2 Korea's economic performance and framework for innovation

This chapter sets out an overarching framework for Korea's National Innovation System. It starts by summarising Korea's past and current economic performance by way of international comparison. Next, it highlights Korea's innovation system's key strengths, given its preparedness for transitional challenges, including the digital transformation, its growth in labour and multifactor productivity and innovation inputs. Subsequently, it elaborates on Korea's industry structure and how it sets the conditions for innovation, particularly regarding knowledge-intensive activities. Pursuant to a discussion of Korea's current positioning in global value chains and the impact it has on technological sovereignty and potential for innovation, this chapter finally addresses Korea's particular vulnerabilities in the face of arising societal challenges, notably the green transition and population ageing, and how these may affect framework conditions for innovation.

There are many contextual factors which have enabled Korea's remarkable success in catching up with advanced economies. Shaping industries of the future is generally dependent on a strong macroeconomic framework, including, among others, a robust industry structure, high labour productivity and a skilled workforce, as well as large investments and influx of talent from abroad. Moreover, governments need to strategically provide the baseline conditions which promote innovative activities, such as when allocating financial resources to research and development. Mounting societal challenges and global transitions are increasingly shaping the contextual conditions for businesses, academia and civil society to proactively engage in innovation and carry substantial risks, which calls for strategic and decisive government action to minimise these risks whilst taking advantage of emerging opportunities early.

This chapter sets out an overarching framework for Korea's National Innovation System,[1] how it has contributed to economic development in the past and its prospects for promoting continued growth in the future. The sections provide a comprehensive overview of the National Innovation System, in particular in view of its preparedness for transitional challenges, notably the digital transformation. The first section summarises Korea's past and current economic performance by way of international comparison with other OECD countries in particular. Secondly, Korea's innovation system's key strengths, such as its growth in labour and multifactor productivity and innovation inputs, are highlighted. The subsequent and third section elaborates on Korea's industry structure and how it sets the conditions for innovation, particularly regarding knowledge-intensive activities. Pursuant to a discussion of Korea's current positioning in global value chains and the impact it has on technological autonomy and potential for innovation in its fourth section, this chapter finally addresses Korea's particular vulnerabilities in the face of arising societal challenges, notably the green transition and population ageing, and how these may affect framework conditions for innovation.

Based on a comprehensive analysis, the chapter derives the following conclusions.

- First, Korea's rapid economic growth has been driven by a developmental state in the past which prioritised export-led growth, in particular in the manufacturing and ICT-intensive sectors. Furthermore, innovation inputs such as human capital and research and development expenditure are some of the highest worldwide and have contributed to Korean success in innovation, which manifests itself in global leadership, in particular in some digital technologies.
- Secondly, the speed of Korean catch-up has, in part, led to imbalances in industry and society as a lot of growth occurred in specific sectors, population segments and regions. For instance, knowledge-intensive services and non-ICT industries have significant potential and universities and SMEs in rural areas often lag behind those in the metropolitan areas where most innovative activity accumulates. The government has recognised this and launched multiple efforts to counter partially widening gaps in industry and society.
- Thirdly, Korea shows very strong internationalisation when considering its production value chains, which tend to be highly embedded globally. In view of recent geopolitical tensions, more strategic collaboration with like-minded partners may be a worthwhile choice for Korean technological autonomy. Furthermore, despite high investments from abroad as well as immigration of foreign students, there is potential for further growth and diversification.
- Finally, compared to other advanced nations, Korea is particularly strongly affected by some of the global transitions, notably population ageing and the green transition, which will require structural reforms to its established manufacturing industries, in particular in terms of achieving emission targets. There is ample scope for policy to shape the Korean innovation success story for the decades to come when addressing societal challenges effectively.

2.1. Korea's economic performance has been impressive and leads the digital transformation

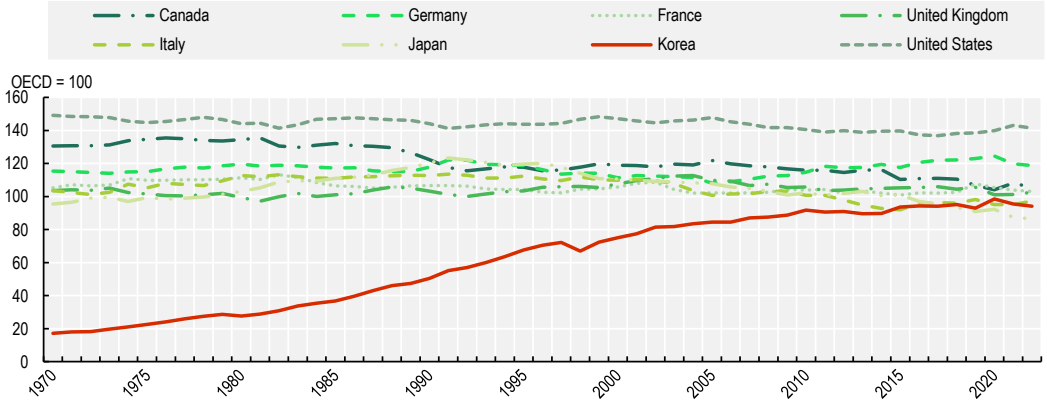
2.1.1. Korea has seen a highly successful transition to high-income status

Korea achieved remarkable success in catching up with other high-income economies between the early 1960s and the late 1990s. This has come to be known as the *Miracle on the Han River*, largely spurred by Korea's import substitution and export-oriented strategies in competitive manufacturing industries; high levels of investments in physical and human capital; improvements in institutional quality; and strong strategic initiatives spearheaded by the government and the private sector. Within its investment-led economic growth scheme, science and technology policies had been considered largely subordinate to industrial policies and a means to achieve rapid economic growth. Until the late 1970s and 1980s, the focus had been on technological capacity building for the heavy and chemical industries. However, as those industries started to decline, the government took on a more proactive role in fostering the development of core technologies, which would prove to be longer-term growth engines for the economy.

Korea's gross domestic product (GDP) per capita has caught up with that of high-income OECD economies and shown impressive growth since the 1970s when its income level relative to the OECD average stood at 17% compared to 99% in 2021 (Figure 2.1). In 2021, Korea had the 18th highest GDP per capita among OECD countries, with USD 48 985 per head. The compound annual growth rate (CAGR) of its GDP per capita had been as high as almost 12% during the 1980s but slowed to 7.2% in the 1990s and further declined to 4.8% in the 2000s. In the most recent decade, between 2011 and 2021, the CAGR has been 2.4%. Overall, the pace of growth has slowed and is converging with that of advanced OECD economies. In 2018, Korea's GDP per capita surpassed Japan's, one of its leading benchmarking countries.

Figure 2.1. GDP per capita for selected countries, 1970-2022

Current PPPs, OECD = 100



Source: OECD (2023), "National Accounts at a Glance", *OECD National Accounts Statistics* (database), https://doi.org/10.1787/data-00369-en (accessed on 19 June 2023).

