12] The online education platform enables teachers to prepare for classes efficiently, communicate with students through the Classroom service and simplify course management.

Amazon

Amazon launched its AWS Diagnostic Development Initiative program through cloud platform affiliate Amazon Web Services (AWS).[13] This initiative aims to accelerate the development and commercialization of COVID-19 diagnostic solutions. It supports large-scale data processing and rapid analysis with advanced cloud platform technology. Amazon also integrates a communication service via AWS called Chime, a video conferencing platform utilizing its Alexa technology.

Unlike other digital companies, Amazon continue to invest in experimental new lines of business during the COVID-19 pandemic. Fully-automated, brick-and-mortar Amazon Go offline stores and an online prescription medication delivery service are among other recent new ventures.

Amazon opened its first Amazon Go outlet in January 2018 well before the onset of the COVID-19 crisis. But following the outbreak of the COVID virus, demand soared. Amazon Go is essentially a supermarket without queues, a time-consuming payment process or even a cashier. The automation technologies that power the Go stores provide consumers with a safe and convenient shopping environment. Key techs include computer vision, sensor fusion and deep learning.

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[12] Google, "Google G Suite for Education Office of Science and Technology Policy, OSTP," https://edu.google.com/products/gsuite-for-education/?modal_active=none (Accessed on: June 23, 2020)

13 Min-soo Kim (2020), "Amazon, support the development of COVID 19 diagnostic methods ...Supercom Open to IBM/MS Vaccine and Treatment Development," *Dong-A Science*, http://dongascience.donga.com/news.php?idx=35357/ (Accessed on: June 23, 2020)

Amid the ongoing COVID-19 crisis, consumers have gone online to meet needs for prescription medication. Amazon's pharmacy business revolves around offerings that help customers conveniently purchase their prescription medications from home. Amazon Pharmacy allows customers to buy prescription medicines through desktop or mobile devices via the Amazon app. With a secure pharmacy profile, customers can input their insurance information, manage prescriptions, and choose payment options before checking out. Prime members receive unlimited, free two-day delivery on orders from Amazon Pharmacy included with their membership.[14]

Microsoft

Microsoft provides an open portal for COVID-19 research and its Healthcare Bot telehealth service. Azure Machine Learning is an open data access portal. It helps to improve the accuracy of immune response features, making real-time data open to all public health officials, researchers, or organizations globally. Healthcare Bot services are used for screening COVID-19 infections by asking users health-related questions via the Azure system. The answers provide information on symptoms, risk factors, and behavioral tips related to COVID-19. Microsoft made these services available to the Centers for Disease Control and Prevention (CDC) in the United States. Like other platform companies, Microsoft also provides an online business platform called Teams, which allows for normal business activities through video conferencing services, co-editing, and cloud storage.

IBM

IBM has launched a blockchain network called Rapid Supplier Connect, a cloud platform that connects buyers with companies that offer COVID-19-related relief supplies based on blockchain technology. To ensure that supplies are efficiently distributed and utilized, the platform identifies excess inventory and displays real-time supply data to help authorities prioritize procurement[15]. The technology helped in alleviating medical equipment shortages as COVID-19 spread by streamlining the procurement system for disease control and medical equipment and simplifying supplier screening through blockchain technology.

IBM also devoted resources to providing information updates through its Watson AI system. IBM channels up-to-date information on COVID-19 through Watson and its suite of data analysis tools, which allow it to gather and collate data from the World Health Organization as well as individual governments. Watson data is provided through the Weather Channel app and site as well as a unique online dashboard. These

14 Amazon, "Introducing Amazon Pharmacy: Prescription Medications Delivered," Press release, https://press.aboutamazon.com/news-releases/news-release-details/introducing-amazon-pharmacy-prescription-medications-delivered (Accessed on: December 3, 2020)

15 Geospatial World, "COVID-19: IBM launches Rapid Supplier Connect to tackle supply chain shock," April 29, 2020, https://www.geospatialworld.net/csr-initiatives/COVID-19-ibm-launches-rapid-supplier-connect-to-tackle-supply-chain-shortage (Accessed on: June 23, 2020)

IBM Watson and Cognos Analytics-based interactive dashboards are designed to allow data scientists, researchers, journalists and members of the public to analyze and filter local data in depth, with substantiated, sourced and curated information[16].

Alibaba[17]

Alibaba developed its Smart Infectious Robot System and actively employed the platform in its COVID-19 response. The Smart Infectious Robot System makes outbound calls to investigate and prevent disease transmission. It also provides disease counseling services. Alibaba uses the platform for projecting disease spread, CT analysis, genome sequencing, COVID-19 diagnostics, high-performance elastic computing and as a global communication tool. Alibaba Group also offers free online telemedicine via its Alibaba Health service to Chinese citizens, having recently expanded the service to make it available to Chinese expatriates living abroad.

Cooperative approach

Digital companies do not act alone. As the earliest isolated cases COVID-19 quickly evolved into a global pandemic, digital companies sought a cooperative approach to combat the COVID virus. Various attempts at cooperation between digital companies and other private firms, the public sector and international organizations are worth noting.

