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Promoting the diffusion of technology to boost productivity and well-being in Korea

Mathilde Pak

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PROMOTING THE DIFFUSION OF TECHNOLOGY TO BOOST PRODUCTIVITY AND WELL-BEING IN KOREA

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Abstract/Résumé

Promoting the diffusion of technology to boost productivity and well-being in Korea

Korea is a top player in emerging digital technologies, with an outstanding digital infrastructure and a dynamic ICT sector. The COVID-19 outbreak highlighted the importance of digitalisation to contain the spread of the virus, by allowing quick testing and tracing of infected people, and spurred the development of the "untact economy". Remote access both facilitated physical distancing and mitigated the economic impact of the crisis by enabling more people to continue working. Digital technologies offer opportunities to raise firms' productivity and the population's well-being. However, wide productivity gaps between large firms and SMEs and between manufacturing and services weigh on economy-wide productivity, which is far below the OECD average. A wide skills gap between youth and older generations prevents an increasing share of the population from taking part in and enjoying the benefits from a digitalised economy. This paper suggests ways to narrow the digital divide by enhancing the diffusion of digital technologies among firms and among individuals. Increased participation in quality ICT education and training for students, teachers, SME workers and older people is key to address the lack of adequate skills and awareness of digital benefits or dangers (online security, cyberbullying, addiction). Promoting innovation networks between SMEs, academia and large firms through vouchers or platforms can support SMEs' R&D and commercialisation of innovative goods and services. Waiving stringent regulations through regulatory sandboxes can help identify and alter regulations that hinder the adoption and diffusion of digital technologies.

This Working Paper relates to the 2020 OECD Economic Survey of Korea (http://www.oecd.org/economy/korea-economic-snapshot/)

JEL classification: I31; J24; L25; L51; O3.

Keywords: Korea, digital divide, productivity, well-being, SMEs, regulatory sandboxes, COVID-19.

Promouvoir la diffusion technologique pour stimuler la productivité et le bien-être en Corée

La Corée est une référence dans le domaine des nouvelles technologies numériques, avec une infrastructure numérique exceptionnelle et un secteur TIC dynamique. L'épidémie du COVID-19 a mis en avant l'importance de la numérisation pour contenir la propagation du virus, en permettant de tester et retrouver rapidement les personnes contaminées, et a favorisé l'essor de « l'économie sans contact ». L'accès à distance a facilité la distanciation physique et a limité l'impact économique de la crise en permettant à davantage de personnes de continuer à travailler. Les technologies numériques offrent des opportunités pour augmenter la productivité des entreprises et le bien-être de la population. Cependant, des écarts importants de productivités entre les grandes entreprises et les PME et entre le manufacturier et les services pèsent sur la productivité globale qui est bien en-deçà à la moyenne OCDE. Un écart considérable de qualifications entre les jeunes et les générations précédentes empêche une part croissante de la population de participer à et profiter des avantages d'une économie numérisée. Ce papier propose des solutions pour réduire la fracture numérique en stimulant la diffusion des technologies numériques entre les entreprises et entre les individus. Il est important de d'augmenter la participation à une éducation et une formation de qualité en TIC pour les étudiants, les enseignants, les travailleurs dans les PME et les personnes âgées, afin remédier à l'insuffisance de qualifications adéquates et de prise de conscience des avantages du numérique ou de ses dangers (sécurité en ligne, harcèlement en ligne, addiction). Promouvoir des réseaux d'innovation entre PME, le monde académique et les grandes entreprises grâce à des bons ou des plateformes peut soutenir la R&D des PME et la commercialisation de leurs produits et services innovants. Renoncer à des régulations contraignantes grâce à des sandboxes réglementaires peut contribuer à identifier et modifier les régulations qui empêchent l'adoption et la diffusion des technologies numériques.

Ce Document de travail a trait à l'Étude économique de l'OCDE de la Corée, 2020 (http://www.oecd.org/fr/economie/coree-en-un-coup-d-oeil/).

Classification JEL : I31 ; J24 ; L25 ; L51 ; O3.

Mots clés : Corée, fracture numérique, productivité, bien-être, PME, sandboxes réglementaires, COVID-19.

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Promoting the diffusion of technology to boost productivity and well-being in Korea

By Mathilde Pak[1]

Rapid diffusion of technology is key to supporting productivity growth and raising well-being standards in the context of a rapidly ageing population and a weakening trend in global growth. The COVID-19 outbreak is also strengthening the existing trend towards digitalisation, with a growing use of artificial intelligence and remote services by firms and households (Box 1). While Korea has made tremendous economic progress over the past decades, its productivity remains below the OECD average. This largely reflects gaps between large firms and SMEs and between industry and services. Productivity gaps are mirrored by wage inequality, which is among the highest in the OECD, and more broadly by differences in working conditions and levels of social protection among different categories of workers (OECD, 2021). Digitalisation offers huge opportunities to raise productivity economy-wide and to tackle inequality, but widespread diffusion requires adequate policies, notably to enhance skills, adapt regulations, create networks for technology diffusion and innovation, and ensure cybersecurity.

Korea is a frontrunner in digital technologies and one of the top five contributors to the development of emerging digital technologies. Over 2013-16, Korea accounted for 4 to 46% of global patenting in fast-growing information and communication technology (ICT) fields (Figure 1). The digital infrastructure is also outstanding. Access to high-speed internet is almost generalised and 5G was introduced nationwide earlier than in any other country in the world. More than a year after 5G services' commercial introduction on 3 April 2019, the number of subscribers had reached over 10 million in December 2020, with high fibre-backhaul availability enabling fast adoption (OECD, 2019a). Korea's density of broadband fibre subscriptions is the highest OECD-wide (Figure 4).

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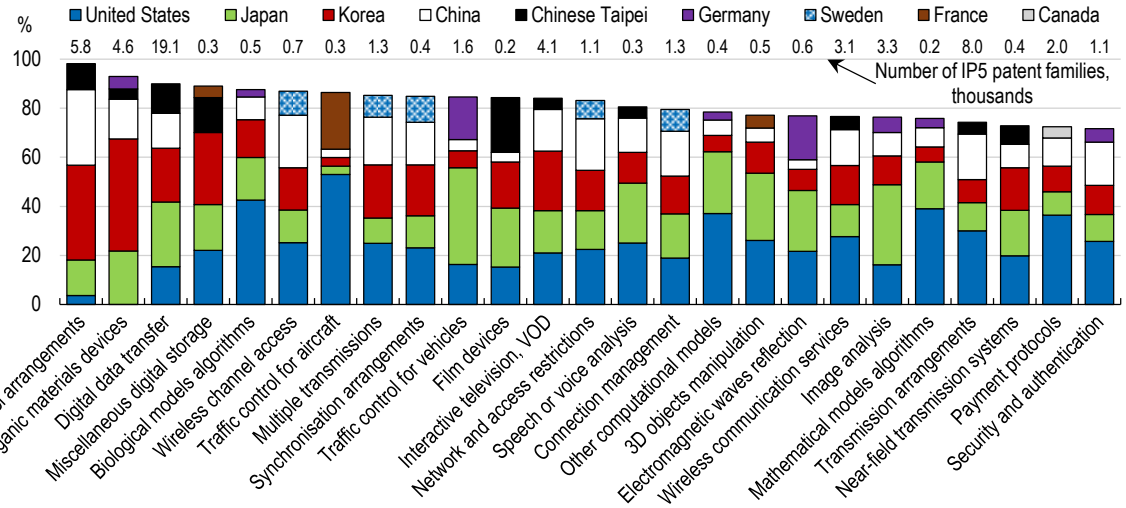
Figure 1. Korea is one of the top players in emerging digital technologies

Share of top five economies' patents in top 25 technologies fast accelerating from 2010 onwards, 2013-16



Note: IP5 denotes the five largest intellectual property offices worldwide (European Patent Office, Japan Patent Office, Korean Intellectual Property Office, National Intellectual Property Administration of People's Republic of China and United States Patent and Trademark Office). Fast-accelerating ICT fields are defined as technology fields where substantial increases in the number of patents are observed.
Source: OECD (2019b), calculations based on STI Micro-data Lab: Intellectual Property Database.

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Box 1. Use of digitalisation to tackle COVID-19

Korea has been leveraging various digital tools to contain COVID-19 without shutting down the economy, by quickly testing and tracing infected people and facilitating a contact-free lifestyle.

Artificial intelligence and fast testing

Artificial intelligence (AI) contributes to significantly shorten research-to-market cycles and improve diagnosis efficiency. A famous example is the Seegene COVID-19 test kit: an AI-based big data system was used to develop this test within two weeks, instead of two to three months had it been done manually. VUNO developed AI techniques used by public health centres and hospitals to quickly identify patients requiring intensive care by reading lung X-rays within seconds.

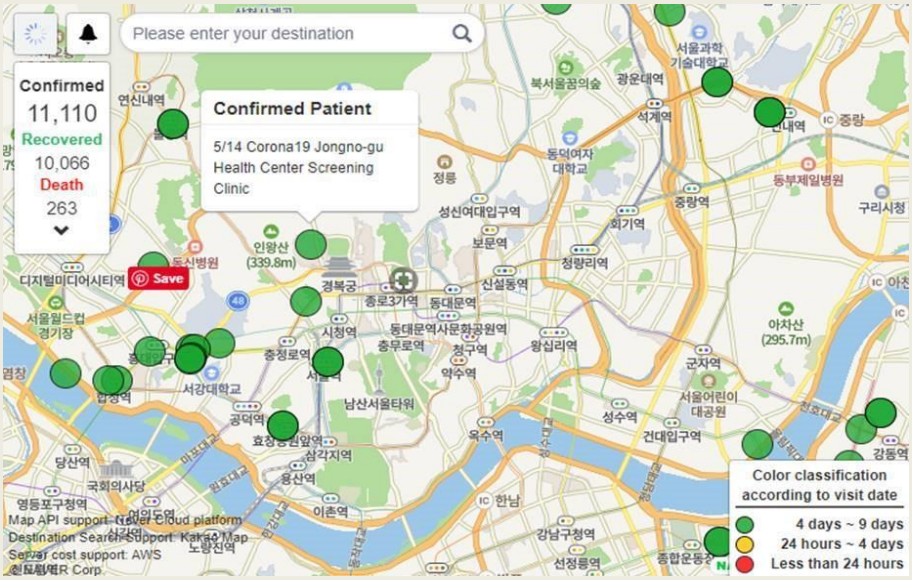
Mobile apps and transparent information

Several mobile apps have been developed since the outbreak of COVID-19 to inform and advise the public in real time. Korea Spatial Information & Community developed a map service to direct people with COVID-19 symptoms to the nearest testing stations, using a geographic information system. Inbound travellers are required to install an app on their smartphone to submit a daily self-diagnosis for 14 days and check the location of screening clinics.

Naver, Kakao and other software developers use data provided by pharmacies to share information on the sales and inventories of publicly-supplied filtering respirators within their respective map apps. 22 000 out of Korea's 23 000 pharmacies have agreed to share their data. This helps reducing crowding at pharmacies and ensuring physical distancing.

Apps like Corona 100m or Corona Map plot locations visited by patients diagnosed with COVID-19 (Figure 2). In the case of Corona 100m, information such as age, gender and nationality, is also made available, which raises privacy concerns. Other privacy concerns involve the potential use of wristbands connected to a mobile app and alerting the authorities in case of self-quarantine violations.

Figure 2. Corona Map App plots locations with confirmed cases of COVID-19



Source: https://coronamap.site

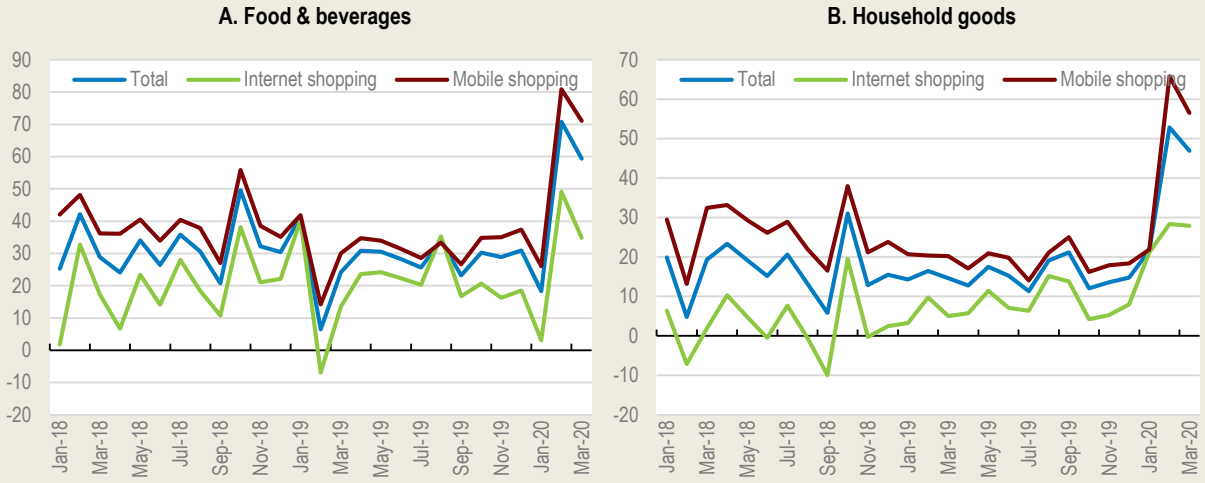
Remote services and untact lifestyle

The COVID-19 outbreak has led to the emergence of a new lifestyle with less physical contact to limit the spread of the virus. Many firms have allowed their employees to work from home, while schools have started online classes in April. In both cases, a continuous internet connection and reinforced cybersecurity are key to ensure the proper functioning of remote work and videoconferences. For students, it also implies the need to have easy access to a digital device and, for the younger ones, adult assistance, to complete studies at home. For teachers who are still inexperienced in holding classes online and often lack digital skills, it requires specific training.

Households have increasingly turned to e-commerce for their daily purchases. In March 2020, year-on-year online purchases of food and beverages and household goods were up respectively by 59% and 47%, after a year-on-year surges of 71% and 53% in February (Figure 3). AI robots are allowed to deliver food and parcels in the Magok and Gangseo districts of Seoul, thanks to a regulatory sandbox.

Figure 3. Households turned to e-commerce during the COVID-19 outbreak

Year-on-year changes, %



Source: KOSIS.