Manufacturing contributes the largest share of Korea's GDP (27%), a share that has largely remained stable between 2011 and 2021 (Table 2.1). Services activities have grown in their contribution to GDP, notably in finance and insurance (5%), information and communication (3.6%), as well as in the sector of human health and social work (5.7%). It is worth noting that the growth trajectories of some of the sectors have been strongly affected by the coronavirus (COVID-19) pandemic as well as the ongoing war in Ukraine, which may see hindered imports of raw materials in the medium to long term, notably in

semiconductor production, which is highly reliant on such inputs from Ukraine and the Russian Federation. This applies particularly to the cultural and other services sector, which saw modest growth between 2011 and 2019, with a CAGR of 1.4%. In contrast, the industry has significantly declined between 2019 and 2021 from KRW 46.5 billion (Korean won) to KRW 36.4 billion, reducing the CAGR over the past decade between 2011 and 2021 to -1.1%. Most sectors follow a similar trend. Nevertheless, some industries have not only grown between 2019 and 2021 but have also had a higher 2011-21 CAGR than 2011-19 CAGR, which implies even higher growth than before the pandemic. This holds notably for manufacturing, finance and insurance, as well as information and communications technology (ICT) industries and agriculture.

Table 2.1. Breakdown of real GDP by economic activity, Korea, 2011-21

Constant prices (2015)

Economic activity	2011		2019		2011-19	2021		2011-21
	KRW billions	%	KRW billions	%	CAGR	KRW billions	%	CAGR
Agriculture, forestry and fishing	30 571.2	2.07%	32 099.3	1.67%	0.54%	32 634.3	1.70%	0.60%
Mining and quarrying	2 345.5	0.16%	2 008.9	0.10%	-1.71%	1 879.5	0.10%	-1.99%
Manufacturing	40 2282	27.20%	485 401.2	25.22%	2.11%	517 025.0	26.99%	2.31%
Electricity, gas and water supply	39 822.6	2.69%	36 644.3	1.90%	-0.92%	48 610.4	2.54%	1.83%
Construction	72 504.5	4.90%	104 855.2	5.45%	4.18%	85 901.7	4.48%	1.55%
Wholesale and retail trade, accommodation and food services	143 211.0	9.68%	184 603.8	9.59%	2.86%	174 342.0	9.10%	1.80%
Transportation and storage	52 570.8	3.55%	60 688.7	3.15%	1.61%	55 309.9	2.89%	0.46%
Finance and insurance	70 355.9	4.76%	104 251.7	5.42%	4.47%	119 644.0	6.25%	4.95%
Real estate	113 402.0	7.67%	141 409.0	7.35%	2.48%	139 494.0	7.28%	1.90%
Information and communication	61 600.8	4.16%	83 040.6	4.31%	3.37%	91 317.4	4.77%	3.64%
Business activities	116 793.0	7.90%	175 384.5	9.11%	4.62%	162 133.0	8.46%	3.03%
Public administration, defense and social security	84 904.4	5.74%	121 818.0	6.33%	4.09%	115 623.0	6.04%	2.85%
Education	77 321.3	5.23%	94 401.2	4.91%	2.24%	89 488.1	4.67%	1.34%
Human health and social work	49 824.9	3.37%	89 510.8	4.65%	6.73%	91 405.7	4.77%	5.67%
Cultural and other services	41 211.8	2.79%	46 515.8	2.42%	1.35%	36 415.9	1.90%	-1.12%
Gross value added at basic prices	1 356 276	-	1 762 633.0	-	2.95%	1 759 054	-	2.39%
Taxes less subsidies on products	122 815	8.30%	161 865.1	8.41%	3.12%	156 837	8.19%	2.25%
Gross domestic product at market prices (GDP)	1 479 198	100.00%	1 924 498	100.00%	2.97%	1 915 778	100.00%	2.38%

Note: CAGR: Compound annual growth rate. 2019 included to show the trend up until the COVID-19 pandemic.
Source: OECD calculations based on Bank of Korea Economic Statistics System (n.d.[1]), *National accounts*, https://ecos.bok.or.kr/#/SearchStat, June 2022.

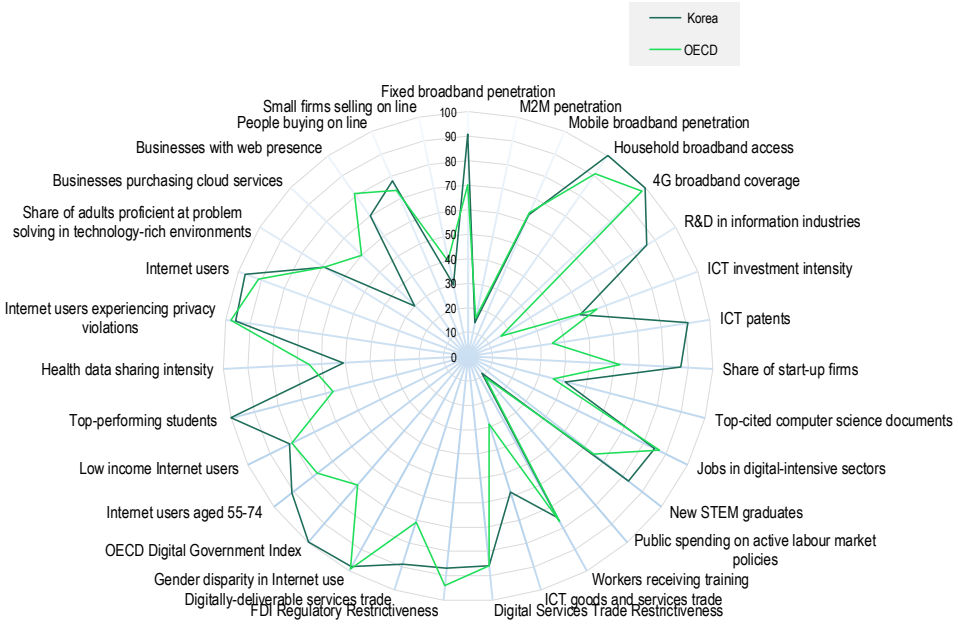
2.1.2. Korea has demonstrated leadership in the digital transformation

Korea has demonstrated its global leadership in the digital transformation through its proactive stance in developing strategic initiatives, such as the national 5G vision, which was among the first among OECD

countries. Korea was not only the first country worldwide to adopt 5G technology on a large scale in April 2019, but the government launched a comprehensive "5G+" strategy envisioning a whole infrastructure based on 5G technology for selected "core services and industries", including smart manufacturing, smart cities, digital healthcare, information security, robots and drones. This initiative includes investments in the public sector and incentivising private investment, e.g. to encourage small- and medium-sized enterprises (SMEs) to uptake 5G technology. Furthermore, the government plans to ensure greater utilisation through cost reduction, and bridging divides in terms of access, to establish a domestic 5G industrial base as well as to support globalisation efforts for 5G technology by promoting 5G services internationally and by taking the lead in setting standards (Ministry of Science and ICT, 2019[2]). As of November 2021, 5G subscriptions exceeded 20 million, which is around 28% of mobile subscriptions (Ministry of Science and ICT, 2021[3]). This is higher than the regional average for Northeast Asia, which currently stands at 24%; North America at 20%; and Western Europe at 6% (Ericsson, 2021[4]).

The *OECD Going Digital Toolkit* shows that Korea's positioning in the digital transformation is exceeding the OECD average on many indicators (Figure 2.2). Korea fares particularly well in the quality of students, the number of ICT patents, the Digital Government Index, the share of start-up firms among all businesses, research and development (R&D) in information industries, and broadband penetration. Regarding the latter, for instance, Korea has the highest share of fibre subscriptions among OECD countries, with about 86.6% of total fixed broadband in 2021 (OECD, 2021[5]). The advantages of fibre are multi-fold for businesses, including cost savings, improved reliability and security, as well as very high speed, allowing for the seamless transfer of increasing volumes and traffic of data, which in turn enables the adoption of productivity-enhancing digital technologies, such as cloud computing.