Apple and Alphabet jointly developed a contact-tracing technology. When contact occurs at close range with a confirmed host, information documenting that contact is recorded on each individual's smartphone via Bluetooth. A warning notification is then sent to those who have made secondary contact, once the original case is confirmed[18]. As prohibiting contact is the most crucial tool authorities have in preventing the proliferation of COVID-19, the potential uses of this technology are plain to see.

In addition to instances of bilateral corporate cooperation, some firms launched multilateral consortiums. The COVID-19 High-Performance Computing Consortium is on such organization, led by the Office of Science and Technology Policy (OSTP) and representatives from leading global digital companies such as Amazon, Alphabet, IBM and Microsoft. It launched in late March of 2020.[19] The consortium's primary

16 KISDI (2020), "Artificial Intelligence, Meets COVID-19 - The Present and Future of AI based on the COVID-19 outbreak," 20(4), *AI Trend Watch*.

17 KISDI (2020), "Artificial Intelligence Meets COVID-19: The Present and Future of AI based on the COVID-19 outbreak," 20(4), *AI Trend Watch*.

18 Apple, "Apple and Google Partner on COVID-19 contact tracing technology," Apple Newsroom, April 10, 2020, https://www.apple.com/kr/newsroom/2020/04/apple-and-google-partner-on-covid-19-contact-tracing-technology, (Accessed on: June 25, 2020)

19 Min-soo Kim (2020), "Support the development of Amazon, COVID 19 diagnostics ...Supercom Open to IBM/MS Vaccine and Treatment Development," *Dong-A Science*, http://dongascience.donga.com/news.php?idx=35357 (Accessed on:

goal is to support the development of COVID-19 vaccines and treatments by making supercomputers available to researchers worldwide.

Cooperation also includes public-private partnership initiatives between companies and local governments as well as companies and international organizations such as the OECD. As digital technologies are essential tools for combating and managing the COVID-19 crisis, government and public sector agencies are actively seeking out private sector expertise based on technological competencies.

In Korea's case, major digital outfit Naver and the city of Seongnam agreed to provide a telephone counseling service called Clova Care Call.[20] It uses Naver's proprietary AI system Clova to automatically call and manage COVID-19 monitoring targets twice a day. Those with fever and respiratory symptoms are subject to active monitoring. After phone counseling, relevant data is sent to health center staff in Seongnam City by e-mail to support local governments' monitoring and tracing activities, which also helps alleviate problems occurring due to a lack of on-duty public health personnel in the evening and nighttime hours. This constitutes an example of an effective public-private cooperative COVID-19 response.

OECD launched its Digital for SMEs Initiative (D4SMEs) alongside major digital companies, focusing on the relatively weak infrastructure and competencies of small and medium-sized enterprises (SMEs). OECD selected three large digital companies (Amazon, Facebook and Korean mobile software firm Kakao) as private sector partners for D4SMEs.[21]

Key sectors' responses to digital technologies

Digital companies are actively engaging in three key arenas: health care, logistics and distribution and social sectors that include education and culture. The ongoing shift to a contactless way of life is expected to continue as companies improve their digital competencies, and the above areas are relatively well-integrated cases. The following are suggestions for how digital companies can maintain service quality and productivity in specific areas.

Health care

In COVID-19 crisis management, health care is the most important sector as it is at

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June 23, 2020)

[20] "Seongnam City, Korea's first 'artificial intelligence care call service' in response to COVID 19," *Vision Seongnam*, March 9, 2020, http://snvision.seongnam.go.kr/11788 (Accessed on:: June 23, 2020)

21 Ji-hyun Oh (2020), "OECD partners with Amazon, Facebook, and Kakao," *Seoul Economy*, April 17, 2020. https://www.sedaily.com/NewsVIew/1Z1IE9RGFW (Accessed on: June 23, 2020)

the front line in ending this pandemic. Naturally this has meant that various cutting-edge technologies have been widely adopted and utilized. Among them, AI and robots are broadly used to support preventive measures such as diagnosing infections, monitoring, and social distancing. An observed increase in telemedicine is also notable, as its contactless nature makes it a suitable alternative to face-to-face medical consultation. And critically, contact-tracing technologies have made identifying and tracking positive cases easier for health authorities.

Digital technologies have supported quarantine systems from the beginning (forecasting) to the end (development of treatment) of the viral transmission control process. These technologies have been and are being used to measure body temperature, test patients, deliver food and medicine, provide telemedicine services and optimize medical resource management.

Canadian startup BlueDot warned of the spread of the COVID-19 epidemic on December 31 based on AI and data analysis. Chinese search giant Baidu uses a camera equipped with computer vision and infrared sensors to estimate the body temperatures of people in public spaces. Chinese Taipei firm Advantech builds robots that check body temperatures and whether or not individuals are wearing masks in major Chinese airports and shopping malls. For preventing contact with confirmed carriers of the virus, autonomous service robots and drones are being used to deliver food and medicine.

As an alternative to face-to-face medical services, telemedicine services are also being actively utilized. The Providence Regional Medical Center in Everett, a town in the U.S. state of Washington, utilizes remote a team of medical robots called Vici that allow medical staff to perform remote diagnosis and examinations.[22] Alibaba has also introduced a healthcare platform.