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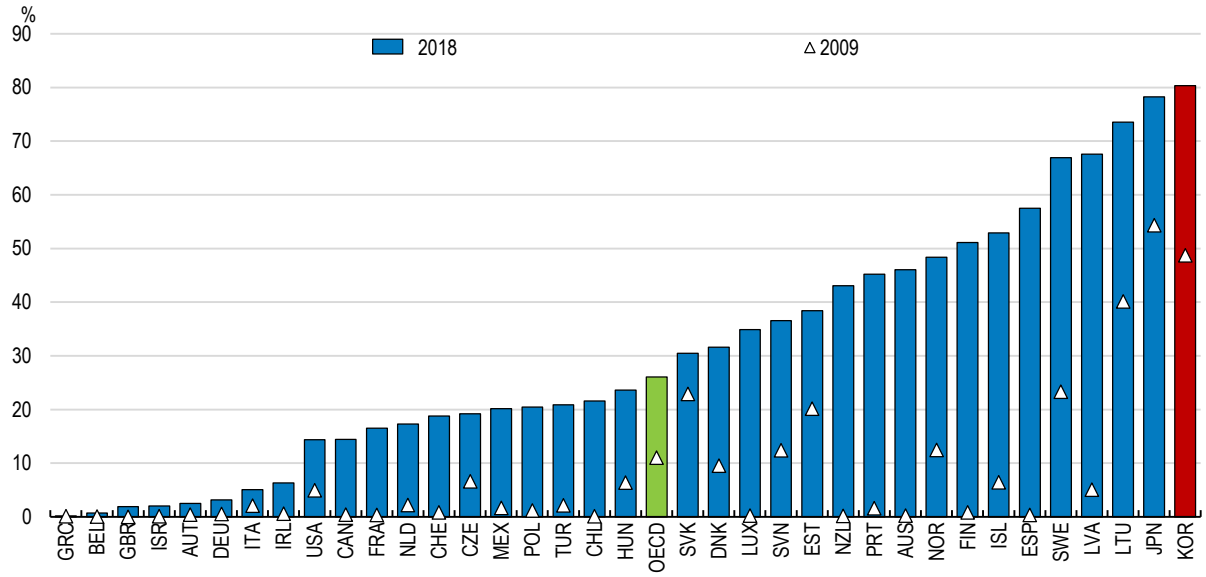
Healthcare services also went through important changes, especially in the case of telemedicine. Since the end of February, doctors are temporarily allowed to treat patients with mild symptoms on the phone. Other ways of being informed on COVID-19 while avoiding physical contact involve AI robots. Wisenut developed a public chatting robot that informs people on ways to prevent and respond to COVID-19, while Naver developed an AI-based voice robot that automatically calls people needing attention, inquires about their health condition and then informs the public health centre.

Source: ITU (2020); Tonby et al. (2020).

Figure 4. High-speed broadband is widespread in Korea

Percentage of fibre connections in total fixed broadband



Note: 2010 for Canada, Turkey and United Kingdom instead of 2009.
Source: OECD Broadband Database.

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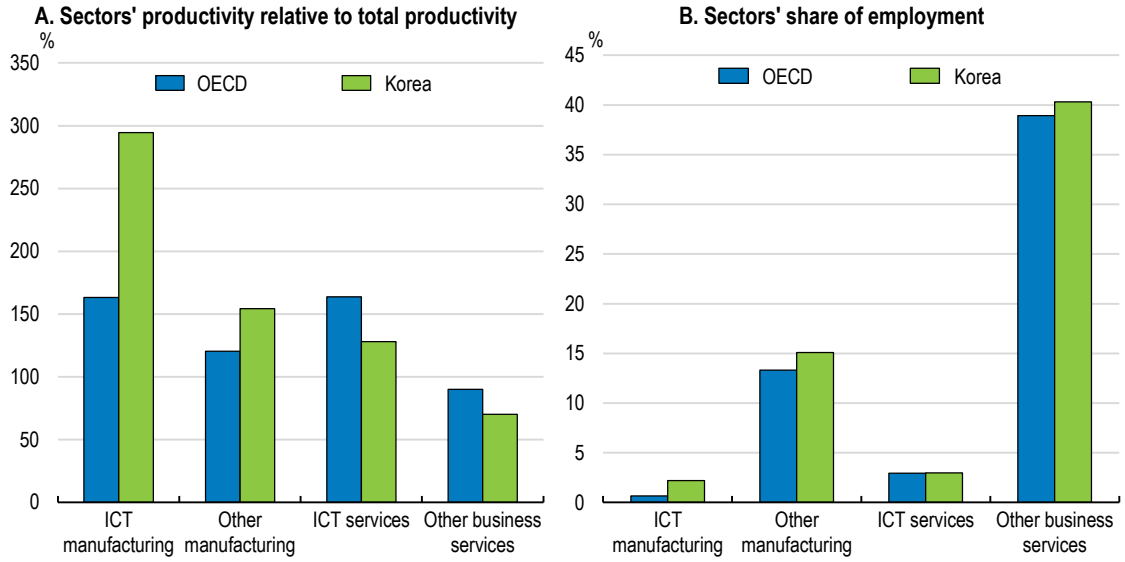
The government's plan for innovative growth focusses on digital opportunities raised by the use of 5G, which brings three key advantages. First, its higher speed allows the transmission of large volumes of data, for instance for virtual reality TV or hologramme calls. Second, its lower latency allows instant response, for example for automatic and connected vehicles or Internet of Things (IoT) devices. Third, its hyper-connectivity allows the simultaneous connection of numerous sensors and devices, as needed in smart factories and smart cities. The government promotes numerous projects relying on 5G to increase competitiveness and innovation in industries (for example smart manufacturing, smart grids and smart healthcare) or enhance the quality of life by solving social problems with smart cities and homes (notably in Sejong), as well as smart roads and traffic systems. The expected effects include higher production, exports and employment (Fourth Industrial Revolution Committee, 2017). Amid the COVID-19 outbreak, Korea contained the spread of the virus, using advanced digital tools based on artificial intelligence and mobile apps, as well as remote access to daily life services (telework, online classes, e-commerce, telemedicine…). The recent New Digital Deal further supports the use of digitalisation with projects exploiting synergies between the government and the business sector, including strengthening data infrastructures, expanding data collection and usage, establishing 5G network infrastructure early, promoting untact industries and developing artificial intelligence.

Korea's dynamism in digital technologies is reflected in its high share of value added and employment in ICT sectors (Figure 5). Even so, economy-wide productivity is far below the OECD average (Figure 6). This reflects several structural features. Low-productivity services like trade, transportation, accommodation and catering account for a higher share of total employment than the OECD average (28% against 25%), while being even less productive than the OECD average. Moreover, most jobs created in new Korean small and medium sized enterprises (SMEs) are in low productivity activities, like in many OECD countries (OECD, 2019c): in 2017, 56% of jobs created by the birth of new SMEs were in trade, transportation, accommodation and food services. Furthermore, in high-productivity sectors like manufacturing, SMEs account for a high share of enterprises and of employment, but are less productive

than large firms (*2018 OECD Economic Survey of Korea*). This productivity gap is observed across OECD countries but is substantially larger in Korea (OECD, 2021).

Firms can raise their productivity by adopting digital technologies or benefit from spillover effects from firms adopting digital technologies within the same industry (Gal et al., 2019). In Korea, there is scope to increase productivity in services, especially in ICT services, which are knowledge-intensive and tend to be more productive than other services (Sorbe et al., 2018). ICT manufacturing productivity is far higher than in other industries, with a much wider gap than in the average OECD country (Figure 5). Non-ICT manufacturing also enjoys a larger relative productivity advantage than the OECD average, albeit much smaller than in ICT. However, this reflect the performance of large firms and manufacturing SMEs can benefit from digital technologies to increase their productivity.

Figure 5. Low-productivity sectors account for a high share of total employment



Note: Data refer to 2015. 'ICT manufacturing' includes manufacture of computer, electronic and optical products. 'ICT services' include publishing, telecommunication and IT services. 'Other business services' excludes the housing sector.
Source: OECD STAN Database.

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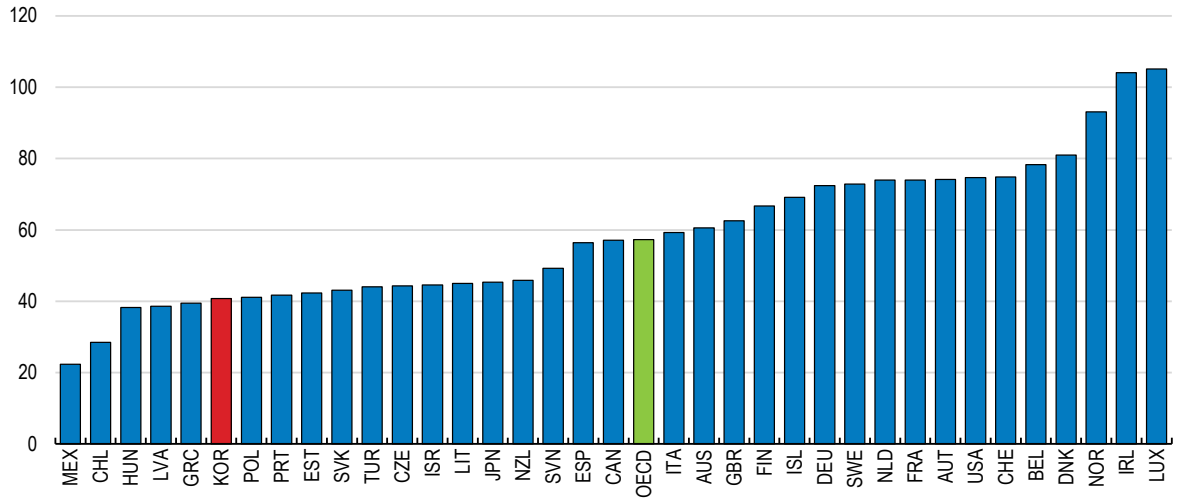
Figure 6. Economy-wide productivity in Korea is far below the OECD average

USD (current PPPs) per hour, 2018



Source: OECD Productivity Database.

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Digital opportunities to raise productivity are not used to their full potential

Smartification of factories can raise SME productivity in manufacturing

Smart factories use information and intelligence technology (cloud computing, big data, artificial intelligence, IoT) to move the production process from traditional automation to a fully connected, flexible and optimised system, and design customised products at mass-production prices (Kim et al., 2019). (Box 2). Smart factories present several advantages in terms of production performance and employment. In enterprises that have adopted smart technology and actively used and shared data generated by technology, productivity and product variety have improved, while defect rates have fallen (Kim et al., 2019). Smartification of factories can contribute to job creation in the country by allowing factory reshoring (Fourth Industrial Revolution Committee, 2019). The composition of workers in smart factories can also change as the use of advanced technologies attracts young workers and lowers the intensity in physical labour, facilitating the employment of women and older workers. There is already evidence of a slight increase in youth employment in some enterprises, after they adopted smart technologies, but not yet in the employment of women and older workers (Nho, 2019).

Box 2. Smart factories around the world

Since 2016, the World Economic Forum and McKinsey & Company have monitored progress in advanced manufacturing around the world, identifying frontrunners as “Lighthouses”. As of June 2020, the Global Lighthouse Network comprises 54 leading factories in 22 countries. These Lighthouses successfully leveraged fourth industrial revolution technologies – on-site or across the value chain – to improve their productivity, sustainability, agility, speed to market or customisation.

Table 1. Examples of Lighthouses in OECD countries

	Country	Industry	Main tools	Impact
Nokia	Finland	Electronics	Virtualisation of new product introduction; flexible robotics; private wireless network; cloud-based digital data control; connected mobile robots	Improved productivity and mobile robotics efficiency and reliability; reduced lead-time and process defects
Groupe Renault	France	Automotive	Digital-enabled service training; connected workforce; digital and IoT energy management system	Improved productivity; reduced cost, safety incidents, waste elimination and energy consumption
AGCO	Germany	Agricultural equipment	Digitally enabled variable takt time; virtual build; intelligent transportation management system; advanced analytics; digital supplier performance management	Improved productivity and time delivery; reduced cycle time, transportation costs and time to identify field-quality issues
Henkel	Germany	Consumer goods	Digitally enabled real-time global OEE-boosting platform; digitally integrated E2E demand sensing; digital twin; digital E2E dispatching and GPS tracking; digitally steered lights-out warehouse	Improved OEE and forecast accuracy; reduced energy, logistics cost and proceeding costs
GE Healthcare	Japan	Healthcare	App-based production lines; biometric authentication; real-time production performance monitoring and visualisation; RFID; eSpaghetti diagram	Improved efficiency; reduced labour and total walking distance for picking
Hitachi	Japan	Industrial equipment	Digitally enabled operator and equipment performance management; IoT infrastructure; digital twin	Improved capacity and inspection efficiency; reduced production lead time and CO2 emissions
POSCO	Korea	Steel products	Machine vision and deep learning; visualisation and digitalisation; AI; machine learning	Improved production output and productivity; reduced cost and quality deviations
Ford Otosan	Turkey	Automotive	Digital tool; real-time digital performance and energy management; robot data analytics; predictive maintenance	Improved production output and employee engagement and cost saving; reduced die manufacturing time, per-robot failures and electric consumption
Petkim	Turkey	Chemicals	Industrial Internet of Things (IIOT); predictive analytics; virtual reality training; digital maintenance	Improved yield and earnings; reduced energy and lost time incident rate
GSK	United Kingdom	Pharmaceuticals	Advanced analytics; deep learning image recognition; AI; digital twin; cycle time monitoring and visualisation digital tool	Improved overall equipment effectiveness, throughput and capacity; reduced cost and cycle time
Johnson & Johnson Vision Care	United States	Medical devices	Digital customer collaboration; Modular platform; IIOT; E2E supply chain visibility platform; vision-guided robotics	Improved conversion rate of customers; reduced development and launch timeline, cost, inventory levels and employment
Zymergen	United States	Biotechnology	Sensor network and data architecture; reconfigurable modularity; dynamic, digital work instructions; real-time process monitoring and control; dynamic simulations-based scheduling	Improved line output; reduced scrap, production line design and reconfiguration time, cycle time and labour

Note: IoT stands for Internet of Things; OEE for overall equipment effectiveness; E2E for end-to-end; RFID for Radio frequency identification; AI for artificial intelligence; IIOT for Industrial Internet of Things.
Source: World Economic Forum (2019).

Smart factories are central to the government's plan for the Fourth Industrial Revolution. At the end of 2019, Korea had 12 660 smart factories. To promote the development of SME smart factories, the government has introduced pilot smart factories as benchmark for other SMEs, inspired by experiences in countries like Germany and in relevant industries. Factories operating successfully can be designated as pilot factories and get financial support for half of their expenses spent to purchase smart devices and develop partnership programmes. In early 2020, 51 SMEs in car parts, paper, electronic parts, aircraft and

machinery industries became pilot smart factories. Other strategies to expand and upgrade smart factories include financial support from the government and large business partners, the construction of a cloud-based smart factory for SMEs with insufficient data storage and management skills, and development of training and diplomas in smart factory-based technology (Fourth Industrial Revolution Committee, 2018). The goal is over 30 000 smart factories by 2022.

Table 2. The five levels of smart manufacturing

Development stage	Level	Goal	Main ICT tools
Basic	Level 1 – Identify	Construct the information system to identify materials	Barcodes and RFID
	Level 2 – Monitor	Gather and monitor in real time data from the workforce, machines, equipment and materials	Sensors
Intermediate I	Level 3 – Analyse	Control, measure and analyse data collected in level 2	Sensors and analysing tools
Intermediate II	Level 4 – Optimise	Gather, analyse and simulate data to optimise the production process (workforce, machines, equipment, materials, operating conditions)	Sensor controller optimisers
Advanced	Level 5 – Customise	Customise the production process by optimising the workforce, machines, equipment, operation and environment conditions	Artificial Intelligence, Augmented Reality/Virtual Reality, Cyber-Physical System

Source: https://www.smart-factory.kr/smartFactoryIntro.

The development of smart factories goes through five levels (Table 2). In Korea, the level of development in smart factories is still low. In 2018, most of them were at the basic or intermediate I level (80.0% and 18.6% respectively), only 1.4% were at the intermediate II level and none of the SMEs had reached the advanced level. The main reasons behind this slow development include a lack of workers with the relevant skills and of an efficient retraining system, as well as underdeveloped innovation networks promoting collaboration between innovative companies, especially between SMEs and large enterprises (Fourth Industrial Revolution Committee, 2019). A sample of SMEs that adopted smart technologies were surveyed by the Korean Agency of Information on Technology. Their main problems included the maintenance or instability of the new production system, its incompatibility with former systems, skill shortages and training difficulties. The lack of awareness from managers was also underlined by these SMEs. This contributes to the low level of development in Korean smart manufacturing, since good management practice and interest of CEOs in upgrading their manufacturing system are important drivers of factory smartification. For instance, factories in the bottom 20% of the distribution of incentives in management practices have not experienced any increase in the level of smartification (Kim et al., 2019). The Ministry of SMEs and Startups (MSS) put forward a wide range of measures to further support and enhance the development of smart SME factories in its 2020 budget (Box 3).