Figure 2.2. Korea's performance on key digital transformation indicators, 2022



Note: Scores range from 0-100, with 100 representing the highest achievement by an OECD country. OECD score refers to the sample average for the OECD countries with available data. Top-performing students refers to proficiency in mathematics, science and reading. M2M penetration is the number of machine-to-machine SIM cards per 100 inhabitants. STEM stands for science, technology, engineering and mathematics.
Source: OECD (n.d.[6]), *Going Digital Toolkit*, oe.cd/4B7, July 2022.

Nevertheless, the share of businesses purchasing cloud services is low compared to the OECD average, reflecting the continuous struggles of SMEs, in particular, with digitalisation. This is notable because these firms feel burdened by the costs of switching to cloud services from traditional systems. The government

is providing businesses with various support measures, including consulting, training, service development and vouchers, to boost the cloud industry. This being said, a lack of relevant skills is an underlying factor for the low uptake of new technologies, not least because SMEs employ a relatively large share of older workers who lag behind in terms of digital and ICT skills (Lee and Kwak, 2022[7]), as discussed later in this chapter. In this regard, it is of particular relevance that spending on active labour market policies is comparatively low, with 0.4% of GDP compared to an OECD average of 0.5%, far behind New Zealand (4%), Australia (1.6%) or Finland (0.7%). Considering Korea's strengths in ICT industries, increasing job readiness through incentives for employment and start-up creation, as well as training to ensure suitable employment, would benefit the digitalisation of SMEs.

The Government of Korea is also aiming to lead in artificial intelligence (AI). Besides its National Strategy for Artificial Intelligence (2019), it is working on a project that collects data (image, video, text, voice, etc.), processes it into a suitable form for AI modelling and presents it on AI Hub (aihub.or.kr) to revitalise and promote a wider AI ecosystem. Furthermore, the Ministry of Science and ICT has opted for a multi-stakeholder approach by encouraging strong involvement from private sector companies in different sectors, including automobile, telecommunications, semiconductors and gaming (World Bank, 2022[8]). Strong engagement by the government is indeed complemented by extraordinary investments from the private sector, including in 5G and AI, most notably by Samsung Electronics, which, in May 2022, pledged USD 356 billion of investments into, besides its core area of semiconductors and bioproducts, high-tech areas such as AI and 5G as well as 6G over the next five years, with the majority of it being foreseen for inside Korea. This investment is expected to create around 80 000 jobs in the country (CNN, 2022[9]).

2.1.3. Korea's labour productivity has grown but remains below the OECD average

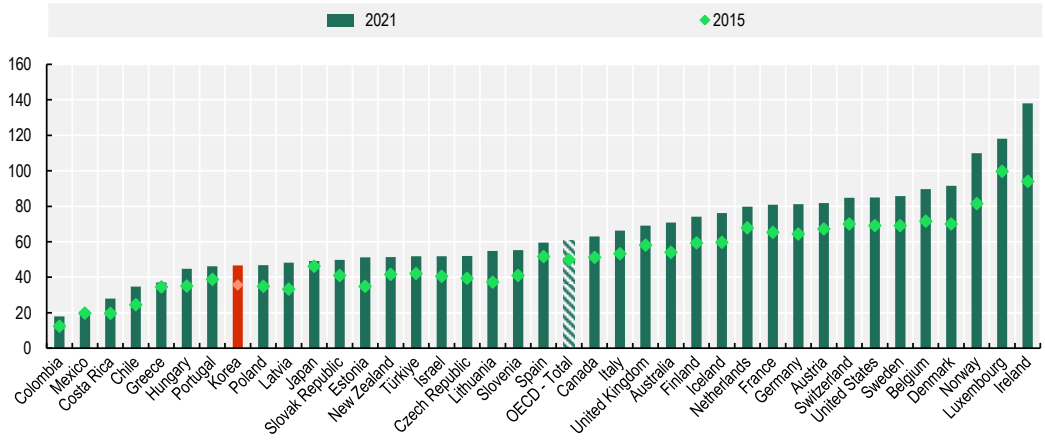
In Korea, the key growth challenge has shifted from accumulating physical and human capital to raising productivity through structural transformation (Swinston, 2021[10]). This calls for rethinking the past success factors that have led to Korea's rapid economic catch-up. Depending on whether Korea makes necessary adjustments and is open to experimentation, such challenges may remain risks or be translated into opportunities.

Labour productivity is the key dimension of a country's economic performance. In Korea, relatively high labour productivity growth until the last decade (7.4% in 1980-99 and 4% in 2001-12) helped reduce the productivity gap (OECD, 2016[11]; OECD, 2019[12]). Thanks to sustained productivity growth, wage growth has been among the strongest in OECD countries (OECD, 2021[13]). As a result, working conditions have significantly improved, and the share of workers working very long hours has been significantly reduced. The labour market has become relatively more inclusive as the share of low-income workers has decreased from 17% in 2006 to 13% in 2019 (compared to an OECD average of 11% in 2019), and the gender pay gap narrowed from 39.5% in 2010 to 32.5% in 2019 (OECD average: 12.5%) (OECD, 2021[14]). However, there exists further scope for progress as, despite continued growth, the productivity level remains below that of most advanced economies and the OECD average (Figure 2.3).

A major reason for low labour productivity in Korea is that the economy's skill composition does not, in part, adequately correspond to business needs, in particular in technology-intensive sectors. Korea's exceptionally high educational attainment (69.8% of 25-34 year-old adults with tertiary education compared to the OECD average of 45.6%) as a source for innovation is considered a role model for many countries. However, the limited availability of workers with the skills required for available jobs demonstrates that their skills are not well-utilised in the market (OECD, 2022[15]). For instance, according to the Survey of Adults Skills (a product of the Programme for the International Assessment of Adult Competencies, PIAAC) (Figure 2.4), the share of adults reaching the highest level in problem solving in technology-rich environments is relatively low, in particular in comparison with other innovation leaders, such as Finland, Japan and Germany. Furthermore, in 2018, Korea had the second-highest rate of adults failing the ICT test in the OECD Survey of Adult Skills, as further explained in Chapter 4.

Figure 2.3. Labour productivity in Korea and selected countries, 2015 and 2022

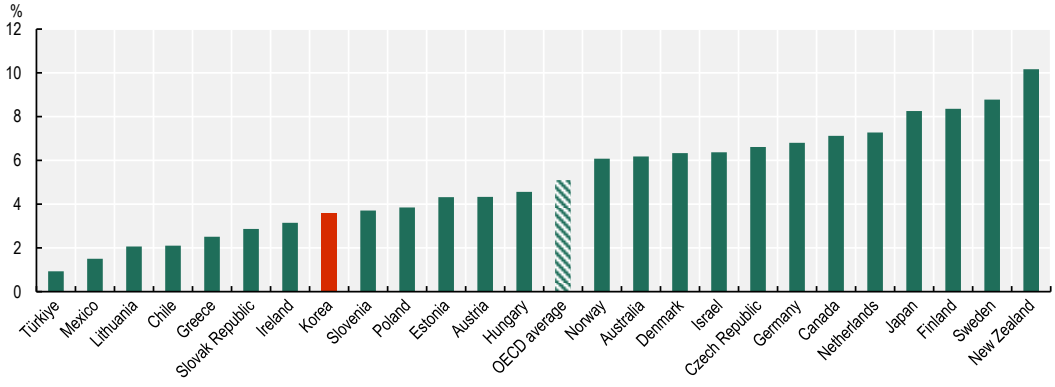
GDP per hour worked, USD, current prices, current PPPs



Note: Current prices (PPP). Data for 2022 or latest available.
Source: OECD (2023), *Productivity Statistics* (database), oe.cd/il/4B8 (accessed on 22 June 2023).