Another area in the health care sector critical to finish the fight against COVID-19 is new drug and vaccine development; many digital firms have actively pursued AI-based researched in related fields. Baidu has developed and collaborated with researchers in predicting the structure of viruses.[23] IBM also facilitates drug research in selecting candidates for treatment with its Supercomputing technology.[24]

Logistics and distribution

Companies in the logistics and distribution sectors are shifting their business strategies to adjust to shifting consumption patterns. To meet rising demand in

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[22] KISDI (2020), "Artificial Intelligence Meets COVID-19: The Present and Future of AI based on the COVID-19 outbreak," 2020(4), *AI Trend Watch*.

23 Ibid.

24 IBM, "The promise of AI and accelerated scientific discovery," July 14, 2010, *Client Success Field Notes*, https://www.ibm.com/blogs/client-voices/ai-accelerated-scientific-discovery/ (Accessed on: July 23, 2020)

contactless consumption and e-commerce, companies have deployed AI technologies and the contactless services empowered by them in various ways.

As contact-free consumption grows due to the influence of COVID-19, the number of retail stores employing customer-facing will decrease. This will be made possible through AI technology. Firms have adopted a so-called “omni-channel” strategy to adjust to huge gaps in online and offline sales, finding ways to minimize personal contact with customers, launching new online sales and expanding online marketing in their business portfolios.[25] E-commerce companies that have introduced AI technologies in logistics operations to aid in ensuring fast deliveries and manage increased quantities have prospered in the COVID-19 era.

As previously observed, Amazon’s contactless Amazon Go offline stores have grown in popularity during the COVID-19 crisis. Similar attempts have prevailed globally. Korean convenience store chain GS25 began automating some of its locations in January 2020. Customers are identified by QR code and smart cameras connected to digital learning networks analyze customer behavior. Weight sensors are used for management and payment is conducted through an AI interface.[26]

In the restaurant and food industry, delivery app services have enjoyed explosive growth due to prohibitions on dining outside the home and reduced operational periods under government curfew. Leading Korean delivery app called Baemin utilizes AI technologies in its delivery distribution system. The AI assigns the most efficient delivery path to orders in consideration of the driver’s movements and food characteristics. The tech is also programmed to filter out fake reviews in real-time; statistics indicate a 70 percent success rate.[27]

25 Myung-rye Choi et al (2020), “COVID19 Response Cases of Global Enterprises and Post-Corona New Strategy,” *Global Market Report*, 20 (17), KOTRA

26 *Financial News*, “GS25, the state-of-the-art AI-based futuristic convenience store has opened,” January 1, 2010, https://www.fnnews.com/news/202001140916335518 (Accessed on: July 2, 2020)

27 *Chosun biz*, "The world's No. 1 delivery app company wanted 'AI know-how' of Bae Min," December 14, 2019, https://biz.chosun.com/site/data/html_dir/2019/12/14/2019121400267.html (Accessed on: August 13, 2020)

Other sectors

Digital technologies play vital roles in other sectors as well. The pace of digitalization has further accelerated in the financial sector; education is also shifting online to cope with the pandemic. And the impact of digital technologies is not just economic. New technologies are also contributing to enhanced efficiency in resource allocation and transparency in the administration of social welfare.

Companies are fueling digitalization in the financial sector by introducing operations based on AI, big data analysis and voice recognition technology. These are typified by the widespread use of kiosks in the wholesale and retail sectors, virtual reality (VR) shopping, and AI chatbots.

The operation of many public facilities has been suspended given social distancing measures, while the education sector is actively trying to maintain a semblance of normalcy using digital companies' various online education platforms. Remote education is replacing the in-person classroom. Cultural performances are also being streamed online. Here too AI, augmented reality (AR) and VR being used to facilitate content production and learning effectiveness.

Finally, as part of the joint response to the COVID-19 crisis, platforms for social contributions are growing that support public participation and collaboration. Digital technologies secure transparency and efficiency in resource allocation and online platforms simplify recruiting by connecting volunteers to the people that need them.

In summary, digital companies are actively responding to COVID-19 using advanced technologies in a variety of areas. Existing platform and cloud computing companies are directly providing solutions as part of coordinated COVID-19 responses or even becoming the focal point of the joint response system. Telecommuting, telemedicine, and online education have become commonplace in the COVID-19 crisis. Even in the post-COVID-19 era, these trends are expected to continue. Therefore, capacity building in high-tech sectors such as AI and big data and keeping up with rapid trends in the digital transformation will be necessary.

IV. Responses to the digital transformation in APEC member economies

Digital enterprises are playing an essential role in responding to COVID-19 and in shaping the digital transformation. As we described in the previous section, digital technology and digital services have made the digitalization of daily social and economic activities possible. To facilitate this process, ICT and digital software are vital.

Although digitalization has accelerated during the pandemic, there is a chasm separating APEC members in terms of digital infrastructure and technological capability. This digital divide is a global issue as it has created an imbalance between economies in the digital development process.