Box 3. Government measures to support smartification projects in 2020

The Ministry of SMEs and Startups (MSS) 2020 budget plan amounts to KRW 13.5 trillion (about USD 11.5 billion), up from KRW 10.3 trillion for 2019 and mainly includes measures to promote manufacturing innovation in SMEs and support their scaling-up.

Measures to support manufacturing innovation and technology development

- Establish the “Manufacturing Data Centre” to analyse and process data generated from smart factories (KRW 6.7 billion).
- Further increase the penetration rate of smart factories in manufacturing (KRW 415 billion).

- Extend the coverage of smart factories from manufacturing to services, with the smart service project (KRW 9.3 billion) and the smart store project (KRW 1.7 billion).
- Further support R&D for technological innovation and commercialisation for SMEs, and for stronger collaboration between SMEs and large enterprises, and between industries, universities and institutes (KRW 1.5 trillion).

Measures to support the scale-up of start-ups and venture companies

- Support 300 start-ups in the fields of semiconductors, bio-health and future cars (KRW 45 billion); set up a mentoring project between retired experts and start-ups (KRW 6 billion).
- Increase the budget for the Tech Incubator Programme for Start-ups (TIPS, KRW 54.4 billion).
- Double the budget for the in-company venture programme (to KRW 20 billion).
- Help promising start-ups become unicorns (KRW 12 billion).

Other measures

- Provide R&D and other funds for seven regulation-free special zones to support regional industries in future cars and bio-health (KRW 61.5 billion).
- Provide vouchers to manufacturing SMEs for technical assistance and consulting services (KRW 59.4 billion).
- Further encourage youth to work in SMEs through the Naeil Cheum Mutual Aid Programme for Youth Employees (KRW 339.9 billion).
- Create a Korea Start-up Centre in Finland and Sweden to help start-ups establish networks there and carry forward the Youth Personnel Global Marketing project (KRW 2 billion).
- Expand the project for Export Vouchers to help SMEs enter the international market (KRW 99.8 billion).

Source: Ministry of SMEs and Startups, Press Release, 29 August 2019.

Digitalisation can increase productivity through servicification of manufacturing

With the development of ICT technologies, services are increasingly embedded in manufactured products, a phenomenon known as “servicification” of the manufacturing industry. Manufacturing firms increasingly rely on services, either as inputs, as production activities within the firm, or as output sold bundled with goods (Miroudot and Cadestin, 2017). For instance, manufacturing uses services, such as R&D, design, transport, logistics, finance, distribution and marketing as inputs. These input services can be produced in-house or outsourced. Manufacturers of cell phones can bundle their product with telecommunication services to allow users to install apps, which will generate additional service transactions, such as audiovisual services with video streaming and music, publishing services with e-books, or computer services with video games. Smart manufacturing, as well as IoT and 3D printing, contribute to the increasing servicification of manufacturing. ICT services, such as computer programming, software publishing, telecommunication, data processing and advanced data analytics, are the main producers and users of data, which are central to smart manufacturing. For instance, data processing services like cloud computing generate data for smart factories, while advanced data analytics services optimise the production process based on this real-time information (Hallward-Driemeier and Nayyar, 2018).

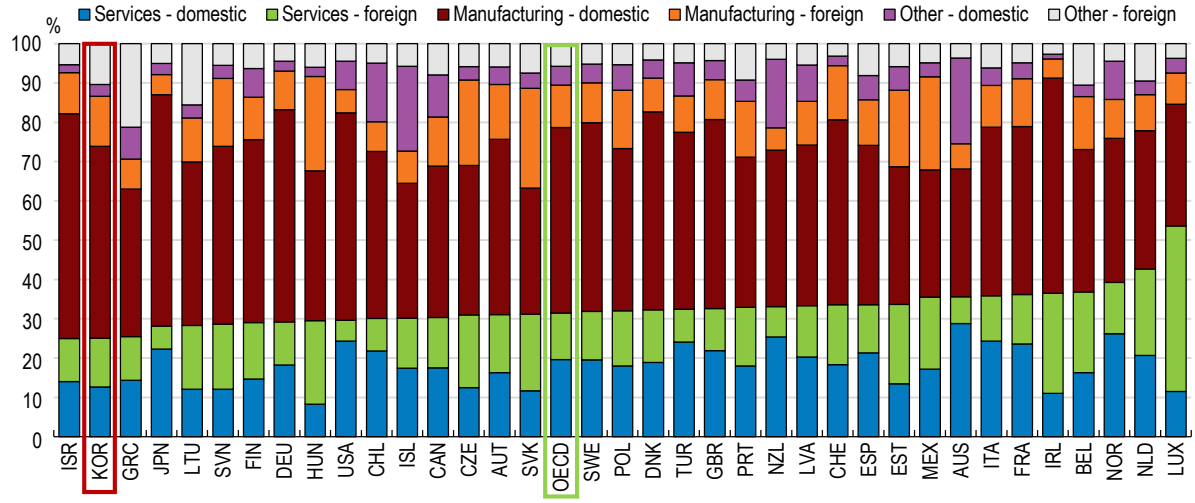
Servicification of manufacturing helps firms create value and increase their productivity and exports. Manufacturing firms use three types of services to create value: input, in-house production, and output (Miroudot and Cadestin, 2017). In the case of service inputs, manufacturing firms may improve their productivity or reduce their costs, by using legal, management, engineering or banking services. In the

case of in-house production, more R&D increases the innovative capacity of the firm and its competitiveness, while more IT services improve the production process and productivity. For example, there is evidence of higher exports for Swedish manufacturing firms that have a larger share of manager, professional or technical services – more likely to be in knowledge-intensive services – in their in-house production (Lodefalk, 2014). In the case of sales of services bundled with manufacturing goods, after-sales services or installation and maintenance services become new sources of income for firms.

Korea is lagging behind the most advanced OECD countries in the development of manufacturing servicification, in terms of service inputs, production and exports. First, the share of service inputs in Korean manufacturing exports is one of the lowest among OECD countries (25%), with half of these inputs outsourced to foreign firms (Figure 7). Like in other OECD countries, Korean manufacturing industries mainly use distribution services as domestic and foreign services inputs (12% of manufacturing exports), as well as professional and administrative services (5%), while ICT services are barely used as inputs (1%). Second, the share of in-house services produced by Korean manufacturing firms to export their goods is one of the lowest among OECD countries (less than 10% of gross exports), along with Eastern European countries, while the United States and Germany have over 20% of in-house services in their exports (Miroudot and Cadestin, 2017). Third, Korea has the lowest share of firms selling both manufacturing goods and services (3.5%), after Mexico, Chile and Iceland, based on the ORBIS database (Miroudot and Cadestin, 2017). The share of firms exporting both manufactured goods and services is even lower (0.5%).

Figure 7. The contribution of domestic services to Korean manufacturing exports is low

Value added share of manufacturing gross exports by industry inputs, 2015



Note: 'Other' includes primary, utilities and construction industries.
Source: OECD TiVA Database.

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Digital technologies can increase productivity in services

In Korea, productivity in ICT services and other business services are respectively equal to 74% and 41% of that of manufacturing. Productivity is even lower in trade, transportation and accommodation (31% of manufacturing productivity). Traditional services have intrinsic characteristics that reduce the scope for productivity gains. Compared to goods, they tend to be less standardised and require more face-to-face

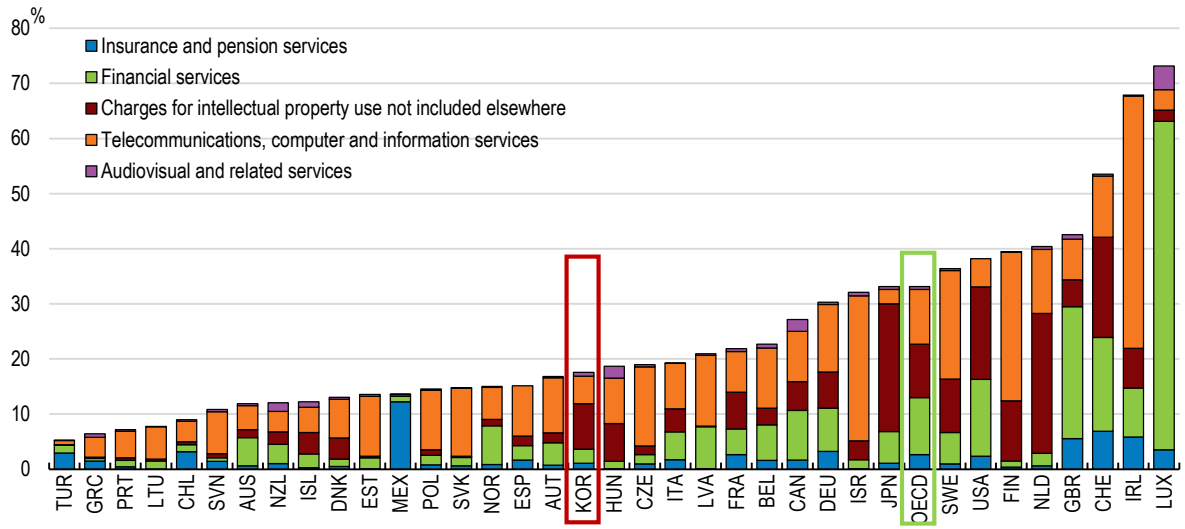
interactions in their delivery. This reduces productivity in services through three channels. First, the additional transaction costs reduce competitive pressures, efficient reallocation mechanisms and hence incentives to improve productivity. Second, the gains from economies of scale and automation are smaller. Third, services are less tradable within and across countries, which limits productivity gains from trade through knowledge spillovers, better specialisation and heightened competitive pressure (Sorbe et al., 2018).

Digital technologies offer new ways of producing and consuming services. For instance, artificial intelligence and advanced robotics can automate cognitive tasks typically carried out in service activities. Digital platforms can enhance competition among service providers and increase productivity in services, by reducing information asymmetries between consumers and service providers, thanks to ratings and reviews, or by substituting existing services, like Kakao T and TADA for taxis or Baemin for delivery services. Digital platforms also provide a wide range of services for consumers, like market services that can replace home production, such as housework with gig economy platform Daelijubu, or innovative FinTech services, such as peer-to-peer money transfer services proposed by Viva Republica's mobile app "Toss". However, the rapid emergence of digital platforms is facilitated by strong network externalities and the intensive use of data as input to their matching algorithms, which favour the emergence of dominant platforms and hinders competition, hence lowering the level of innovation for "neck-and-neck industries" (Aghion, 2005). In Korea, Kakao T emerges as a dominant platform in transportation, with 24 million users registered, representing over 84% of the economically active population as of September 2019 (Kakao, 2019). The exact definition of gig economy workers is under discussion among tripartite partners. The National Learning Card introduced in 2020 will support the participation of gig workers in vocational training. Other measures under discussion include the extension of industrial accident compensation insurance and unemployment insurance to platform workers.

Digital technologies improve the tradability of services and provide alternative ways of trading. For instance, blockchain provides new financial services that are fully digitally tradable and require no direct physical interactions. However, in the case of Korea, exports of digitally deliverable services are well below the OECD average, even though barriers to digital service trade are among the lowest in OECD (OECD, 2019d; Figure 8). SMEs can also benefit from digital technologies to gain access to international markets and take advantage of enhanced linkages to increase their productivity (*2018 OECD Economic Survey of Korea*). E-commerce can help SMEs expand their business within and across countries, by significantly reducing upfront fixed costs, such as logistics or customer services (OECD, 2019e). In low-productivity sectors like accommodation and trade, where SMEs are more numerous, the share of Korean firms using websites for online ordering or reservation has significantly increased and has room to rise further (Figure 9).

Figure 8. Korean exports of predominantly digitally deliverable services are weak

As a percentage of total services exports, 2017



Source: OECD (2019b), calculations based on EBOPS 2010, https://www.oecd.org/sdd/its/EBOPS-2010.pdf; WTO, Trade in Commercial Services, October 2018.

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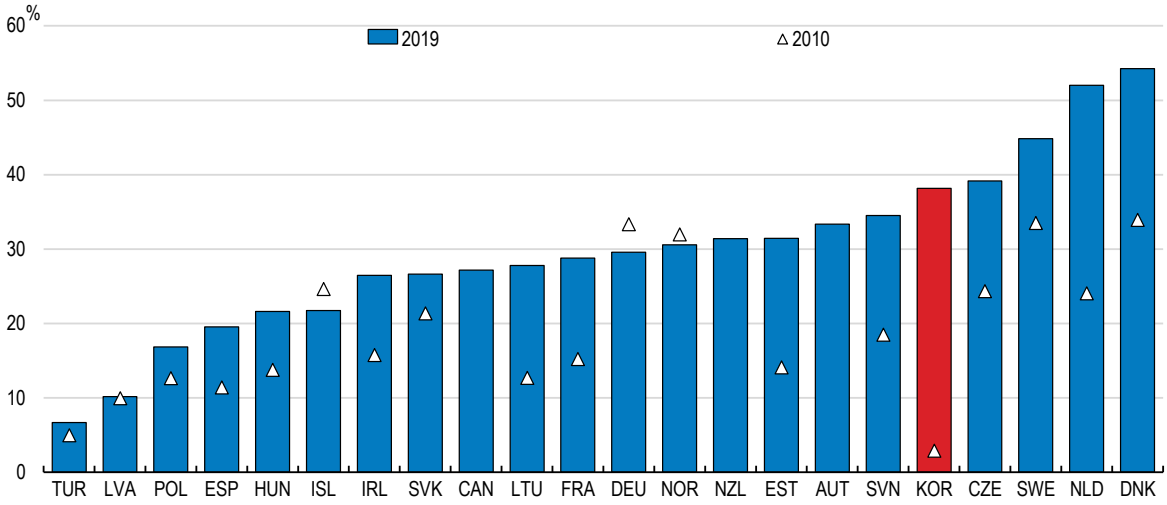
Figure 9. Use of websites for online ordering or reservation has increased rapidly in Korea

As a percentage of enterprises with ten or more employees; Accommodation and trade sectors



Note: Simple average of the share of enterprises in the accommodation, wholesale and retail sectors. 2018 for Germany, Iceland, Korea and New Zealand and 2017 for Canada instead of 2019; 2011 for France, Latvia, Poland and Sweden and 2013 for Korea instead of 2010. The statistical unit for Korea is the establishment and not the enterprise and covers public and private sectors.
Source: OECD ICT Access and Usage by Businesses Database.