Figure 2.4. Adult proficiency in problem solving in technology-rich environments in Korea and selected countries, 2018

Percentage of adults with the highest level of proficiency in problem solving in technology-rich environments



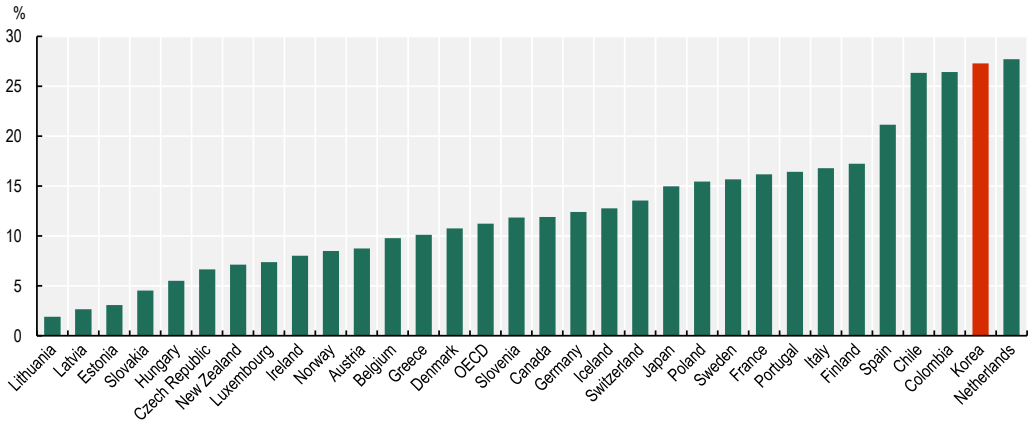
Note: Highest level refers to level 3 out of 3.
Source: OECD (2018[16]), *Survey of Adult Skills (PIAAC)*, oe.cd/4BE, June 2022.

Even though technology literacy and proficiency are improving dramatically among the younger generation, skills mismatch continues to be a concern due to student preferences to enrol in university programmes that do not necessarily correspond to their interests or skillsets – in order to study at top-ranked institutions (OECD, 2022[17]). In addition, the skills mismatch also relates to the high number of fixed-term contracts in Korea. The correlation between mismatch and contract types, i.e. whether workers on fixed-term contracts are more likely to be mismatched relative to indefinite contract holders, has proven to hold significance in Korea as well as Ireland, Poland and Sweden (Adalet McGowan and Andrews, 2015[18]) (OECD, 2022[15]). Furthermore, temporary employment has been shown to reduce technology efficiency and productivity in firms (Choi, Choe and Lee, 2021[19]), which is of particular relevance for Korea since it has the second-highest temporary employment rate among OECD countries (26%), second only to Colombia (27.3%) (OECD average: 11.4%) (Figure 2.5). This may be the consequence of the high protection of workers

under fixed contracts. Korea has the 13th most stringent dismissal regulation for workers on regular contracts (index 2.41), next to Sweden (2.45), compared to the OECD average of (2.06) (OECD, 2020[20]).[2] In the end, both the youth and female workforces, for whom the incidence of temporary employment is disproportionately high, may face deteriorating working conditions (Swinston, 2021[10]), affecting economy-wide productivity by causing an inefficient "revolving door", whereby workers who are constantly subject to short-term employment and unemployment, see reduced investment in on-the-job training measures and thus less accumulation of skills (Cabrales, Dolado and Mora, 2014[21]).

Figure 2.5. Temporary employment rates in Korea and selected countries, 2022

Temporary employment % of dependent employment, 2022 or latest available year



Note: Temporary employment includes wage and salary workers whose job has a pre-determined termination date. National definitions broadly conform to this generic definition but may vary depending on national circumstances.
Source: *OECD Labour Market Statistics: Employment by permanency of the job: incidence* (database), oe.cd/dp/4Bq (accessed on 21 June 2023).

2.1.4. Korea's GDP growth has been supported by a high level of multifactor productivity

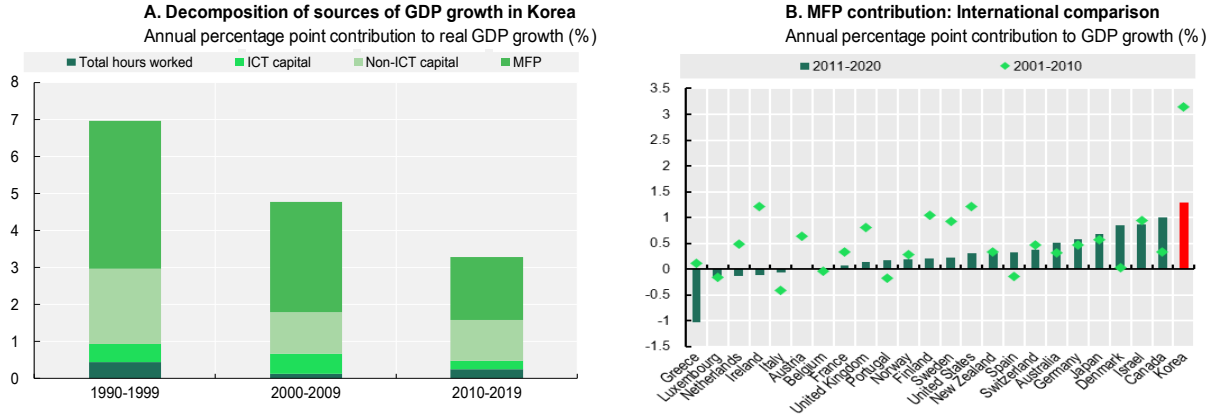
Among the various enablers of Korea's successful catch-up is its high multifactor productivity (MFP) growth. MFP represents the efficiency of the combined use of labour and capital in the production process (OECD, 2019[12]). Growth in MFP is measured as a residual, therefore capturing what cannot be explained by capital and labour inputs. Its variations reflect, for instance, the changes in management, organisational aspects, general knowledge and spillover from production factors and are generally associated with innovation and technology.

The relatively high contribution of MFP to GDP growth helps explain Korea's catch-up economic trajectory (Figure 2.6, Panel A). Capital services and MFP accounted for the biggest part of GDP growth in most OECD economies in the last two decades. However, the pace slowed over time, in parallel with the slowing pace of overall economic growth. Moreover, nearly all countries experienced a deceleration in MFP growth after the global financial crisis. Korea witnessed a significant slowdown along with Finland, Sweden, the United Kingdom and the United States (OECD, 2019[12]). Nevertheless, MFP's contribution to GDP growth in Korea remains the highest among OECD countries (Figure 2.6, Panel B).

When considering industry sectors, the trend in the manufacturing sector is concurrent with the overall change in MFP (Swinston, 2021[10]). Swinston finds that MFP growth in export-oriented manufacturing, especially in the high-tech industries, has been a key driver for Korea's economic growth. MFP in high-tech sectors soared from the 1980s until the 1990s, which coincides with the period when Korea's electronics industry greatly expanded. Helpful findings are presented by Foster-McGregor and Verspagen

(2017[22]), where MFP growth in Korea's manufacturing industry (78.6%) between 1995 and 2009 is found to have outpaced those of other countries except for the People's Republic of China (hereafter "China").

Figure 2.6. Multifactor productivity growth and GDP growth in Korea and selected countries



Source: OECD (2022[23]), *OECD Productivity Statistics* (database), oe.cd/il/4B8, May 2022.