UNCTAD (2019) describes the yawning gulf in digital capacity between developed and developing economies in its *Digital Economy Report 2019*. There is significant observed spatial heterogeneity not only in terms of simple Internet usage but also in the utilization of data and advanced digital technology. To illustrate this point, Africa and Latin America were found to be home to less than five percent of the world's colocation data centers, and just one in five people in LDCs have Internet access, compared to four out of five people in developed economies.

What is noteworthy here is that the digital gap does not reflect the traditional North-South divide. The digital transformation is being led by one developed and one developing economy: the United States and China. These two economies have continued to expand their dominance, together accounting for 50 percent of global spending on IoT, 75 percent of blockchain-related patent applications and more than 75 percent of the global market for public cloud computing (UNCTAD, 2019).

Furthermore, the two economies' technological capabilities are preeminent. Combined, American and Chinese tech firms account for 90 percent of the market capitalization of the world's seven largest digital platforms. The imbalance is enormous; see Europe's mere four percent share and the negligible one percent combined share of Africa and Latin America. The leading digital multinational firms (including Amazon, Apple, Alphabet, Facebook, Alibaba and Tencent, among others) account for two-thirds of the total market value. Most global digital companies are based in either the United States or China, which have the upper hand in developing digital technologies (UNCTAD, 2019).

The gulf between hyper-digitalized economies and economies with weak digital links is an issue of future economic competitiveness. Highly unequal digital development will affect all economies, sectors and stakeholders and a formulating a comprehensive response is critical.

To aid in devising such a response, this section examines the digital infrastructure and capacity of APEC member economies and addresses digital policies. This overview of digital capabilities, which also observes a digital divide within APEC, is intended to shed light on future pathways for digital development in APEC.

4.1 Digital competitiveness of APEC member economies

First, we will look at APEC member economies' digital capabilities based on their IMD World Digital Competitiveness Rankings (WDCR). WDCR is an annually-announced index of the IMD World Competitiveness Center. It measures and ranks capabilities and readiness regarding the adoption and exploration of digital technologies for economic and social transformation in 63 economies.[28] The three Digital Competitiveness Factors measured in this index are knowledge, technology, and future-readiness. Each factor is evaluated through the sub-elements illustrated in the table below

Table 4: Three key factors and sub-elements

Knowledge	Technology	Future-readiness
1.1 Talent	2.1 Regulatory framework	3.1 Adaptive attitudes
1.2 Training & education	2.2 Capital	3.2 Business agility
1.3 Scientific concentration	2.3 Technological framework	3.3 IT integration

Source: IMD World Competitiveness Center (2020), *IMD World Digital Competitiveness Ranking 2020*

The US and Singapore have competed for top billing over the past five years. The US has won and kept the crown since 2018. In 2021, the rise of Hong Kong, China by ranked 2nd and Singapore dropped by 5th from 2nd in 2020. Chinese Taipei and Korea are strong performers in the index among APEC member economies, and Chinese Taipei has climbed the ranks over time. Canada and China are considered ready for the digital transition, both being ranked in the top 15 out of 63[29].

[28] IMD World Competitiveness Center (2020), *IMD World Digital Competitiveness Ranking 2020.*

[29] IMD World Competitiveness Center, IMD World Digital Competitiveness Ranking 2019 and 2021.

Table 5: World Digital Competitiveness Ranking (APEC member economies)

IMD WORLD DIGITAL COMPETITIVENESS RANKING (Overall, 2017-21)

APEC Member economies	2017	2018	2019	2020	2021
United States	3	1	1	1	1
Hong Kong, China	7	11	8	5	2
Singapore	1	2	2	2	5
Chinese Taipei	12	16	13	11	8
Republic of Korea	19	14	10	8	12
Canada	9	8	11	12	13
China	31	30	22	16	15
Australia	15	13	14	15	20
New Zealand	14	19	18	22	23
Malaysia	24	27	26	26	27
Japan	27	22	23	27	28
Thailand	41	39	40	39	38
Chile	40	37	42	41	39
The Russian Federation	42	40	38	43	42
Indonesia	59	62	56	56	53
Mexico	49	51	49	54	56
Peru	62	60	61	55	57
The Philippines	46	56	55	57	58
Viet Nam	-	-	-	-	-
Brunei Darussalam	-	-	-	-	-
Papua New Guinea	-	-	-	-	-

Source: IMD World Competitiveness Center (2020), *IMD World Digital Competitiveness Ranking 2019, 2021*

The United States is particularly strong in two factors: knowledge and future preparation factors. The index also shows that the U.S. possesses the best digital capabilities in education and R&D as of 2020, exhibiting adaptability and business agility with high levels of scientific and technological employment and extensive use of robots as well as ample venture capital in the financial sector.

The IMD index rates Singapore as possessing strong digital capabilities in knowledge and technical factors. The APEC member has a particularly competitive labor force as well as favorable regulatory and technological systems that support it. Its ranking in employment in training and education rose from 28th to 16th, improving its standing in the overall science and technology employment index.

We have seen that American and Chinese digital companies are leading the digital transformation, but some digital capability indicators betray Chinese vulnerabilities.