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The diffusion of digital technologies among firms and workers is slow

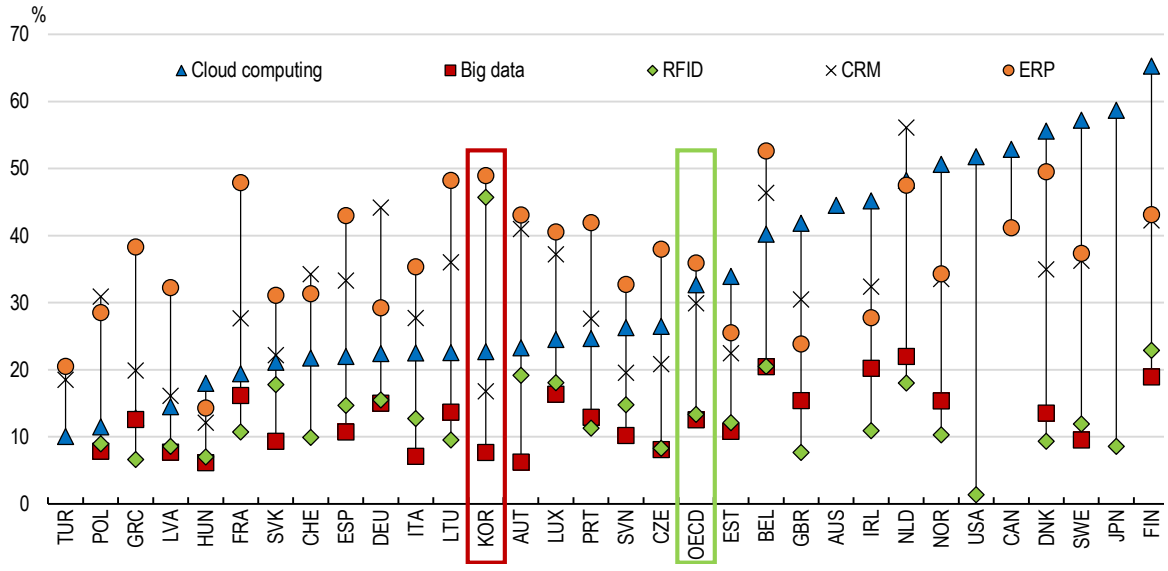
The development of smart factories, servicification of manufacturing or digital platform requires sophisticated digital technologies, such as cloud computing, big data, IoT and artificial intelligence. Korea actively contributes to the development of emerging digital technologies and benefits from a nationwide coverage of 5G. However, Korea still lags behind most advanced OECD countries in the adoption of these sophisticated digital technologies, especially in SMEs. This hinders the development of smart manufacturing. The stalling technology diffusion is also associated to productivity divergence between the most productive firms and the least productive ones, especially in ICT intensive services (Andrews et al., 2016). The lack of digital skills in SMEs and among older workers is also a barrier to the diffusion of digital technology.

Korea has margins for improvement in the adoption of sophisticated digital technologies

Over the past two decades or so, Korea remained at the cutting edge of ICT technologies, thanks to outstanding achievements in mobile devices, chips and appliances. In recent years, Korean firms have strived to reinforce their global competitiveness in new digital technologies, such as artificial intelligence, cloud computing, big data, 3D printing and IoT. However, IITP (2019) estimates Korea has a two-year lag in 3D printing, artificial intelligence, big data and cloud computing, and a one-year lag in IoT compared to the United States, which is considered the frontrunner in these technologies. Only 23% of Korean companies use cloud computing, against over 50% in the Nordic countries (Figure 10).

Figure 10. Korea is below the OECD average in sophisticated digital technologies adoption

As a percentage of enterprises with ten or more employees, 2019 or latest available year



Note: RFID stands for Radio frequency identification; CRM for Customer relationship management; ERP for Enterprise resource planning. Data for cloud computing refer to 2018, except for Canada, Switzerland and United States (2017) and Australia (2016). Data for big data refer to 2018, except for United Kingdom (2016). Data for RFID refer to 2017 except for Japan and Korea (2018). Data for CRM refer to 2018 for Korea and to 2017 for Iceland and Switzerland. Data for ERP refer to 2018 for Korea and to 2017 for Canada and Switzerland. The statistical unit for Korea is the establishment and not the enterprise and covers public and private sectors.
Source: OECD ICT Access and Usage by Businesses Database.

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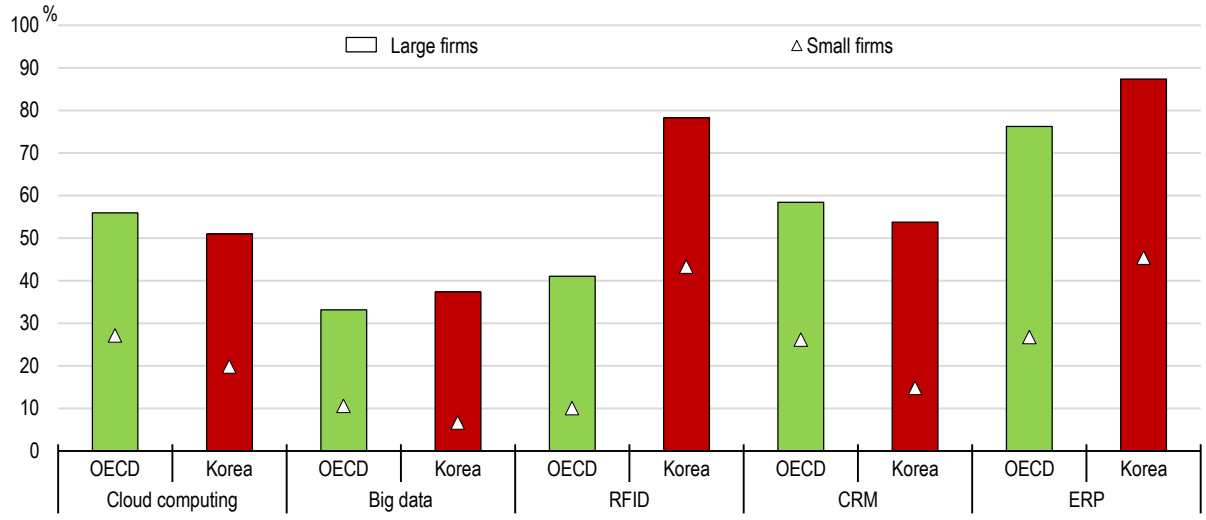
However, the Korean government and private firms are taking measures to catch up, especially in the adoption of cloud computing and artificial intelligence. Major business groups like Samsung and LG already committed to ambitious plans to expand their cloud-based systems. Samsung is expected to establish a cloud-based business management system by 2020, while LG is expected to switch 90% of its subsidiaries' IT infrastructure to a cloud-based system by 2023. Cloud computing services are key to lowering barriers to the adoption of the latest technologies (OECD, 2019c). They provide both individuals and businesses with on-demand access to ICT over a network at any given time. For SMEs and young firms, cloud-computing services are an important asset for digital transition, reducing the cost of experimenting with new technologies and increasing flexibility, as data processing and storage are managed in a remote data centre. During the COVID-19 outbreak, Korea stood out among OECD countries with its use of artificial intelligence to significantly speed up and improve diagnosis efficiency, especially with its test kits (Box 1).

The digital divide between SMEs and large enterprises is wide

Digital technologies are increasingly powerful and affordable for SMEs, but are not used to their full potential. The gap between SMEs and large firms in the adoption of sophisticated digital technologies is wide and higher than the OECD average (Figure 11). This gap reflects several obstacles to the adoption of digital technologies faced by SMEs. First, Korean SMEs are concentrated in services like trade, transportation, accommodation and food services, which are less knowledge intensive (Sorbe et al., 2018) and hence less prone to innovation than manufacturing: 56.7% of service firms are not innovating (against 47.9% in manufacturing) and they are less likely than manufacturing firms to engage in innovation to pursue cost reductions (Kang and Lee, 2019).

Figure 11. Digital gaps between large and small firms remain high

Percentage of enterprises with ten or more employees using selected digital tools, 2018 or latest year



Note: RFID stands for radio frequency identification; CRM for customer relationship management; ERP for enterprise resource planning. The statistical unit for Korea is the establishment and not the enterprise and covers public and private sectors.
Source: OECD (2019b); OECD ICT Access and Usage by Businesses Database.

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Second, SMEs tend to lack information and funds. They are often not aware of the potential new digital tools could offer to increase their productivity or lower their production costs. They also consider the costs of adopting more sophisticated digital tools to upgrade their business model as too high (OECD, 2019c).

According to the Survey on the Informatisation Level in Small and Medium Business conducted by the Korean Agency of Information on Technology, these are the main difficulties SMEs faced while participating in the smart manufacturing programme. In 2017, 57.4% of the 356 companies surveyed mentioned the lack of information on smart factories and 50.8% the issue of raising initial investment. The lack of information causes a lack of trust, which is the main obstacle to the adoption of cloud computing by SMEs (OECD, 2019c).

Third, SMEs face a lack of skilled workers and low access to training. For one third of SMEs in the 42 countries covered by the OECD/Facebook/World Bank Future Business Survey, hiring and keeping skilled employees is the most pressing challenge (OECD, 2019c). Compared to other OECD countries, Korean SMEs have more difficulties to hire high-skilled university graduates than larger firms because they offer less attractive jobs in terms of wages, stability, working hours and career advancement opportunities (OECD, 2020a). Across OECD countries, smaller firms lack soft skills for innovation, such as managing and communication skills, readiness to learn and creative problem-solving skills (Grundke et al., 2017). In Korean micro-firms, 34% of workers have low problem-solving skills in technology-rich environments (against 28% for the OECD average), while this share is much lower in large firms (19%), according to the OECD Survey of Adult Skills (PIAAC). In addition, training participation in Korean SMEs is one of the lowest among OECD countries, especially in micro-firms. The duration of training is also shorter in SMEs than in large firms: the median hours spent on (non-formal) job-related training is 32 hours per year for SME workers, compared to 48 hours in larger firms, according to PIAAC data. For SME workers, the main barrier to training is the lack of time because of work (52% of workers, against 32% for the OECD average). For firms, the lack of manpower is the most frequently cited reasons for not implementing or supporting training (30% of SMEs), along with fear of poaching (OECD, 2020a).

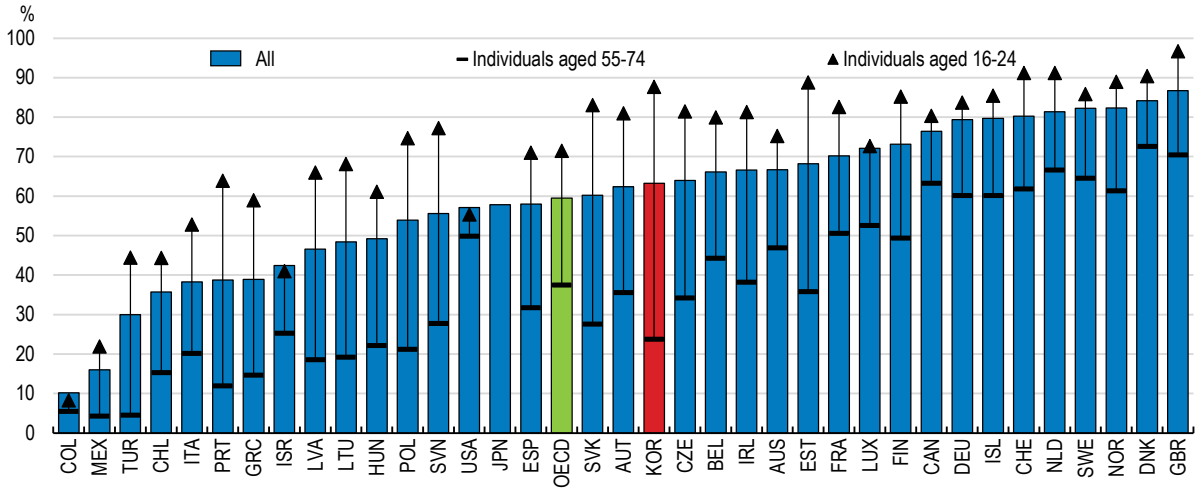
The digital divide between generations exacerbates social inequality

Adequate digital skills are key to thrive in an increasingly computerised society and economy. A digital divide is opening up between those who can get the most out of the Internet and online activities and the others. This in turn exacerbates well-being inequalities. Koreans have access to high-speed Internet, which allows them to undertake diversified and sophisticated online activities, such as online purchasing, Internet banking, online learning or uploading self-created content on sharing websites such as Youtube. The types and sophistication of activities undertaken on the Internet depend on several factors, like age, educational attainment, familiarity with online services, trust and skills (OECD 2019b).

In Korea, the types of activities carried out by Internet users vary widely across age groups. In 2019, 92% of Koreans aged 16-74 used Internet daily, the highest share among OECD countries, after Iceland, Denmark and Norway (OECD ICT Access and Usage by Individuals Database). While this share varies across age groups, with nearly all Koreans aged 16-24 being daily Internet users, it is also one of the highest for Koreans aged 55-74 (78%). The difference between youth and older people relates to the sophistication of their online activities. Individuals aged 55-74 limit their use of the Internet to basic activities, such as reading newspapers and news magazines online, and do not make the most of the wide range of online activities available. For instance, e-commerce gives access to a wider choice of products and can offer a more convenient shopping experience for persons with low mobility. Across OECD countries, young individuals engage more in online purchasing, but the age gap between e-consumers is usually small. In Korea, the age gap is the highest among OECD countries: 88% of individuals aged 16-24 versus only 24% of those aged 55-74 participate in e-commerce (Figure 12).

Figure 12. The age gap in online purchasing is the highest among OECD countries

Share of individuals participating in e-commerce, 2019 or latest available year



Note: Data refer to 2018 for Canada, Columbia, Japan and Mexico, 2017 for Chile, Israel and United States, 2016 for Australia.
Source: OECD ICT Access and Usage by Individuals Database.

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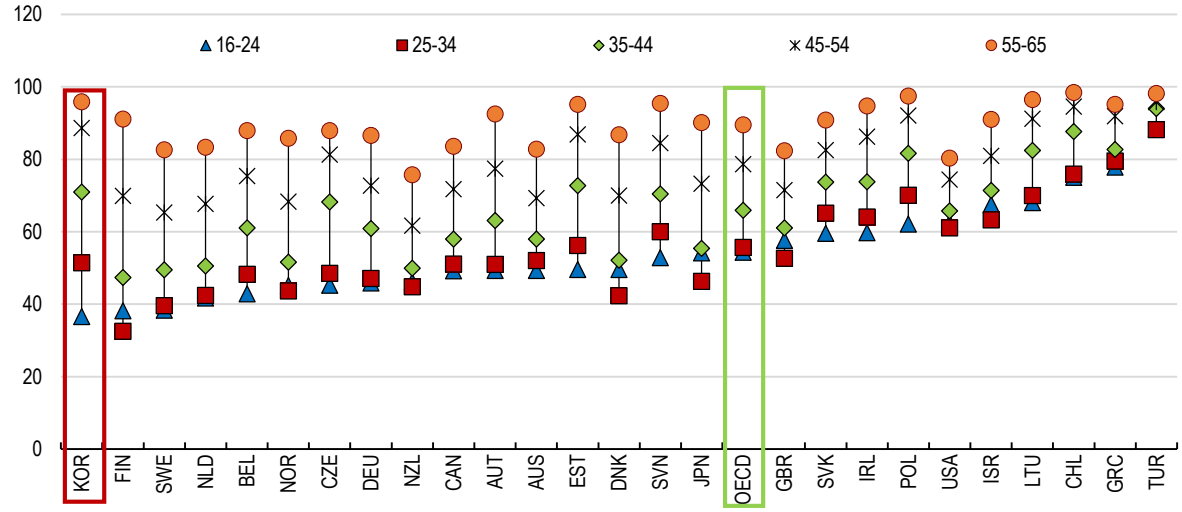
This digital divide in the diversity and sophistication of online activities reflects gaps in digital skills (problem-solving skills in technology-rich environments), as well as in basic skills (literacy and numeracy). An analysis on a sample of European countries directly connects digital and basic skills to the profile of Internet users. Lacking basic cognitive skills is a barrier to performing any online activities, while lacking digital skills is a barrier to performing diversified and complex online activities like e-finance, learning and creativity (OECD, 2019f). Korea has the largest gap in digital skills between youth and older people (Figure 13). The share of 16 to 24 year-olds with limited or no digital skills is the lowest across OECD countries (37%). But nearly all adults aged between 55 and 65 lack digital skills. Age gaps in Korea are also observed for basic skills, though they are smaller than for digital skills. Less than 2% of Koreans between 16 and 24 lack basic skills in literacy and numeracy, against 30% of Koreans between 55 and 65 (OECD, 2019f). Digital and basic technology divide between the elderly and young generations is primarily due to a sharp increase in educational investment during the period of rapid economic growth in the 1970s and 1980s, as well as insufficient investment in lifelong learning.