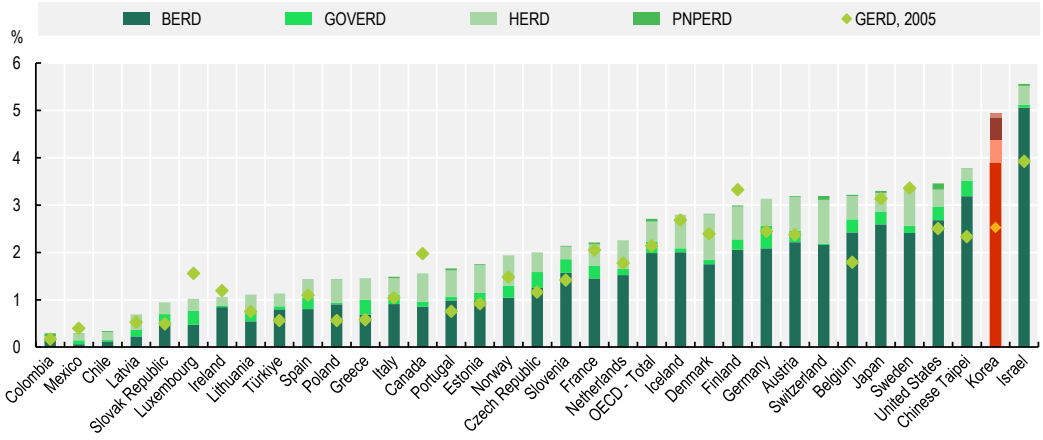
2.1.5. Korea is a leader in R&D spending

The extent to which countries mobilise financial and human resources for science, technology and innovation (STI) varies markedly across countries. Korea stands out among OECD countries for its high spending on innovation, as measured by gross expenditure on research and development (GERD) (Figure 2.7), amounting to 4.9% of GDP, which is second only to Israel. As is the case for most countries across the OECD, business expenditure on research and development (BERD) as a percentage of GDP (3.9%) significantly outweighs government (GOVERD) and higher education expenditure (HERD), which account for comparable shares with 0.5% each. In addition, overall GERD has increased significantly compared to 2005, when it stood at 2.5%, implying Korea not only belongs to innovation-intensive countries in terms of the highest absolute shares of GDP but also growth, with a CAGR of 4.1% since then.

In terms of human resources for innovation, Korea belongs to the OECD countries with the highest shares of R&D personnel per thousand labour force (Figure 2.8, Panel A). This share has demonstrated a steeper rise since 2005 compared to other innovation leaders and China. Notably, Korea has the highest share of R&D personnel in the business sector in absolute and relative terms (Figure 2.8, Panel B), with about 15 per thousand labour force. In most OECD countries, businesses account for the largest share of R&D human resources. This particularly holds for Korea, where comparatively small shares of personnel are in the higher education (2.8) and government (1.44) sectors. A more detailed breakdown of BERD and R&D personnel in businesses is provided in Chapter 3. HERD and GOVERD, as well as research personnel in the public sector, are discussed in Chapter 4.

Figure 2.7. Expenditure on R&D in Korea and selected countries, 2021

Percentage of GDP, 2021 or latest year available



Source: OECD (2022[24]), *Main Science and Technology Indicators* (database), oe.cd/msti, May 2023.

Table 2.2. Korea's expenditure on R&D by sector of performance and source of funds

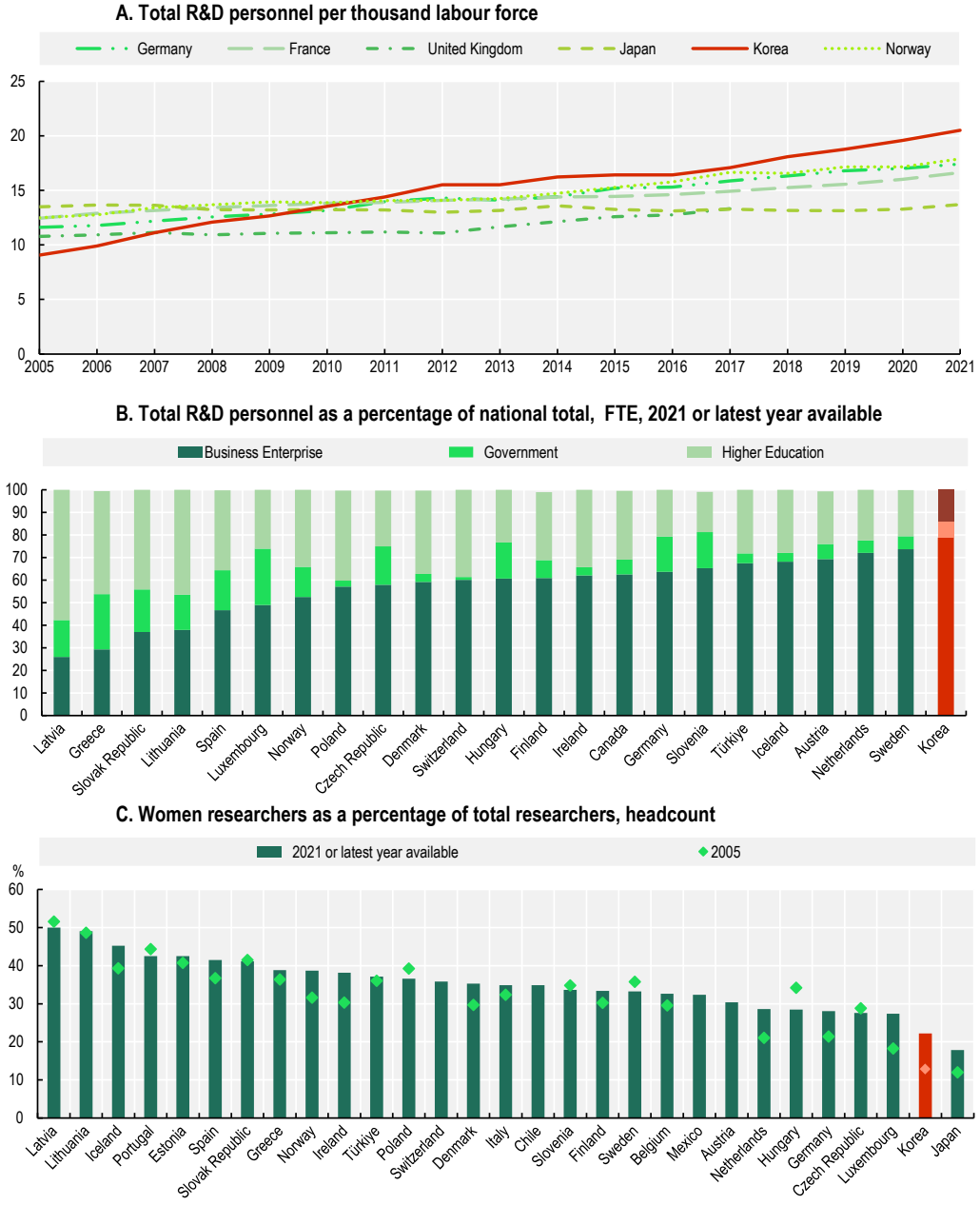
In USD, share of expenditure in parentheses

Sector of performance Source of funds	Business enterprise	Government	Higher education	Total (performance)
Business enterprise	54 117.4 (97.8%)	202.3 (2.3%)	833.4 (12.3%)	55 153.1 (74.3%)
Government	2 952.3 (5.3%)	8 383.4 (96.2%)	5 345.3 (79.2%)	16 681.0 (22.5%)
Higher education	21.0 (0.03%)	16.3 (0.2%)	439.5 (6.5%)	476.8 (0.6%)
Private non-profit	16.1 (0.03%)	84.1 (1%)	76.5 (1.1%)	176.7 (0.3%)
Funds from abroad	430.4 (0.8%)	29.0 (0.3%)	55.2 (0.8%)	514.7 (0.7%)
Total (funding sector)	55 326.2 (100%)	8 715.1 (100%)	6 750.0 (100%)	74 217.7 (100%)

Source: OECD (2022[24]), *Main Science and Technology Indicators* (database), oe.cd/msti, May 2023.