China's ranking digital competitiveness ranking climbed six places, from 22nd to 16th. This result was achieved through strides made in training (from 19th to 13th), science concentration (from 9th to 2nd), and adaptability (24th to 17th). But China struggles by other measures; its performance in STEM employment, high-tech patent subsidies, e-participation and e-government and market capitalization of IT and media stocks rankings was laggard.

Table 6: Digital Competitiveness Ranking 2020 (Top 10)

		Knowledge	Technology	Future Readiness
1	**United States**	1	7	1
2	**Singapore**	2	1	12
3	Denmark	6	9	1
4	Sweden	4	6	7
5	**Hong Kong, China**	7	2	10
6	Switzerland	3	11	5
7	Netherlands	14	8	4
8	**Republic of Korea**	10	12	3
9	Norway	16	3	6
10	Finland	15	10	9
*****	**APEC member economies**			

Source: IMD World Competitiveness Center (2020), *the IMD World Digital Competitiveness Rankings 2020*

Hong Kong, China and Korea lead APEC member economies in digital competence, with Hong Kong, China maintaining its digital competitiveness primarily owing to its utilization of advanced technology. Hong Kong, China ranked second in the technical framework category, with high-tech exports (manufacturing exports and total export share) and the private sector topping both opportunities and threats. It also ranked second in STEM graduates and second in high-tech patent subsidies.

Historically, many member economies have exhibited strengths in one or two areas and weaknesses in others, but balanced development across the board characterizes Korea's performance. Its best showings were in future preparation factors (third), business agility (third) and adaptability (first). Regarding business agility, Korea has benefited as its corporate executives' management of opportunities and threats has

evolved, as well as from the extensive use of big data and analytics. In terms of adaptability, it ranks first in electronic participation and online retail.

While the US, Singapore, Hong Kong China, Korea and China have strong digital capabilities and Mexico, Peru, Indonesia and the Philippines ranked among the top 10 overall evaluation, the digital capacity gap separating APEC member economies is more like a chasm.

Mexico actually fell, from 49th in 2019 to 54th in 2020, dropping well out of the top ten in the overall ranking. The decline was attributed to a drop in telecommunications investment, the deleterious effects of immigration laws, a lack of measures encouraging students to major in STEM fields and weak public electronic participation.

Peru rose up in the digital ranks in the most recent issue of the index, from 61st to 55th, but still brought up the rear in the overall rankings. Business agility (from 59th to 47th) and capital (from 45th to 37th) indices both improved, while others remained stagnant; its rankings in the number of talented workers (58th), technical framework (59th), and science concentration (59th) did not budge.

Indonesia ranked 56th despite strong future-ready factors through improvements in e-participation (58th to 45th) and Internet retailing (58th to 50th). The Philippines saw its rating sink from 55th to 57th, a decline due to a shrinking talent pool along with weak performance in the training and education sub-factors. Deteriorating performance in the sector is due primarily to the APEC member's difficulty in attracting highly skilled personnel from overseas, with a resulting shortage of senior managers with international experience.

Table 7: Digital Competitiveness Ranking 2020 (Bottom 10)

		Knowledge	Technology	Future Readiness
54	**Mexico**	52	56	52
55	**Peru**	55	58	55
56	**Indonesia**	63	54	48
57	**The Philippines**	62	53	54
58	Ukraine	38	59	61
59	Argentina	50	62	47
60	South Africa	60	55	57
61	Colombia	59	61	50
62	Mongolia	58	60	59
63	Venezuela	61	63	63

* **APEC member economies**

Source: IMD World Competitiveness Center (2020), *the IMD World Digital Competitiveness Ranking 2020*

The use of ICT is a crucial way to overcome some of the pandemic's obstacles and alleviate its many inconveniences. Furthermore, digital infrastructure such as ICT technology is essential to enable active participation in online activities that are instrumental in limiting person-to-person contact and thus mitigating the spread of COVID-19 and but also critical components of rapid digital change occurring at large. Without a foundation in digital infrastructure and digital software, participating in the digital economy and digital society is difficult. Therefore, bridging the gap between APEC member economies in digital capabilities and infrastructure is critical to strengthening competitiveness.

4.2 Digital policies in APEC member economies

As the usage of digital technology in daily life intensifies and proliferates amid the pandemic, adept utilization of it is becoming more and more crucial to strengthening competitiveness. Knowledge creation and human resources development combined with an effective regulatory regime and robust infrastructure play a central role in enhancing and maintaining digital competitiveness (ITU, 2020). In addition, corporate and individual flexibility and rapid adaptability in the digital environment will serve as the foundation for future development in digital-savvy member economies. In responding to the COVID-19 crisis, some APEC members have already recognized that digital flexibility is critical to addressing economic and social problems and have upped their investments while promulgating new policies.

Amid expanding telework and e-commerce, the COVID-19 outbreak has fertilized the economic soil for digital companies. Internet-based and bandwidth-intensive activities have fueled demand for low-latency connectivity, and governments have shifted focus to deploying AI and 5G technologies.

Digital-related agenda and policies

To counter COVID-19, a number of major economies (the United States, China, EU members, Japan, India, and Indonesia) have tapped their treasuries to inject large amounts of cash into the economy. Some economies are linking mid-to-long-term policy goals in consideration of industrial synergies, rather than brute-force economic stimulus measures that focus on direct support for low-income families and reviving the economy.