In an ageing and increasingly digitalised society, it is essential to keep up with the need for new skills and equip individuals with the adequate skills to participate in diversified and sophisticated online activities. Otherwise, the digital divide will exacerbate well-being inequalities as part of the population will be left behind. For instance with e-commerce, if higher competitiveness of online vendors causes physical stores to close down, it could limit the access to certain products for part of the population (OECD, 2019b). In addition, the COVID-19 outbreak underlines the growing importance of e-commerce as consumers increasingly switch to online shopping to avoid further spreading of the virus (Box 1). In addition, individuals with a well-rounded skill set (literacy, numeracy and digital) are better prepared to face changes in their job content induced by digitalisation and automation (OECD, 2019f). This is particularly relevant for workers in Korean SMEs whose jobs face higher automation risk than in larger companies (44.3% against 36.5%, OECD 2020a). Having a well-rounded skill set can help workers be re-assigned to non-routine tasks more easily. Higher productivity is also associated with higher task-based ICT skills like the use of office software, programming language, Internet or emails (Grundke et al., 2017).

Figure 13. The digital skills gap between generations is the highest among OECD countries

Share of adults with limited or no digital skills, by age group, 2012 or 2015



Note: No digital skills' includes adults who have had no computer experience, failed the ICT core test or opted out of taking the test. 'Limited digital skills' includes adults scoring below or at level 1 of proficiency in problem solving in technology-rich environments
Source: OECD Survey of Adult Skills (PIAAC).

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Policies supporting digital adoption and productivity need strengthening

The lack of adequate skills and knowledge is the main barrier to the diffusion of digital technologies among firms and workers. In addition, lifelong learning helps firms with low productivity enhance their productivity growth, especially in more digital and skill intensive industries (Berlingieri et al., 2020). Preparing individuals to thrive in a digital society begins in families and at school and continues at work with on-the-job learning and training. The lack of strong innovation networks between SMEs and academia or large firms and the presence of stringent regulations hinder the adoption and diffusion of digital technologies. Low-productive SMEs are heterogeneous and while some SMEs are “zombie” firms, others are young innovative firms with high-growth potential (Berlingieri et al., 2020). R&D and commercialisation of new products and services should be further promoted in productive as well as innovative SMEs. Stringent barriers in product markets and in services should be lowered to adjust to the rapid development of digital innovations.

Better quality training for teachers and SME employees is crucial

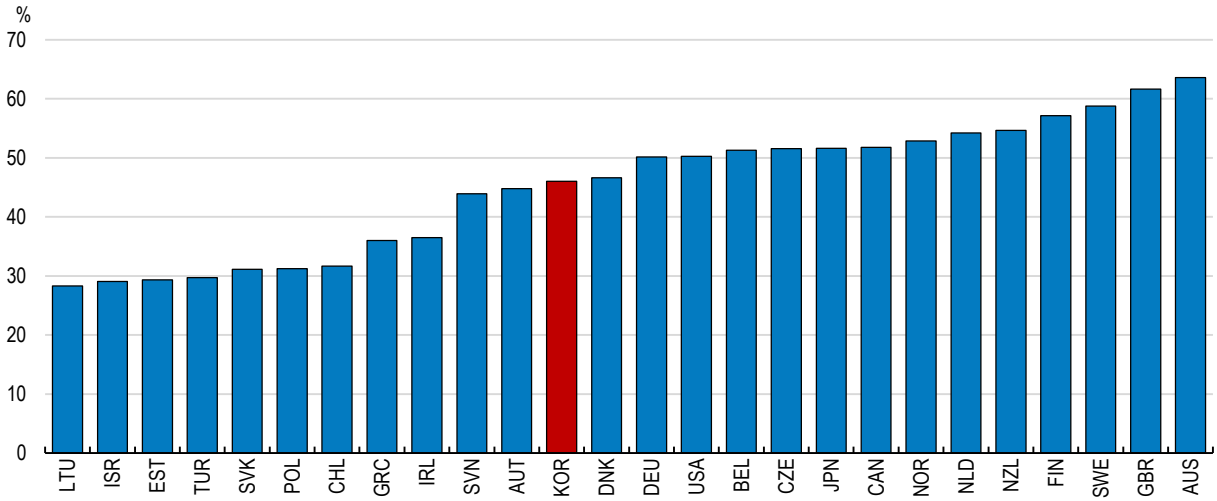
Teachers play an important role in ensuring that students and workers develop relevant skills to thrive in the context of the digital transformation, but also in raising awareness of the risks associated with new technologies. Teachers’ digital competencies are key in that regard and there is a positive relationship between teacher problem-solving skills in technology-rich environments and student performance in computer problem solving and computer-based assessment of mathematics (OECD, 2019f). In Korea, the share of teachers (including adult learning teachers) with high digital skills is low compared with the most advanced OECD countries (Figure 14). The lack of digital skills raises issues amid the COVID-19 outbreak as teachers had to switch to online teaching (Box 1). Among OECD countries, a relatively high share of Korean teachers have the “use of ICT for teaching” included in their formal education or training, or in their

recent professional development (for instance attending courses and seminars outside of school). Nonetheless, more than half of Korean teachers do not feel sufficiently prepared for the use of ICT for teaching and the share of teachers in high need of training in ICT skills for teaching is above the OECD average (Figure 15). The quality of their training in ICT skills should be improved. As is currently discussed by the government, lifelong learning teachers should have mandatory refresher training to update their skills on a regular basis. Furthermore, to attract highly-qualified lifelong learning teachers, and hence increase the quality of training, their working conditions and wages should be enhanced. Their pedagogical and professional skills could also be publicly highlighted, as it is the case with Singapore's adult education network SkillsFuture SG (OECD, 2020a).

Workers with ICT professional skills (such as programming and data analytics) are needed to support the diffusion and the efficient use of digital technologies, as well as to compete in the digital economy (Cho et al., 2019; Sorbe et al., 2019). In terms of graduation fields, the share of Korean tertiary graduates is the second to Germany among OECD countries in natural sciences, engineering, ICTs, and creative and content fields (Figure 16). These qualifications are especially useful in increasingly digitalised working environments (OECD, 2019b). Artificial intelligence and big data have proven to be core technologies to tackle the COVID-19 outbreak, which implies that more specialists and high-level researchers in these technologies are needed (Box 1). The Korean government started to take steps in this direction by promoting plans to train more experts in fourth industrial revolution core technologies. In December 2019, the government initiated a strategy promoting the adoption of artificial intelligence, which includes making artificial intelligence courses compulsory in primary and secondary schools, opening artificial intelligence departments in colleges and providing training to the military and public officials. Such courses and training should be extended to other fourth industrial revolution core technologies like big data and training should be provided to private sector workers as well.

Figure 14. The share of teachers with high digital skills is relatively low in Korea

Share of top performing teachers in problem solving in technology-rich environments, by country



Note: Top performers are defined as scoring Level 2 or 3 in problem solving in technology-rich environments.
Source: OECD (2019f), calculations based on OECD Survey of Adult Skills (PIAAC).

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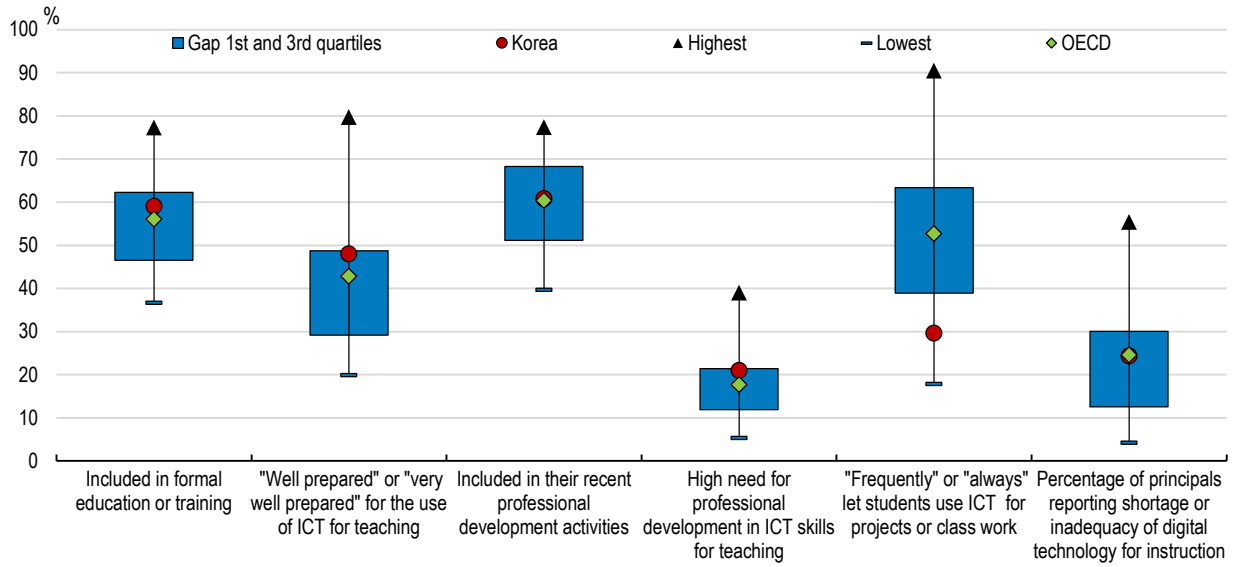
Figure 15. Teachers can further improve their use of ICT for teaching

Share of teachers reporting about the "use of ICT for teaching"



Source: OECD, TALIS 2018 Database, Table I.4.13, Table I.4.13, Table I.5.18, Table I.5.21, Table I.2.1 and Table I.3.63.

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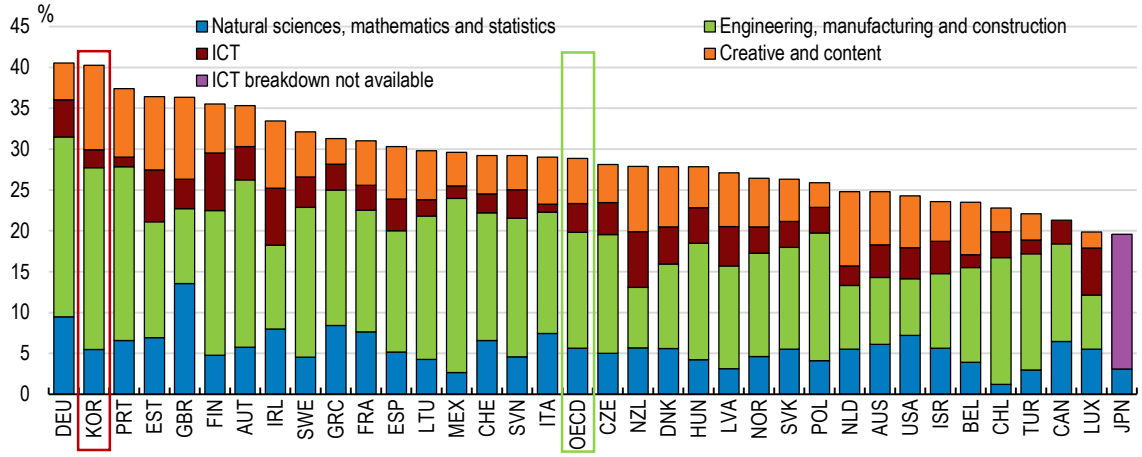
Figure 16. The share of tertiary graduates in science, engineering and ICT is high

As a percentage of all tertiary graduates, 2016



Note: The 'Creative and content' field includes arts (including graphic design), journalism and information.
Source: OECD (2019b), calculations based on OECD Education Database, September 2018.

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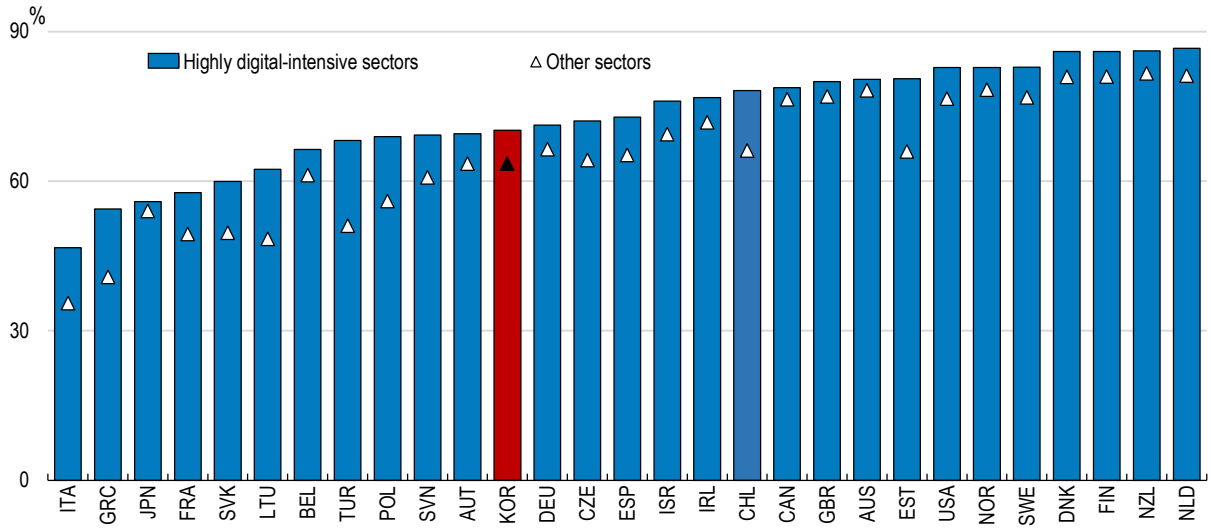
Firm-based training can complement and update academic qualifications and enhance the generic digital skills of all workers, as well as complementary skills like managerial skills. High managerial skills are required to improve business processes and are associated with higher digital adoption and productivity (Bloom et al., 2019; Sorbe et al., 2019). Among OECD countries, workers in very digital-intensive sectors are more likely to receive formal firm-based training leading to official qualifications than workers in other

sectors. Korea has scope to increase firm-based training, as even in very digital-intensive sectors, participation is relatively low compared to OECD frontrunners (Figure 17). The lack of access to training in SMEs, compared to larger firms, and the low quality of training are important issues. In 2015, 52% of SMEs provided only legally mandatory training (mostly industrial safety and health training) or no training at all to their workers, based on PIAAC data. Compared to other OECD countries, Korean SME workers seem to be less satisfied with their training, with less than a third of them finding it useful. The government is already addressing issues related to the lack of training participation in SMEs. Nevertheless, there is still a lack of information about the benefits of training, available training options and their quality, as well as available financial support (OECD, 2020a). Career guidance services can raise SME workers' awareness of training opportunities and understanding of their training needs. However, Korea counts numerous competing online career guidance platforms (HRD-net, Neulbaeum, Work-Net, Q-Net, regional lifelong learning portals, K-MOOC, Smart Tech Education Platform), which makes finding information more difficult for workers. The government should merge the many online career guidance portals into a single one to centralise information on available training programmes and help users navigate training options. Targeting adult learning programmes on SME managers would help ensure they are aware of the potential of digital technologies and hence supportive of workers training. Korea could learn from other countries like the United Kingdom, Mexico, New Zealand and Australia, where special management programmes are provided to SMEs' CEOs and owners. Financial incentives to reduce training costs are numerous for Korean SMEs and are funded by the Employment Insurance for SMEs that meet a number of criteria. Making these criteria less restrictive would allow more SMEs to be eligible to these government-supported subsidies. Furthermore, financial incentives should be aligned to SMEs' training needs and hence be more generous for innovative training contents or methods that better fit SMEs' need. Finally, developing an online guide like in Ireland (Supporting SMEs Online Tool) would help SMEs be aware of all the subsidies.