Regarding the share of female R&D personnel in OECD countries (Figure 2.8, Panel C), Korea had the strongest increase from 2005, with 13% of human resources for R&D being female to 21% in 2020. Nevertheless, this rise occurred from relatively low levels, and as of 2020, Korea still only had the second-lowest share of female R&D personnel.

Figure 2.8. R&D personnel in Korea and selected countries, 2005-2021



Note: In Panels A and B, R&D personnel is measured in full-time equivalents (FTE).
Source: OECD (2023), *Main Science and Technology Indicators* (database), oe.cd/msti, June 2023.

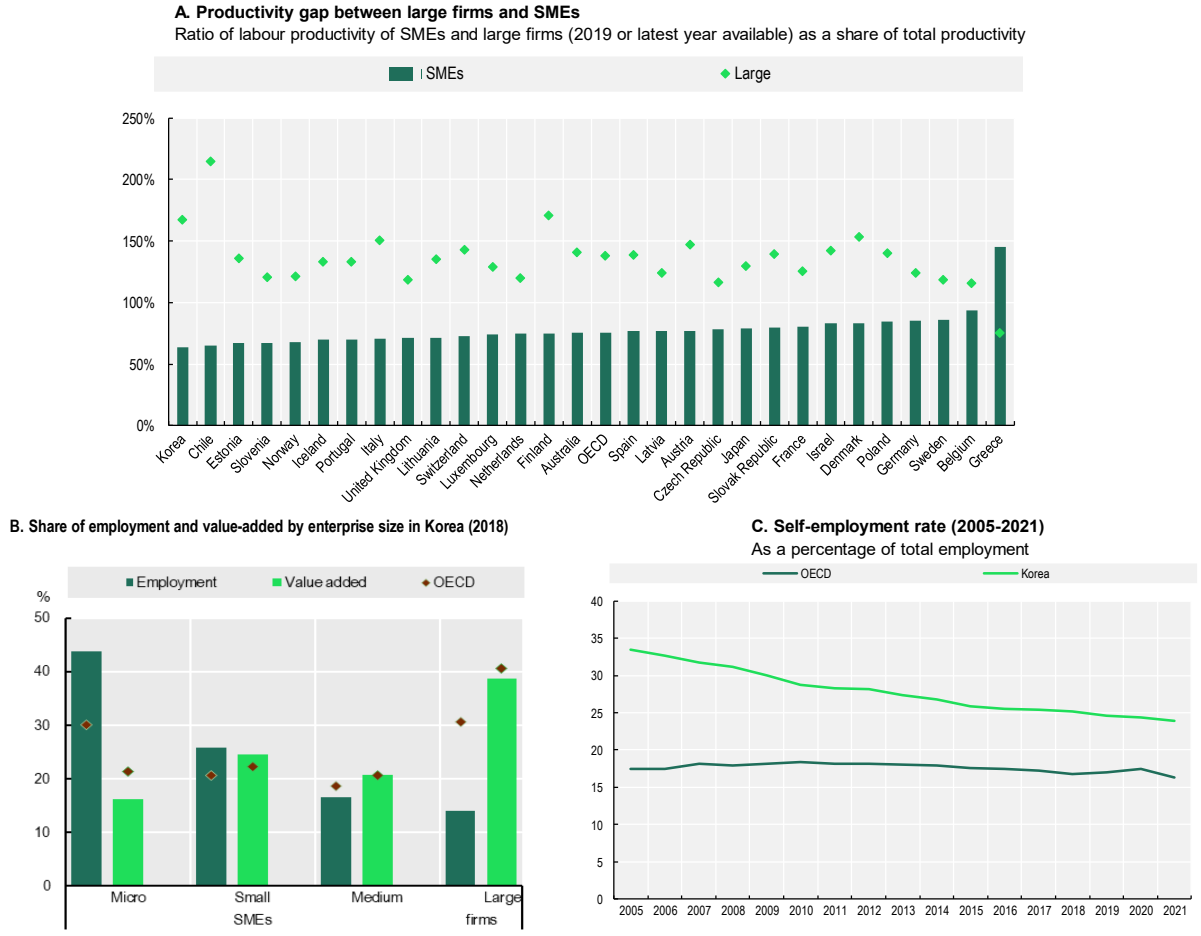
2.2. Korea's industry structure is largely imbalanced

2.2.1. Wide performance disparities exist between SMEs and large enterprises

Within the Korean economy, one striking observation is the dual productivity gap, first between SMEs and conglomerates and second, between manufacturing and services. Regarding the first, Korean SMEs are significantly less productive than OECD countries on average, while large firms tend to be more productive, implying one of the highest productivity gaps (Figure 2.9, Panel A). In many OECD countries, SMEs contribute most to net job creation, and strong SMEs tend to promote broad-based income gains across

regions and industries. In this regard, innovative entrepreneurship is considered a means to achieving inclusive growth (OECD, 2017[25]). However, in Korea, the productivity of SMEs has been declining steadily since the Asian financial crisis in 1997, in marked contrast to the experience of large firms, which boosted their productivity growth, mainly through operational restructuring. Consequently, the government has ramped up its support to SMEs as a potential growth engine (Jones and Kim, 2014[26]).

Figure 2.9. Productivity gap between large firms and SMEs, share of employment and self-employment in Korea and selected countries, 2019



Note: In Panel A, large firms are defined as entities with 250+ employees and SMEs as those with 1-249 employees.
Source: OECD (2022[27]), *Structural Business Statistics (SDBS)* (database), oe.cd/4BI, May 2022; OECD (2021[28]), *SME and Entrepreneurship Outlook 2021*, https://doi.org/10.1787/97a5bbfe-en; OECD (2022[29]), *Self-employment rate*, oe.cd/dp/4BJ, May 2022.

Nonetheless, policies in Korea have sustained the survival of non-viable SMEs despite their dwindling productivity, therefore hampering economy-wide productivity growth (Jones and Lee, 2018[30]). Moreover, non-selective financial support to SMEs not only limits their chances to restructure the excess capacity but also encourages SMEs to remain small at the expense of efficiency gains, as noted in a previous OECD review (OECD, 2014[31]). Furthermore, exit rates of inefficient companies leaving the market were the third lowest in the OECD (OECD, 2017[25]), indicating in part a weakness in the insolvency regime, a longer time to discharge and the lack of an early warning system for bankruptcy. In addition, preferential treatment in public procurement has created unintended moral hazard, encouraging SMEs to overly depend on it at the expense of potential productivity gains. Finally, Korean SMEs receive exceptionally large shares of public funds spent on financial instruments, such as government loan guarantees that reached KRW 80 trillion in 2020 compared to KRW 40 trillion in 2007 (OECD, 2022[32]). Recently, however, the government, notably the Ministry of Economy and Finance, has incorporated policy aspects of enhancing competition and

lowering support to less productive SMEs as part of the new government's economic policy directions (Ministry of Economy and Finance, 2022[33]).