Major strategies differ to some degree, but most emphasize the digital acceleration. These measures aim to speed up infrastructure development and introduce policies to support increased use of 5G and AI.

In an examination of significant agenda items announced by APEC member economies, we see that policies prioritizing digitalization are being promoted and implemented. The major policies of the United States, China, Japan and Indonesia are as follows.

The United States is pushing ahead with policies focusing on continuous deregulation through executive orders. These orders aim to rebuild the US supply chain, with a top priority on reviving manufacturing. The federal government is also promoting a digital sector strategy: a kind of digital offset that seeks to maintain United States digital superiority over China.[30]

In China, the digital transformation and green growth are the main foci. Its core policies aim for a transition to productive, innovative and high-tech research and industrial convergence. It is also striving to lay the foundation for green growth in consumption, production, distribution and finance.31

The government of Japan promulgated a policy agenda in the COVID-19 pandemic carrying the tagline With COVID (New Daily Life), which aimed to bolster the spread of digitalization by introducing digital administration and smart city technologies in municipal governments, as well as promoting teleworking and education ICT[32].

Finally, Indonesia also appears to be pushing ahead with policies to promote manufacturing innovation. These include policies to enhance digitalization in five major industries and relax regulations on foreign investment and incentives, all for the purpose of cultivating manufacturing innovation[33].

As described above, many APEC member economies are striving to enhance their infrastructure and digital technology capabilities to both adapt to and prosper in the digital transformation and cope with the COVID-19 crisis. However, there are differences in the speed and scope of policy implementation between member economies, so it is still essential that the gap in digital capabilities be narrowed.

APEC members' technology policies

The main priorities of each APEC member economy, taken collectively, constitute a broad vision of digitalization, but each economy is also implementing targeted, technology-specific policies. These sub-policies are directed toward AI, 5G, blockchain and quantum computing technologies, within larger frameworks. Policy supports for enhancing the use and spread of AI and 5G technologies are particularly prominent.

Some APEC members' central governments have developed AI strategies. These economies see AI as a core technology in the digital transformation and also as a

[30] KIET (2020), "America's industrial policy outlook and response - the case for Trump's re-election," Vol. 96, *i-KIET.*

[31] Yong-min Choi et al (2020), "WITH COVID-19, National Agenda and Economic Innovation Strategies of Major Countries," Trade Focus, 20 (32), KITA.

32 Ibid.

33 Ibid.

weapon for combating COVID-19. AI-related policies cast a wide net, targeting fields including R&D, AI adoption, AI skills, and AI systems development. Some governments have established bodies dedicated to coordinating and observing implementation of AI strategies at the regional level. Governments are also encouraging the adoption of AI in the public sector, setting guidelines for ethical AI behavior and conducting foresight and impact assessments for the various technologies. Governments have recognized AI-related risks and social issues, addressing ethical concerns through the adoption of binding legislation in high-risk AI applications such as autonomous aircraft systems.

An OECD report from 2020 also shows how some APEC member economies have developed 5G strategies, facilitating data sharing within the private sector and establishing open innovation centers to promote 5G development. These policies have been accompanied by blockchain strategies and funding for quantum computing R&D. The report also notes the participation of digital security agencies in the COVID-19 crisis response.

Table 8: Digital strategies and policies in major APEC member economies

Digital strategies and policies	Participating member
AI strategies	
- AI-related research and development (R&D)	United States, Canada
- AI adoption	Korea, Canada
- AI skills	Australia, U.S, Canada
- Developing AI systems	United States
- Establishing dedicated bodies to coordinate implementation of AI strategy	United States, Canada
- Establishing AI observatories at the regional level	Canada(Quebec)
- Encouraging adoption of AI in the public sector	Korea
- Introducing guidelines for trustworthy AI	Australia - AI Ethics Framework Japan - AI R&D Guidelines and AI Utilization Guidelines Singapore - Model AI Governance Framework Canada - Directive on Automated Decision-Making
- Conducting technology foresight and impact assessment	United States, Canada
- Addressing ethical issues	Singapore, New Zealand
- Adopting binding legislation for areas of AI applications deemed high risk	United States - unmanned aircraft systems
Developing 5G strategies	United States, Australia, Korea
Facilitating data sharing within the private sector	Australia, Japan, Singapore, U.S, Canada
Establishing open innovation centers	Australia
Blockchain strategy	Australia; China
Quantum computing R&D funding	United States; China
Digital security agencies' COVID-19 crisis response	United States; Canada

Source: Author summary of policies suggested OECD (2020), *Digital Economy Outlook 2020*

The scope of policy implementation varies by member economy. The United States is most actively formulating strategies and policies for various technologies, while Singapore, Australia, Canada, Korea, China and Japan are also pushing strategies and support programs at the domestic and local levels.[34]

United States

The United States has developed and promulgated an ambitious set of goals designed to maintain global leadership in digital technology. The American AI strategy addresses AI R&D, AI skills and AI systems, with dedicated bodies to coordinate and supervise its implementation and promote the use of AI in conducting technology foresight and impact assessments. With regards to high-risk AI applications, the United States has enacted laws governing the use of autonomous aerial vehicles. The American strategy is not limited to AI, however, with policies pursuing 5G, quantum computing and private sector data sharing goals having been implemented. The United States has also deployed its digital security agencies to increase the effectiveness of its crisis management.