Figure 17. Korea can further increase the share of workers receiving firm-based training

As a share of workers in each sector group, 2012 or 2015



Source: OECD (2019b), calculations based on OECD Survey of Adult Skills (PIAAC).

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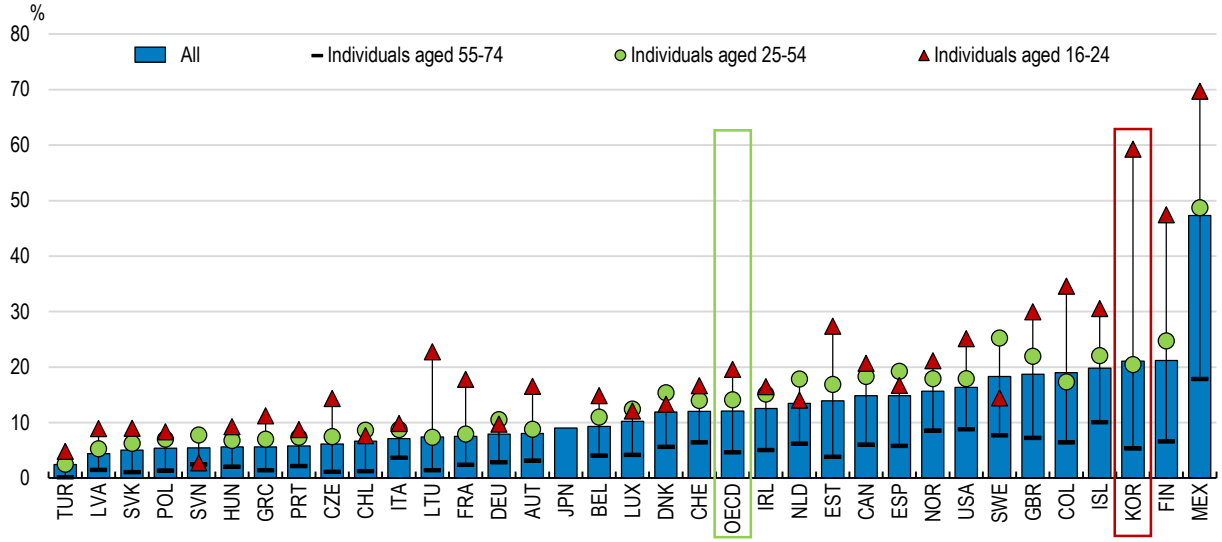
Digital technologies create new opportunities to update and develop new skills throughout life, for instance via distance and modular learning. Education systems such as massive open online courses (MOOCs) provide a wide range of courses to anyone at any age by top universities, the business sector, international

institutions or independent experts. In Korea, MOOCs like those provided by Tooling U-SME specifically for manufacturers and their workers can teach needed digital manufacturing skills (Kim et al., 2018). E-learning allow studying and working at the same time and even obtain full degrees with modular learning, providing flexibility to workers and savings to firms, especially in SMEs where lack of time is the main barrier for workers (OECD, 2019f; OECD, 2020a). Korea has the third highest participation rate in online courses in the OECD, after Mexico and Finland (Figure 18). Drawbacks of e-learning include the lack of information on their quality and the risk of exacerbating inequalities. Indeed, youth and high-educated adults are more likely than older and low-educated adults to further develop their skills through such education systems. In Korea, 59% of youth aged 16-24 have used Internet online courses in 2019, while this share is only 20% for people aged 25-54 and 5% for 55-74 year-olds (Figure 18). A similar pattern is observed in other OECD countries, but the age gap is the highest in Korea. More basic ICT courses should be provided to older and low-qualified adults who are also over-represented in SMEs (OECD, 2020a). Regarding older adults, Korea could take advantage of existing infrastructure like senior universities which help improve seniors' well-being and could operate as an extension of adult lifelong learning (Jun and Evans, 2019). Users are over 60 years old and courses are mainly related to hobbies and health maintenance. But courses dedicated to ICT could be introduced, either as basic courses or as university-level courses like in Germany's Universities of the Third Age (Schmidt-Hertha, 2019). Finally, the government should collaborate with education and training providers, employers, job-search agencies and MOOC platforms, to increase participation in open education and expand the use of distance and modular learning on the job, as well as define standards and good practices to better signal quality courses (OECD, 2019f).

Figure 18. The participation in online courses is the third highest in Korea

Share of individuals participating in online courses, in 2019 or latest available year



Note: Data refer to 2018 for Canada, Columbia, Japan and Mexico, 2017 for United States.
Source: OECD ICT Access and Usage by Individuals Database.

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R&D support needs to better target innovative and productive SMEs

The digital divide between Korean SMEs and large enterprises is high and Korean SMEs do not take advantage of advanced technologies enough to enhance their productivity. Access to finance is critical for SMEs to adopt innovation and scale up. Overall, SMEs in OECD countries face financial barriers to the adoption of innovation, especially young firms, start-ups and innovative ventures (OECD, 2019c). In

addition, venture capital dropped and risk aversion of investors increased in Korea since the COVID-19 outbreak, exacerbating financial constraints for SMEs. The Korean government supports SMEs through the Korea Small Business Innovation Research (KOSBIR) programme and R&D grants since 1998. KOSBIR is based on the US Small Business Innovation Research (SBIR) programme that supports SMEs in three phases: feasibility, R&D and commercialisation. Compared to SBIR, KOSBIR dedicates most of the funding to the R&D phase, at the expense of the feasibility and commercialisation phases. Reallocating financial support for turning successful technology R&D into commercial applications could help SMEs convert their R&D inputs into economic benefits. The proportion of firms able to launch new products or significantly improve existing products is much lower in smaller firms than in larger ones. The lack of funds and of market analysis and research consulting on project feasibility are considered as the main barriers to commercialisation, especially for small firms (Yang, 2018). Promoting e-commerce could help SMEs sell their products to a wider range of consumers, especially across borders. For instance, Israel's National Digital Programme has a component dedicated to e-commerce with an assistance package that includes subsidised training and grants to establish a digital marketing system. Furthermore, streamlining public support schemes for SMEs and start-ups can increase their efficiency. United Kingdom's Business Support Simplification Programme achieved substantial streamlining by selecting programmes according to three criteria (rationale, effectiveness and need), grouping them around a number of common business themes like finance access, R&D, training or overseas trade, and setting an online tool for guidance (OECD, 2021).

However, when it comes to support commercialisation, financial markets and innovative financial services like Fintech should also be considered for funding and expertise on project feasibility. Directing R&D support towards innovative SMEs and boost their productivity requires an efficient selection process of recipients. For instance, recipients of R&D grants selected on the number of their registered patents expanded their investments in R&D, intellectual property rights, tangible assets, human capital and marketing over the period 2010-15, but on average did not show significant improvement in their value added, operating profits and sales, unlike non-recipient SMEs (Lee, 2018a). Fintech brings new opportunities for SMEs seeking finance (OECD, 2019c). In August 2020, the three data bills (Personal Information Protection Act, Information and Communications Network Act and Protection of Credit Information Act) were to come into effect. Fintech companies are expected to be among the first applicants to have access to anonymised personal data like electricity bills and use them to establish new credit ratings using algorithms. SMEs can then have higher credit ratings than those provided by commercial banks and have access to funding for their R&D and commercialisation projects.

R&D support mainly benefits firms already investing in R&D. Providing SMEs with innovation vouchers not only in manufacturing but also in services would encourage them to engage in innovative projects and assess the feasibility of their research projects, for instance by purchasing studies on potential for new technology introduction from universities and research institutions (Kim et al., 2018). Introduced for the first time in the Netherlands in 1997, innovation vouchers are now used by many European countries, as well as in regions of Canada and the United States. Vouchers are usually granted as a one-off payment to SMEs that covers all the eligible costs. In some countries like Estonia, Germany, Ireland and Italy, recipient SMEs are required to provide a share of own-funding (Box 4). Evidence of advantages in using innovation vouchers include increased R&D projects, reduced time-to-market, and further collaboration with academia (Cornet et al., 2006; Matulova et al., 2015; Sala et al., 2016). Overall, innovation vouchers would help developing innovation networks, which are limited in Korea, and facilitate the diffusion of digital technology (*2018 OECD Economic Survey of Korea*).

Box 4. Innovation vouchers for SMEs: case studies of selected European Union countries

Voucher programmes consist of grants given by local, regional and national government to private firms, usually SMEs, as an incentive to adopt new technologies or services, or to invest in skills. In the European Union, such vouchers mainly aim at assisting SMEs in investing in innovative solutions or

services, or acquiring machinery that will facilitate innovation (digital or not). Some vouchers specifically target training of staff and/or citizens to increase their basic or digital skills (for instance in Poland).

Activities covered by these vouchers include consultancy services, knowledge transfers from research institutes, access to research centres and their testing facilities, first-time contacts between entrepreneurs and/or research centres, nationally or internationally and investments in ICT instruments, among others.

Table 3. Main innovation vouchers currently available to SMEs in the European Union

	Amount	Beneficiaries	Purpose	Number of vouchers granted
Austria	Maximum: EUR 12 500 Total: EUR 29.3 million	Smaller firms without R&D staff	Enlist the services of research institutions and pay for these services	4 442 in 2016
Denmark	Large voucher: EUR 13 400 Small voucher: EUR 3 350 Total envelope: EUR 12.3 million (over 2018-21)	SMEs	Strengthen digital and e-commerce capabilities and increase competitiveness	Not available (target of 2 000 by 2021)
Estonia	Maximum: EUR 4 000 Own funding rate: minimum 20% Total envelope: EUR 4 million (over 2014-20)	SMEs cooperating with a higher education institute, test laboratory, or intellectual property experts	Supports the creation of first-time contacts between entrepreneurs and innovation service providers	Up to 4 000 from autumn 2015 until summer 2019
Germany	Maximum: EUR 1 100 (excluding VAT) for a day of consulting services (maximum 30 days of consulting services in a period of up to 6 months) Own funding rate: 50%	SMEs with less than 100 employees	Advance recipients' digitalisation in IT security, digital marketing and digitalised business processes	863 in 2018 1238 in 2017
Ireland	Maximum: EUR 2 500 (excluding VAT) Own funding rate: 50% Total envelope: EUR 7.3 million since 2017	SMEs with limited online trading presence and 10 employees or less, EUR 2 million or less in turnover and at least 6 months of trading	Invest in developing e-commerce capability	5 000 since 2014
Italy	Maximum EUR 10 000 Own funding rate: 50% Total envelope: EUR 45 million (over 2017-19)	Micro enterprises and SMEs in the pursuit of the digitalisation of their processes and modernisation of their technologies	Encourage investments in ICT innovation and digitalisation among micro enterprises and SMEs	10 000

Source: Backer Gonzalez Salido (2019).

In addition to promoting collaboration between SMEs and academia, encouraging collaboration between SMEs and large enterprises would enhance innovation diffusion, for instance through an open collaborative platform to exchange new products, services and big data (Fourth Industrial Revolution Committee, 2019). The United States and other OECD countries focus on the importance of networks for the growth phase of start-ups and SMEs (Box 5). The Korean steelmaker POSCO paved the way for a successful collaborative platform between SMEs, large enterprises and academia. It started introducing new technologies like big data in 2015. In July 2019, POSCO became the first Korean smart factory designated as “Lighthouse Factory” by the World Economic Forum, which establishes a list of global leading factories applying core fourth industrial revolution technologies like artificial intelligence, big data and IoT (Box 2). One of POSCO’s special features is the collaboration with academia, SMEs and start-ups to build its own smart factory platform (World Economic Forum, 2019). POSCO collaborates with universities like POSTECH and UNIST to provide special training in artificial intelligence. This collaboration has brought more than 60 artificial intelligence experts in POSCO. By providing big data to a SME specialised in data mining like ECMiner, POSCO succeeded in optimising their equipment with artificial intelligence. The academics, SMEs and

start-ups that collaborated with POSCO can help constructing another smart factory based on POSCO's technology (POSCO, 2020).

Box 5. Helping SMEs scale up: selected country examples

Since its inception in 1979, the US Small Business Development Center (SBDC) network has grown from a few centres in six states to a nationwide network of nearly 1 000 centres at the service of approximately one million small business owners and aspiring entrepreneurs each year. SBDCs provide one-on-one counselling and training to help micro enterprises and SMEs start their business and grow. The SBDC network is a partnership that includes the US Congress, the US Small Business Administration (SBA), the private sector, colleges, universities, state and local governments. Half of SBDC funding is provided by the SBA, and the other half by the other partners and through donations. SBDCs offer services in general management, assistance in getting financing and more specialised services for gazelles, such as assistance to expand their market at the international level. They also monitor and evaluate business performance using indicators like jobs creation, sales, access to capital, exports and the number of government contracts.

Over a more recent period, other OECD countries introduced similar programmes to help SMEs grow through mentoring and collaboration between companies, the public sector and academia. In 2014, Korea launched the Tech Incubator Programme for Start-ups, which is modelled on Israel's Technology Incubator 1991 programme (*2018 OECD Economic Survey of Korea*). Both programmes provide incubation and mentoring, and they are funded by government R&D combined with angel investors in the case of Korea and venture capitalists in the case of Israel. Over 2018-20, the European Innovation Council supports top-class innovators, entrepreneurs, small companies and scientists for scaling up internationally, by offering new networking, mentoring and coaching opportunities as well as strategic advice for upgrading the European innovation ecosystem. Several countries have used network-based approaches like cluster policies to strengthen industry-science linkages and cross-sectoral interactions (Baltic Sea Region countries, Canada, Korea, Spain).

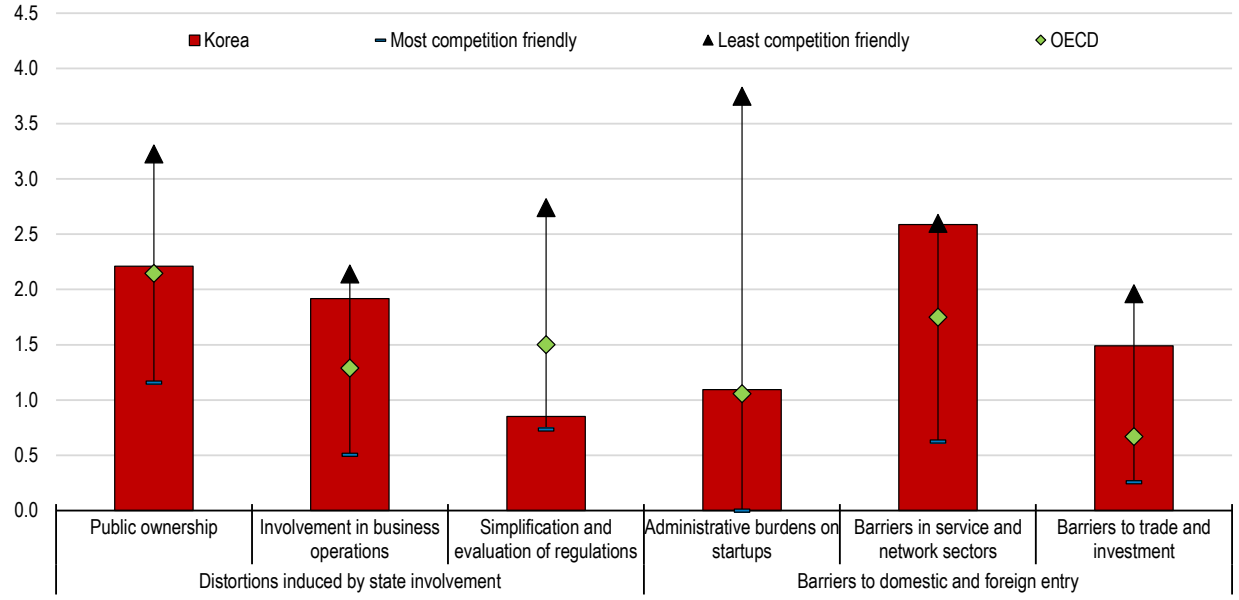
Source: https://americassbdc.org/; 2018 OECD Economic Survey of Korea; Choi (2019); OECD (2019c).