A snapshot of the enterprise landscape in Korea supports such findings (Figure 2.9, Panel B). Employment of the Korean population is more concentrated in micro and small firms[3] (43.8% and 25.7%, respectively) than the OECD average (30.1% and 20.7%). In contrast, large firms account for only 13.9% of total employment compared to the OECD average of 30.6%. Self-employment in Korea is also exceptionally high, but generating lower value-added than the OECD average, although the gap is gradually narrowing (Figure 2.9, Panels B and C) (OECD, 2018[34]) (OECD, 2019[35]).

Uptake of digital technologies by SMEs

In many OECD economies, SMEs and start-ups play a central role in innovation as they tend to benefit from more freedom to experiment with new technologies. In particular, start-ups seek commercial opportunities often overlooked by existing firms (Jones and Lee, 2018[30]; OECD, 2010[36]). In this respect, digitalisation offers several advantages for SMEs to improve performance, spur innovation and enhance productivity to compete with larger firms on a more balanced level-playing field (OECD, 2021[37]). In addition, new ICT applications, such as big data analytics, cloud computing and the Internet of Things (IoT) combined, can enable novel production and organisational processes by increasing firm capacity for simulation, prototyping, decision making and automation (OECD, 2017[38]; OECD, 2021[37]). However, in many OECD economies, size-related gaps often act as a barrier to adopting digital technologies, and SMEs lag in the digital transformation.

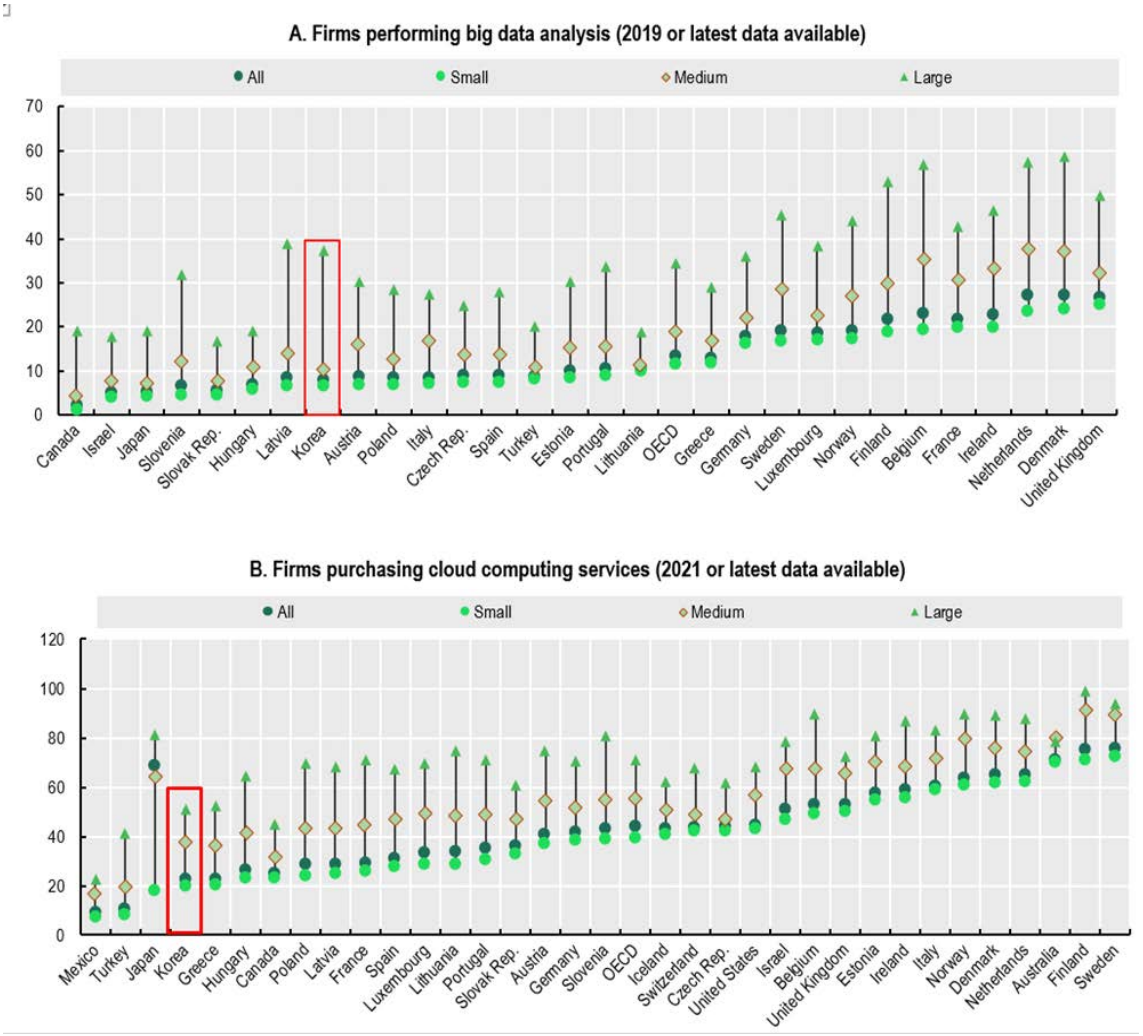
The progress of Korean SMEs, despite the country's leadership in ICT manufacturing and broadband deployment, is slower than that of other OECD economies (Figure 2.10).[4] As the figure illustrates, limited use of new technologies is a universal phenomenon (Panel B) across firms of all sizes, but SMEs face more significant challenges. This can partially be explained by the demographic composition of SMEs, where 43.1% of the workforce was over 50 in 2020 compared to 24.4% in larger firms (KOSTAT, 2020[39]). This has been a long-term trend in Korea, in part due to the low appeal of SMEs for younger skilled workers, while adult employees of SMEs tend to work out of necessity (OECD, 2020[40]). In turn, having lower-skilled employees may result in less labour productivity and revenues, which can further reduce employee remuneration, thereby creating a vicious cycle of lower wages and less appeal for skilled (young) workers.

Innovative firms

Innovative firms are those engaging in at least one product and process innovation (OECD, 2022[41]). The 2018 edition of the *Oslo Manual* defines two types of innovation: "product innovation" and "business process innovation".[5] The two types are often complementary, but business process innovation tends to be more widespread.

Figure 2.10. Share of firms using digital technologies in Korea and selected countries, 2019 and 2021

Percentage of firms in each employment size class



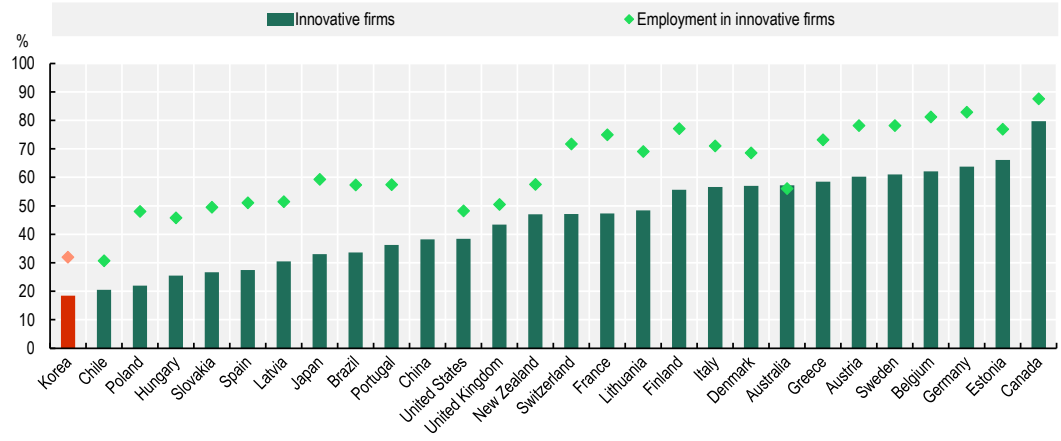
Note: Cloud computing refers to ICT services used over the Internet as a set of computing resources to access software, computing power, storage capacity and so on. Data refer to manufacturing and non-financial market services enterprises with ten or more persons employed unless otherwise stated. Size classes are defined as: small (10~49 persons employed), medium (50~249) and large (250 and more). The OECD average in both Panel A and B is a simple average of the available countries.
Source: OECD (2022[42]), *ICT Access and Usage by Businesses* (database), oe.cd/ds/54K, June 2022.