Australia

Australia has announced issued a wide variety of digital policies. It has made efforts to develop AI skills and has introduced an AI ethics framework consisting of guidelines for building moral AI systems. Australia has also announced 5G and blockchain strategies. It has also made strides in enhancing the base of technology utilization by establishing open innovation centers and facilitating data sharing within the private sector.

Canada

In 2017 Canada established the Pan-Canadian AI Strategy which funds AI R&D and promotes and secures AI skills and talent among other AI priorities for Canada, with CIFAR serving as the functional committee selected to coordinate its implementation. In 2021, the Government of Canada announced the next phase of the Pan-Canadian AI Strategy, with over CAD $443 million to renew support for academic talent and research, support the commercialization and adoption of AI, provide dedicated computing capacity for AI researchers, and further develop AI standards. Provincial governments are also active supporters of talent development, research and innovation, and investment in AI, with provinces such as Quebec establishing AI observatories at the provincial level. Canada is also conducting impact assessments on AI supporting federal government service delivery through the Algorithmic Impact Assessment (AIA) tool. CIFAR and the NRC, among other government and research institutions, are playing critical roles in Canada's COVID-19 crisis response, including through funding AI-assisted diagnosis of COVID-19 research.

[34] Descriptions of policies are based on OECD (2020a), *OECD Digital Economy Outlook 2020*, OECD Publishing, Paris, https://doi.org/10.1787/bb167041-en.

Korea

Korea established an AI strategy to facilitate its adoption, with a salient feature of the Korean strategy being the central government's encouragement of AI adoption in the public as well as the private sector. As a leading 5G economy, the Korean government has also launched 5G strategies.

Singapore

Singapore introduced guidelines for AI ethics, the Model AI Governance Framework. The Singaporean government has also addressed ethical issues related to digitalization, focusing on the facilitation of data sharing within the private sector.

Japan

Japan's guidelines for AI sectors are considerably detailed, often involving the R&D sector as well. The Japanese government has suggested AI R&D guidelines and AI utilization guidelines to promote the development of ethical AI systems. Japan has also made efforts to facilitate data sharing in the private sector.

China

China is more focused on blockchain and quantum computing technologies. The Chinese government has devised a blockchain strategy and has allocated funding for quantum computing R&D.

In this section, we explored the digital competitiveness of APEC member economies and their digitalization policies. The COVID-19 pandemic has accelerated and intensified all aspects of the digital transformation as governments and enterprises respond rapidly using AI and other technologies. Effective results are being observed in the AI sector in particular. The government is implementing various policies to use AI technology to predict and monitor the spread of disease and to provide medical diagnoses and accurate real-time information. (OECD, 2020). Currently, companies and governments are hoping to bring an end to COVID-19 pandemic through deliberate convergence of various advanced technologies in the development and distribution of vaccines and treatments.

Some APEC member economies such as the United States and Singapore possess outstanding competencies in the rapid shift toward the digital transformation. The United States has exceptional digital readiness at the aggregate and firm levels and its global digital leadership is expected to strengthen as the digisphere expands.

As digital technology grows in importance, accelerating the transition to a digital economy, the power of an economy with technological competitiveness is expected to increase in tandem. Therefore, discrepancies between an APEC member economy's digital technology base and its capacity for building technological competitiveness will be resolved at the APEC level in the future. This the single most critical issue in corporate and competitiveness.

With the COVID-19 crisis, APEC member economies are beginning to recognize the need for a comprehensive approach to the digital transformation. Given the economic shocks of the pandemic have matched its impacts on public health, economies are dedicating increasingly more political capital to digital industries.

Amid a prolonged epidemic, digitalization has become an essential element in social and economic activities. And as the long-term effects of the promotion of rapid digitalization are set to be felt for the foreseeable future, now is the time to formulate a plan to strengthen competitiveness in the post-COVID-19 era and to build a digital economic environment at the APEC level. In the next chapter, we will explore ways to strengthen the interregional digital capabilities of APEC.

V. Conclusion

The emergence of new technologies and the rise of global digital companies utilizing them marks the beginning of a full-fledged digital transformation within GVCs. The ongoing COVID-19 pandemic is expected to accelerate the digital transformation by spurring demand for new non-contact technologies in production and consumption. Mature APEC member economies centered on manufacturing are among those that have suffered during the pandemic. Thus, the acceleration of the digital transformation, which is projected to continue following the conclusion of the COVID-19 crisis, must be considered to ensure continued shared prosperity among APEC member economies.

This study examined megatrends and critical issues of the digital transformation in GVCs, which is broadly divided into and associated with ICT sectors. The main drivers behind the digital transformation of GVCs are global digital enterprises offering digital products and services. These companies lead the digital transformation of GVCs by providing epochal products and services. Incumbent firms meanwhile are increasingly utilizing advanced new 4IR technologies. These companies expect to expand their influence in GVC as pandemic response strategies spark demand for untact products and services.