Regulatory barriers to the adoption and diffusion of digital innovations are too high

Regulatory frameworks are often unable to adjust to rapid technological innovations, like FinTech services or gig economy platforms. Stringent regulations limit possibilities to experiment and create uncertainty for innovators, hampering investment in digital innovations and the emergence of new business models (Planes-Satorra and Paunov, 2019). Furthermore, stringent regulations are barriers to competition and reallocation, hindering productivity growth. Reducing them can boost the diffusion of digital tools and maximise their impact on productivity (Sorbe et al., 2019, 2018). Product market regulations in Korea are among the most stringent in the OECD, especially state involvement in business operations, barriers in service and network sectors and barriers to trade and investment, which are among the highest across OECD countries (Figure 19). Reducing barriers to trade and investment would promote foreign investment in R&D and SME innovation through better connection to global innovation networks (*2018 OECD Economic Survey of Korea*). It also enables the creative destruction process that forces inefficient businesses to exit the market (OECD, 2021). Services in Korea also face high trade barriers in transports and telecommunication (Figure 20). These sectors are important for the development of manufacturing servicification and reducing barriers in these sectors would enhance productivity. Indeed, there is evidence of a positive association between services deregulation and productivity of manufacturing firms using services as inputs, for example in the case of Czech Republic (Arnold et al., 2011).

Figure 19. Korea has high regulatory barriers to competition

Index scale 0 to 6 from most to least competition-friendly regulation, 2018



Source: OECD Product Market Regulation Database.

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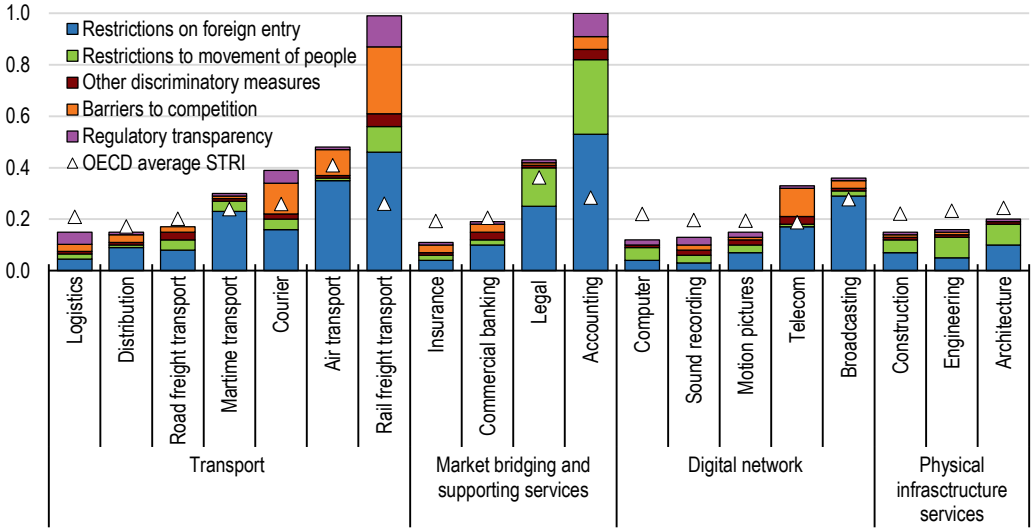
Services like ride hailing and medical services are subject to strict regulations, hindering the development of new business models or the commercialisation of new digital products. Companies like Uber and Kakao Carpool struggle to service the Korean market, because of the "Passenger Transport Service Act" that limits commercial use of private cars during rush hours (7-9 in the morning and 6-8 in the evening). Huinno had to delay the launch of its wearable electrocardiogramme monitoring system until 2019, despite finalising its development in 2015 (before the Apple 4 watch) because of the stringent regulations on medical services. Regulatory sandboxes are recommended to enhance regulatory flexibility as they allow firms to experiment innovative products and business models without being subject to all existing legal requirements (*2018 OECD Economic Survey of Korea*). The government has introduced regulatory sandboxes since January 2019 in areas such as FinTech, the medical sector, manufacturing, electronics, telecommunication, energy and mobility. In terms of digital technology, regulatory sandboxes have been approved for app-based platform technology, IoT, big data, blockchain, artificial intelligence and virtual reality. Huinno was among the first firms to benefit from the regulatory sandboxes programme. Furthermore, amid the COVID-19 outbreak, the ban on telemedicine services was temporarily lifted, allowing patients to consult their doctors without risking mutual exposure to the virus (Box 1). In 2019, 195 projects were approved by the regulatory sandbox system and over 200 projects are aimed at in 2020. The government also announced the designation of regulation-free special zones (Box 6). Like regulatory sandboxes, they allow firms to experiment innovative technologies in designated areas without restrictions from regulations (digital healthcare in Gangwon, blockchain technology in Busan, autonomous driving in Sejong and so forth). After four years at most, if a regulatory sandbox is considered effective and safe, it can lead to the definitive suppression of the regulation that was temporarily waived, its amendment, or the extension of the trial period. It can also lead to the creation of licences with a narrower scope, for example for FinTech companies, which could be allowed to provide some banking services, without needing a full

banking licence. Follow up on this strategy should allow identifying regulation breaches and reviewing regulations, notably in the case of telemedicine.

Figure 20. Korea should be more open to foreign entry and competition

Index scale 0 to 1 from least to most restrictive, 2019



Note: OECD is the simple average across OECD countries. Logistics is computed as the simple average of the four logistic sectors.
Source: OECD STRI database, OECD calculations.

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Box 6. Regulation-free special zones in Korea

Regulation-free special zones designate areas that benefit from an exemption of a set of key regulations for a given innovative business project. Their goal is to spur innovation of local industries, hire local talents and create jobs. To qualify as a regulation-free special zone, several steps must be checked. First, candidate enterprises submit their proposals or request to local governments. Then, local government apply for special zone designation after holding a public hearing to listen to local opinions. Finally, the Minister of SMEs and startups notifies the designated special zones, after a consultation period of 60 days with related agencies and a negotiation period of 30 days. If there is no relevant law or if existing law cannot be applied, regulatory exemption is applied to test and verify products and services. If there is no law, products and services can be temporarily launched. Both regulatory exemption for field tests and temporary authorisation are valid for a period of two years, which can be renewed once until 2024. If necessary, enterprises in these zones can benefit from financial support by state and local governments, as well as investment tax deduction. In total, 21 regulation-free special zones were designated in three rounds: July 2019, November 2019 and July 2020. These special zones are specialised in fields like bio-health, energy and mobility (Table 4).

Table 4. List of regulation-free special zones

Round	Area	Business project	Description of the project
1st round (July 2019)	Gangwon	Digital healthcare	Allowing telemedicine from home
	Gyeongbuk	Next-generation battery recycling	Extracting rare earth metals from waste batteries from electric vehicles
	Daegu	Smart wellness	Sharing medical devices manufacturing infrastructure
	Busan	Blockchain	Creating blockchain-based trusted cities free from forgery and alteration
	Sejong	Autonomous driving field tests	Leading the age of commercializing autonomous vehicles passengers
	Jeonnam	E-mobility	Reducing the discontinuity of the service sections of mini electric vehicles
	Chungbuk	Smart safety control	Controlling gas industry safety wirelessly
2nd round (November 2019)	Gyeongnam	Unmanned ships	Enhancing the competitiveness of the future shipbuilding industry with crewless ships
	Gwangju	Unmanned low-speed special vehicle	Using unmanned vehicles to collect domestic waste downtown
	Daejeon	Biomedical	Quickly providing clinical samples for the development of in-vitro diagnostics
	Ulsan	Green mobility with hydrogen	Building a hydrogen-based innovative growth value chain
	Jeonnam	New energy industry	Securing renewable energy with the next-generation power transmission and distribution technology
	Jeonbuk	Eco-friendly vehicle	Leading the eco-friendliness of medium and large-size commercial vehicles and special small vehicles
	Jeju	Electric vehicle charging services	Building the best electric vehicle charging infrastructure in the country
3rd round (July 2020)	Ulsan	Genomic services	Developing diagnostic markers and prepare a support system for vaccines and treatments based on human genome information
	Daegu	Moving cooperative robots	Manufacturing, production, quarantine and sterilisation of cooperative robots
	Gangwon	Hydrogen liquefaction	Establishing a full-cycle liquid hydrogen industry from production to utilisation
	Chungnam	Hydrogen energy conversion	Allowing the demonstration of hydrogen fuel cell power generation for homes and buildings
	Gyeongbuk	Industrial hemp	Allowing the cultivation of hemp, which are narcotics, for industrial purposes, and material extraction
	Busan	Eco-friendly maritime transport	Allowing the construction and operation of small and medium-sized ships with LPG engine (instead of gasoline or diesel)
	Jeonbuk	Carbon convergence composite technology	Establishing safety standards for commercialisation of carbon convergence material products in connection with Jeonbuk's shipbuilding and automobile industries

Source: Ministry of SMEs and Startups

Ensuring digital trust is key to digital development and well-being

Digital technologies provide a wide range of innovative products and services to individuals. However, increasing online activities entail higher exposure to digital risks like privacy violations or cyberbullying, as well as higher addiction to digital activities and tools. The COVID-19 outbreak also highlights the importance of digital trust, as individuals and firms rely more on remote services like telework, online classes and e-commerce (Box 1). Reaping the full well-being benefits of digital transformation requires ensuring online security, as well as raising individuals' awareness of digital downsides and dangers. This

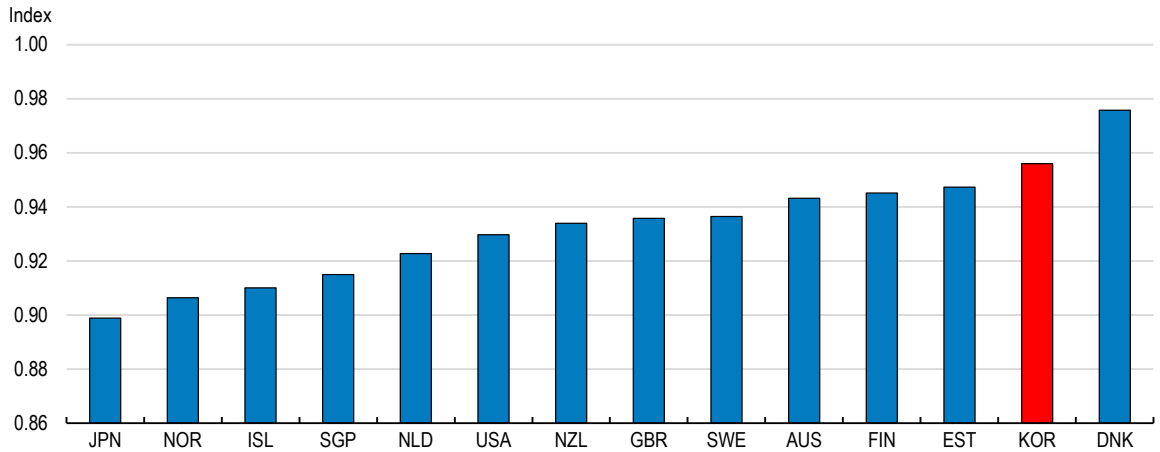
implies the need for better digital education in schools and at work, better digital security technologies and the involvement of the government to lead by example.

Online security must be improved

Ensuring trust in digital technologies is key to promote their adoption and diffusion among individual users. A lack of online security or digital privacy will make users more reluctant to trust such technologies and engage in the digital economy (OECD, 2019g). For instance, better trust in payment services is essential for the development of e-commerce (OECD, 2019e). E-consumers must be protected against financial losses resulting from fraudulent payment card use after completing an online payment. Greater openness of the government to share online data and information previously unavailable to the public can promote innovation in the public sector and improve people's trust in institutions (OECD, 2019g). This in turn can increase people's trust in online activities.

E-government can also encourage firms to adopt digital technologies to exploit synergies between digitalisation in the public and private sectors, and hence increase their productivity (Sorbe et al., 2019). Korea performs well in this regard, ranking second in the world on the United Nations e-Government Development Index (United Nations, 2020; Figure 21) and first among OECD countries in open-useful-reusable government data (Figure 22). In June 2020, the Ministry of Interior and Safety presented the post-Corona Digital Government Innovation Development Plan, following the October 2019 Digital Government Innovation Promotion Plan. Its goal is to promote digitalisation in the public sector. The expansion of non-face-to-face services will be accelerated through the use of mobile ID cards and the MyData portal, which will allow people to use government services from their smartphones from 2021, as well as download personal information held by public institutions, and submit that information directly to public authorities and banks. Besides, online education will be expanded. The Korean government also plans to increase the provision of customised services related to health check-ups, national scholarship applications, civil defence education or tax payments. The openness of public data will be further promoted to strengthen cooperation between the public and the private sectors, and support new industries such as autonomous driving and healthcare. Finally, the government will further develop digital infrastructure in the public sector by increasing 5G wireless networks and building a security control system using artificial intelligence. Civil servants will also follow more training on digital government innovation (Ministry of Interior and Safety, 2020).

Figure 21. Korea is a leader in e-government



Source: 2020 United Nations E-Government Survey.

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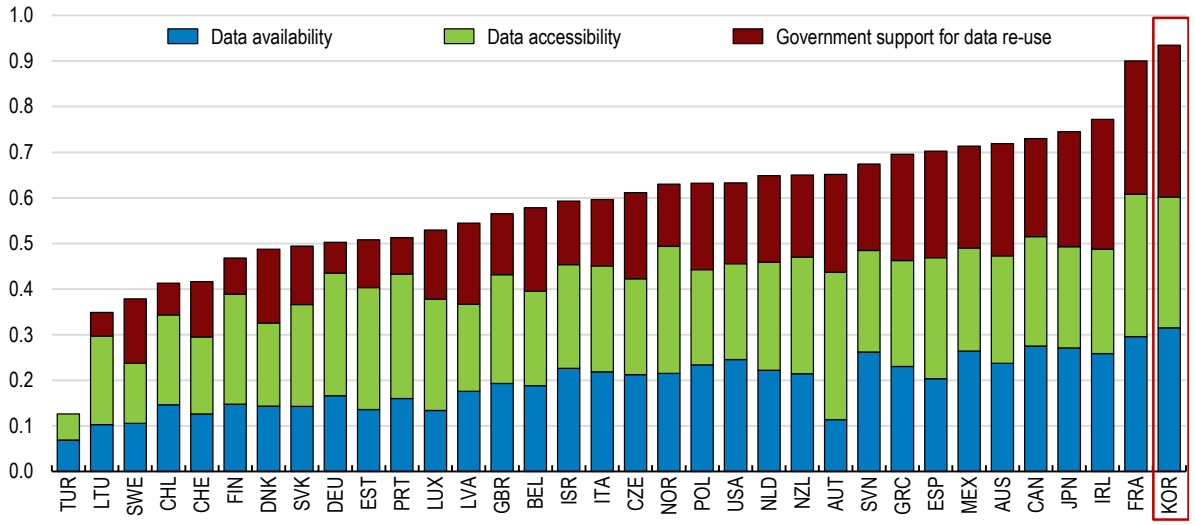
Figure 22. Korea has the highest score in open-useful-reusable government data

OURdata Index scores in the dimensions of data availability, accessibility and reusability, 2019



Source: OECD OURdata Index on Open Government Data.