Despite the general expectation that COVID-19 will accelerate the digital transformation at some firms, it may also hinder ordinary companies' digital preparations. While quarantine and prevention measures have increased the need for a digital transformation, the global economic shock of the pandemic has magnified and exposed uncertainties and risks, keeping many firms from executing preparatory digital strategies for the economy of the future. A survey of Korean manufacturing firms showed a moderate increase in non-face-to-face activities at large companies, partly attributable to the COVID-19 pandemic. Yet the majority of firms were found to have little room to consider global trends in digital transformation as they prioritized coping with the economic fallout and financial risks of the pandemic. Small and medium-sized enterprises in particular were more likely to suffer existentially from the economic pain caused by spread of the novel coronavirus.

While the pandemic dealt a blow to SMEs and many firms in manufacturing industries, digital companies have thrived in the COVID-19 crisis. Digital firms are building and marketing technology products for use in the healthcare, logistics, distribution, education and financial sectors, where demand for contactless products has soared. The outstanding pandemic performance of digital companies suggests that they can continue to create new links in GVCs well after the crisis has passed.

On the other hand, however, the trend of fast-growing digital companies in existing GVCs strengthening fortifying their market positions is likely to continue unabated, further skewing the balance of power between digital and non-digital companies in the pursuit of growth through the digital transformation in the post-COVID-19 era.

Given the importance of the relevant infrastructure to the transformation of the digital economy, widening gaps in digital infrastructure among APEC member

economies must be narrowed and a digital-friendly legal foundation laid to enable future growth through GVCs. The establishment of ICT infrastructure, the backbone of all digital industries, is essential to enabling the emergence of new digital industries and the provision of new digital goods and services. It is critical that all APEC member economies participate in digital GVCs to achieve shared prosperity in the digital transformation. Member economies must build infrastructure that can give birth to digital businesses and reinforce digital links. It is thus disconcerting that this study has observed the presence of an ever-widening gap in digital capabilities and readiness between developed and developing APEC member economies.

The findings of this study carry the following implications for both overcoming COVID-19 and preparing for the digital transformation:

Sharing best COVID-19 response practices through digital enterprises

Despite constraints on existing consumption and production methods due to the ongoing COVID-19 pandemic, the production and consumption of digital goods and services using new technologies is expanding. The effective responses to the pandemic of digital firms provide a playbook for navigating a major crisis through the use of digital technology. Notable are the low variable costs incurred by global digital enterprises in the provision of their products. An implication of this being that member economies can share solutions to overcome COVID-19 by utilizing digital enterprises' products and services at minimal additional cost.

It is also necessary to augment the virtuous cycle of delivering more advanced new products and services. The latest products and services by digital companies in response to the pandemic are based on new ideas that combine and utilize existing digital technologies. The best practices of digital companies in response to the emergent COVID-19 situation identified in this report, if shared among APEC member economies, can help those members lead the full-fledged digital transformations of APEC member economies' GVCs going forward.

Narrow the digital infrastructure gap separating APEC member economies

For the APEC economy's ongoing co-prosperity through GVCs, building a digital infrastructure to serve as a breeding ground for new businesses in the digital transformation is essential. While the immediate benefits of digital infrastructure are lost on members whose participation in GVCs is already limited, in a mature global economic environment, one member's participation in a GVC can extend those benefits to all other economies linked through the chain. However, given inequalities in digital infrastructure levels currently observed among APEC member economies, limited participation in digital GVCs in developing economies with weak digital infrastructure is expected. Thus it is of the utmost importance that efforts to narrow the digital gap among APEC member economies be made to maximize prosperity through GVCs amid the digital transformation of the greater APEC economy in the future.

Gaps in the quality and quantity of digital infrastructure between firms must also be addressed. As observed in this study, the economic impact of COVID-19 has made it difficult for SMEs to invest in and prepare for the digital transformation. As a result, despite evidence that the COVID-19 pandemic will accelerate the digital transformation, the degree of heterogeneity in corporate digital capabilities is expected to grow. Especially for digital companies, their infrastructure gap with non-digital firms and small businesses will also have to be considered as they expand during the COVID-19 era.

APEC conventions for digital companies to promote the digital transformation

Best practices for overcoming the COVID-19 crisis and anticipating the digital transformation are not exclusive to specific digital enterprises. Participation and cooperation from various partners are essential in the process of creating new businesses through new technologies. In addition to digital service firms, the digital transformation led by actual digital companies requires building knowledge through cooperation with universities, research institutes and government agencies, and the expertise of the private sector is required during the commercialization phase. Experts from multiple APEC member economies must work together to find solutions to promoting the digital transformation across a bloc whose members have taken multivariate approaches to regulating the digital economy in order to solve real-world problems through technology.

Such a convention should include representatives from private industry, governments, and academia and facilitate innovation activities centered the digital transformation in APEC, ultimately encouraging shared prosperity throughout the bloc. Through the Consortium, APEC member economies should define the practical problems related to the digital transformation, explore the application of combinations of new technologies to solve them, promote experimentation and share best practices to make those solutions a reality.

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