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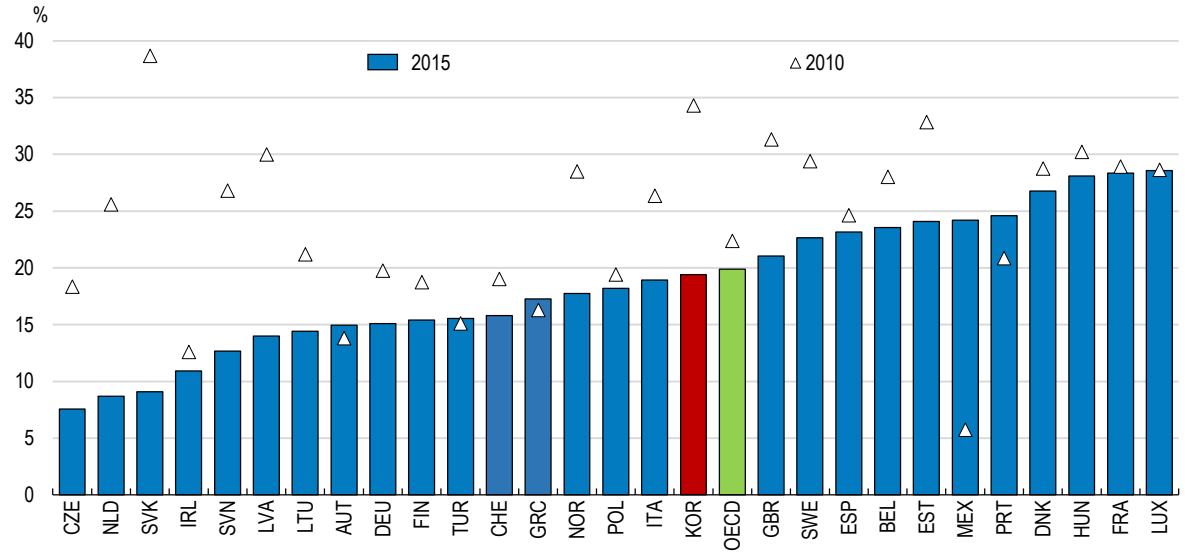
However, Korea has a relatively high share of individuals reporting security incidents, even though this share has significantly decreased since 2010 (Figure 23). Security incidents like losing information, time or device damaging after catching a computer infection (virus, worm, Trojan) are the most frequent, while financial losses resulting from fraudulent messages (phishing), fake websites asking for personal information (pharming) or fraudulent payment card use affect fewer users. For such security incidents, Korea is close to the OECD average. However, Korea has the second highest share of Internet users experiencing privacy violations in the OECD (malicious attacks, poor data security, accidental publication of user data), which may hold back the development of on-line applications (Figure 24). There are also growing concerns across countries about "predictive privacy harm" related to the use of big data by companies to predict individuals' preferences and behaviour, which can harm their physical safety and mental health (OECD, 2019g).

Figure 23. Online security incidents are relatively frequent in Korea

Percentage of individuals who report having experienced security incidents



Note: 2017 for Korea and Mexico; 2014 for Chile and Switzerland. For Korea and Mexico, the share in 2015 is respectively 23.4% and 28.4%.
Source: OECD (2019g), calculations based on OECD ICT Access and Usage by Individuals Database.

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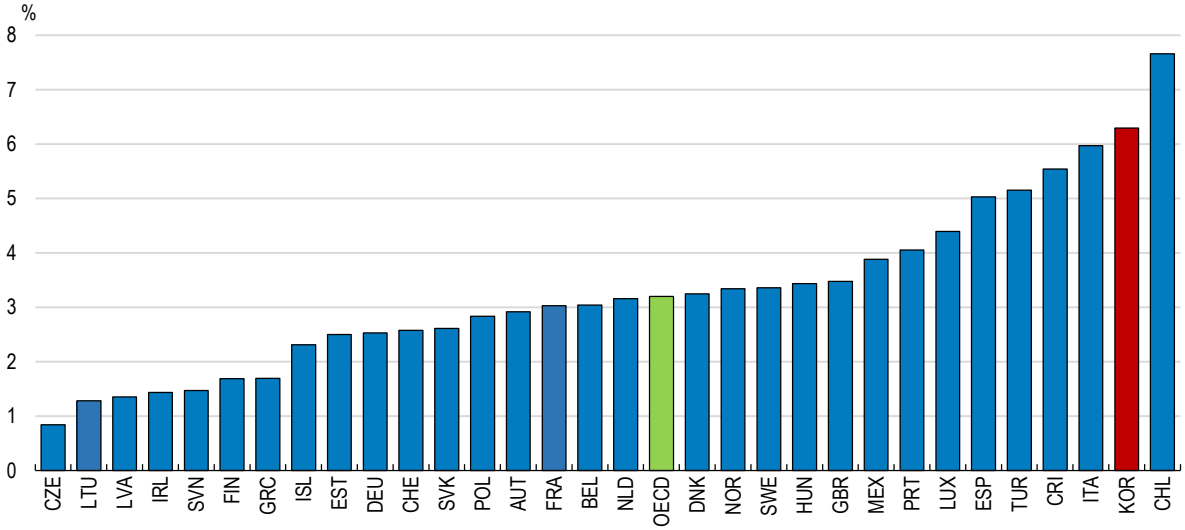
Figure 24. Privacy violations are second highest in Korea

Share of Internet users who experienced abuse of private information on the Internet, 2015



Note: 2017 for Korea and Mexico; 2014 for Chile and Switzerland. For Korea, the share in 2015 is 7%.
Source: OECD (2019b), calculations based on OECD ICT Access and Usage by Individuals Database.

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Better online security can be achieved through higher skills, more robust digital security technologies and the involvement of the government to lead by example. High-skilled individuals are more likely to be aware

of online security threats and find solutions to address them, like managing the access to personal information online, using anti-tracking software and changing website settings to limit cookies (OECD, 2019f). A well-rounded set of skills in literacy, numeracy and problem-solving in technology-rich environments improves individuals' abilities to protect themselves against online security breaches. Additional education from school and training explicitly dedicated to such digital issues can also increase individuals' awareness and help them adopt a safer online behaviour. Digital technologies such as blockchains can also be powerful tools to strengthen safety of transactions and information exchange or block hacking (quantum cryptography communication). In this regard, Korea lags behind countries like the United States, Japan or China (IITP, 2019). Research and investment in these next-generation security technologies must be promoted with financial incentives.

Towards a sound digital society and culture

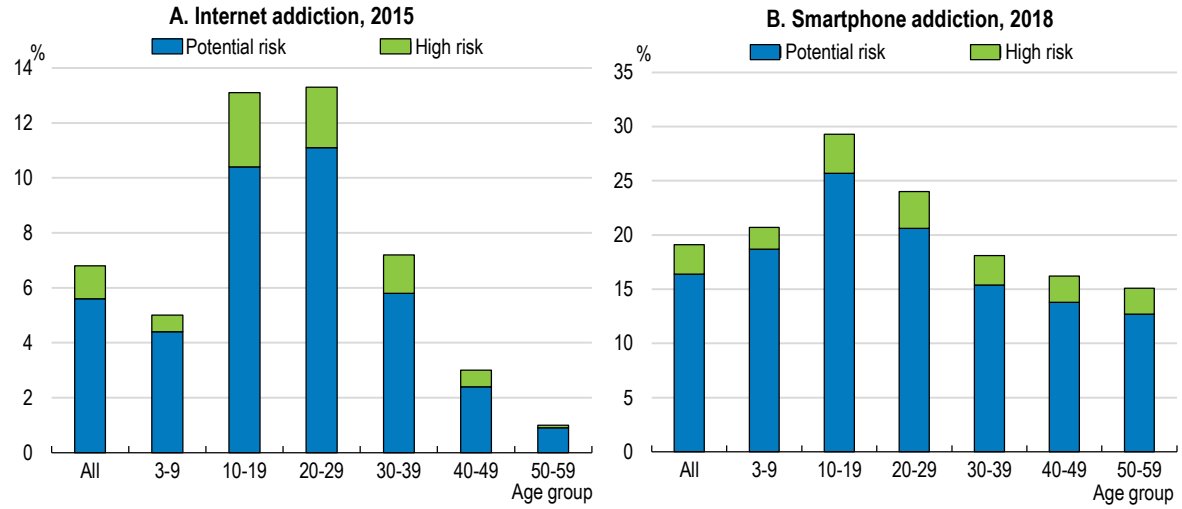
Other downsides of digital transformation include cyberbullying and other forms of online harassment like cyber-stalking, as well as excessive dependence on the Internet or smartphones. Hidden behind the anonymity provided by the Internet, bullying perpetrators feel freer to harass their victims in their public and private lives, at any time, by spreading false rumours or sending threats. Such online harassment can generate severe mental health problems, leading in extreme cases to suicide (OECD, 2019g), as was the case for two K-pop singers in 2019. Children and teenagers are more exposed to online harassment, especially as smartphones keep them connected at all time to the Internet and social networks. Parents with higher digital skills are more likely to educate their children about a sound use of the Internet and address cyberbullying issues (OECD, 2019f). ICT education at school, as well as information campaigns on Internet cyber violence prevention are key to promote a sound web culture. Removing comment sections on entertainment and sports news as Naver and Daum after the K-pop tragedy can also help limiting malicious comments.

The increasing use of new technologies and devices may also generate health problems (such as sleep disorder, depression or stress) and harm social relationships, mainly because of the constant connectivity and the wide range of online activities (Montagnier, 2016). This mainly affects youth and children who can end up missing school. In Korea, youth aged 10-29 are at much higher risk of Internet or smartphone addiction than other age categories. In the case of smartphone addiction, risks are also higher for children less than 10 years old (Figure 25). Provide specific and compulsory ICT courses in school and training in firms, can help raise awareness of dangers related to digital addiction and reduce it.

The relationship to work has changed amid the COVID-19 outbreak as more firms resorted to telework to contain the spread of the virus. In the United States 5% of working days were spent at home before the outbreak, against 40% during the pandemic (Bloom, 2020). Korean firms also rapidly turned to telework. Based on a survey of 300 enterprises, 45.8% of large enterprises, 30.6% of mid-sized enterprises and 21.8% of SMEs practiced teleworking after the COVID-19 outbreak, against respectively 9.7%, 8.2% and 6.7% before the outbreak (Korea Chamber of Commerce and Industry, 2020). The Korean government also encouraged the use of flexible work arrangements in SMEs – staggered hours, work from home, remote work – by simplifying the procedures to apply for a subsidy from late February 2020. The subsidy can go up to KRW 5.2 million (USD 4 300) a year per worker. After the COVID-19 crisis, the number of teleworked days is expected to decrease, while remaining higher than before the pandemic. In the United States, 20% of working days are likely to be spent at home – four times higher than before the COVID-19 crisis (Bloom, 2020). Beyond containing the spread of the virus, teleworking can improve firms' productivity, workers' well-being and help tackle other economic and social issues, such as gender and regional inequalities, housing, carbon emissions and traffic congestion (Bloom et al., 2014; OECD, 2020b). However, teleworking can also have adverse effects, such as lower productivity for workers who lack an appropriate working environment at home, less innovation because of impaired communication or increased hidden overtime. To make the most of teleworking, policymakers can promote the diffusion of

best management practices, self-management and ICT skills, investment in home offices, and fast, reliable and secure ICT infrastructure for firms and workers (Bloom, 2020; OECD, 2020b).

Figure 25. The share of Korean youth at risk of addiction to Internet and smartphones is high



Source: Montagnier (2016), calculations based on based on National Information Society Agency of Korea (NIA) Survey on Internet overdependence 2015; NIA Survey on smartphone dependence.

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Recommendations to promote the diffusion of technology to tackle the COVID-19 shock and to boost productivity and well-being

Key recommendations in bold

MAIN FINDINGS	RECOMMENDATIONS
Diffusion of technology	
Product market regulations remain tight. However, the government has introduced a programme to shift the burden of proof from the regulated to the regulator and regulatory sandboxes are allowing firms in new technologies and new industries to test their products and business models without being subject to all existing legal requirements. The temporary lifting of the ban on telemedicine during the COVID-19 outbreak illustrates the potential benefits of a timely review of regulations.	**Use regulatory sandboxes to identify excessive regulation and revise or abolish it. Facilitate telemedicine, as long as it is compatible with preserving patient safety and quality of care.**
Subsidies to SMEs have limited effects on promoting growth and boosting innovation and productivity. Despite the efforts of the Korean government to better target subsidies, the latter still allow the survival of low-productivity companies.	**Subsidies to SMEs should focus more on promoting growth and boosting innovation and productivity. Provide SMEs in manufacturing and services with innovation vouchers that can be used to commission R&D and studies on potential for new technology introduction.**
Korean SMEs lag behind in the adoption of sophisticated digital technologies, hampering telework and adaptation to digitalisation.	Further strengthen the collaboration of SMEs with large enterprises and with academia, for instance through an open collaborative network to design new products and services, and exchange data.
Korean SMEs face a lack of funds and expertise on project feasibility, which prevents them from launching new products developed through R&D.	Reallocate financial support for technology R&D to commercialisation for SMEs that successfully developed new technology.
Lifelong learning in digital fields	
SMEs face a lack of skilled workers, notably in digital fields, and their employees have limited access to training. Managers' awareness of the potential of digital technologies is insufficient. The digital skills gap between youth and older generations is the highest in the OECD.	**Provide more basic ICT courses to SME employees and older persons, reduce training costs for SMEs and provide targeted adult learning programmes to SME managers.**
Most teachers feel they are not sufficiently prepared to use ICT for teaching, which has been a hurdle during the COVID-19 school closures.	Make refresher training mandatory for adult learning teachers to update their skills on a regular basis.
Fast technological change implies a constant need to update and develop new skills throughout life. SME employees face time constraints preventing them to participate to training and ICT training in SMEs is scarce.	Leverage distance and modular learning for digital skills and lifelong-learning to provide a wide range of courses and more flexibility to learn and work at the same time, and define standards and good practices to better signal their quality.
Lack of information or difficulties to find it because of numerous competing online career guidance platforms, is another barrier to training for SME workers.	Merge all online career guidance platforms to centralise information on available training programmes for SMEs and help users navigate training options.
More specialists and high-level researchers in fourth industrial revolution core technologies like artificial intelligence and big data are needed.	Introduce courses at school, develop tertiary graduation programmes and provide trainings in firms dedicated to artificial intelligence and big data.
Digital security and well-being	
A relatively high share of individuals experienced privacy violations and youth are at higher risk of Internet and smartphone addiction. Privacy issues also arose in the context of the COVID-19 crisis control measures.	Provide specific ICT courses in schools and training in firms to raise awareness of digital dangers such as cyberbullying, privacy violation and addiction to ICT technologies.
Korea lags behind in the adoption of next-generation security technologies like blockchains and quantum cryptography communication.	Reallocate R&D support to promote research and investment in next-generation security technologies.

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