Among the OECD economies, Korea ranks lowest in terms of both the number of innovative firms and employment in innovative firms (Figure 2.11). The result is striking, considering Korea's second-highest R&D intensity among OECD countries and its notable performance in industries with high business process and product innovation intensity, such as manufacturing computer, electronic and optical products. However, a high proportion of reported innovation did not depend on R&D performance but on investments in intangibles. The relative dominance of SMEs in absolute number, although not unique to Korea, paired with their low uptake of digital technologies, helps explain the small share of innovative firms. Nevertheless, it should be noted that the start-up scene has gained significant dynamic in recent years. Since 2018, the number of unicorns has continuously increased, reaching 23 in the first half of 2022, which is an additional 5 compared to the previous year, despite more unfavourable economic conditions, such as the rise of global interest rates (Ministry of SMEs and Startups, 2022[43]). In addition, employment in start-ups grew

by 9.7% between June 2021 and 2022, a three times larger increase than the overall employment increase of enterprises (3.3), suggesting that start-ups are emerging as an increasingly significant contributor to job creation in Korea (Lee, 2022[44]).

Figure 2.11. Number of innovative firms and employment in innovative firms in Korea and selected countries, 2016-18

As a percentage of total firms and total employment, respectively



Note: Innovative firms are those reporting one or more innovations in the reference period (2016-18).
Source: OECD (2022[45]), *Business Innovation Statistics and Indicators*, oe.cd/54O, April 2022.

In Korea, SMEs represent a key element of the social safety net (Jones and Lee, 2018[30]). Employees who plan early retirement from firms use their retirement allowances to create small firms, which explains the government's longstanding support for the SME sector. However, the current landscape poses mounting challenges to Korea's future growth since the dual job market may exacerbate social inequalities across enterprises of different sizes and their employees. As SMEs face significant shortages in skilled human resources, the problem is expected to worsen without targeted and interconnected sets of policy measures. Moreover, conglomerates tend to reap the benefits of the highly dualised labour market, which means they can attract the best-skilled employees while SMEs cannot compete.

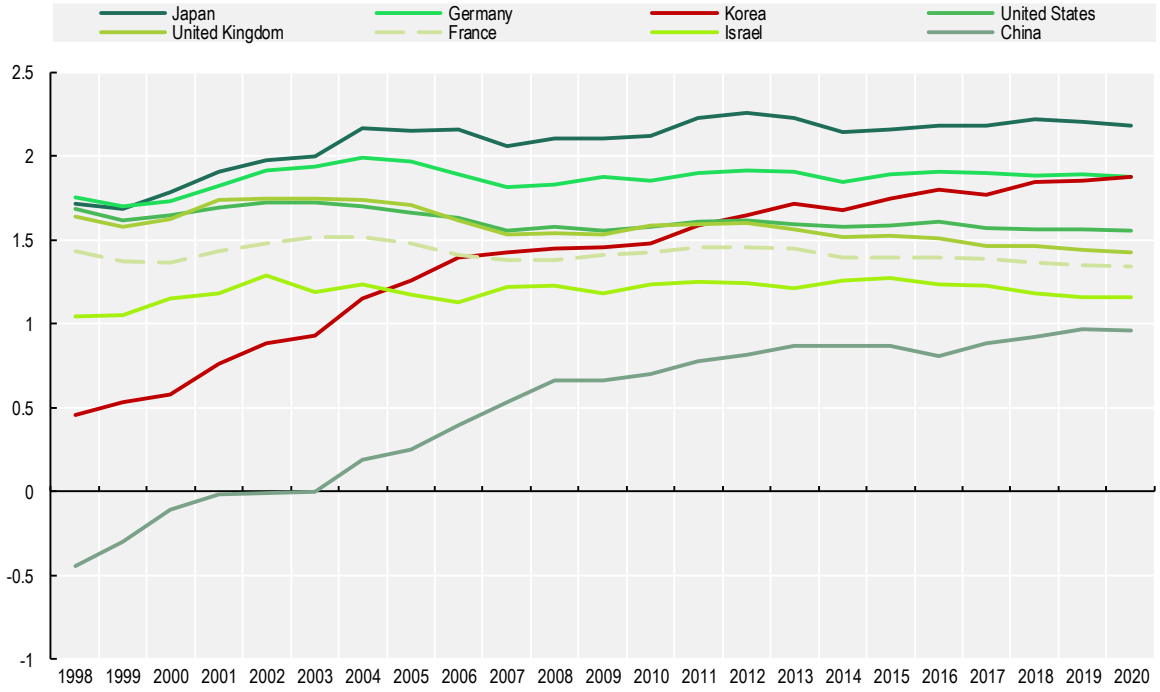
Furthermore, SMEs hold very limited leverage when negotiating cost sharing with large firms, as any gains in innovative activities are transferred to the chaebols. This occurs through several mechanisms that harm the level-playing field, including unfair price fixing, wage differentials and better access to technology. Many SMEs are integrated into the production processes of the chaebols in the manufacturing sector and, as such, must disclose their cost structure and, by extension, their potential productivity gains. This depletion of profit margins, in turn, impedes any possibility of raising wages and attracting better-skilled employees and investments in innovative activities.

2.2.2. Korea's industry structure is highly complex and strongly anchored in manufacturing

Korean industry has undergone a transformative shift towards high knowledge intensity, as measured by the Economic Complexity Index (ECI) (Figure 2.12). It ranked fifth in 2020 after Japan, Switzerland, Chinese Taipei and Germany. Its remarkable trajectory over recent decades from rank 32 in 2000 could only be mirrored by China, albeit at significantly lower levels, from 54th in 2000 to 28th in 2020. The ECI measures the degree to which complex products correspond to a country's productive capabilities. Higher complexity in industry structure is often perceived as indicative of stronger long-term economic growth

(Hidalgo and Hausmann, 2009[46]), lower income inequality (Hartmann et al., 2017[47]) as well as fewer greenhouse gas emissions (Neagu, 2019[48]). A high index implies that a given country's products are complex and indicates a larger number of interconnections between complex products, meaning that these can rely on shared capabilities (Alcorta et al., 2021[49]).

Figure 2.12. Economic Complexity Index for Korea and selected countries, 1998-2019



Note: Economic complexity provides an indication of an economy's capacity for future growth by calculating the relatedness (product space) between industries in a given location and, thus, the extent to which similar industries can benefit from comparable factor inputs.
Source: Observatory of Economic Complexity (n.d.[50]), *Economic Complexity Rankings*, https://oec.world/, May 2022.

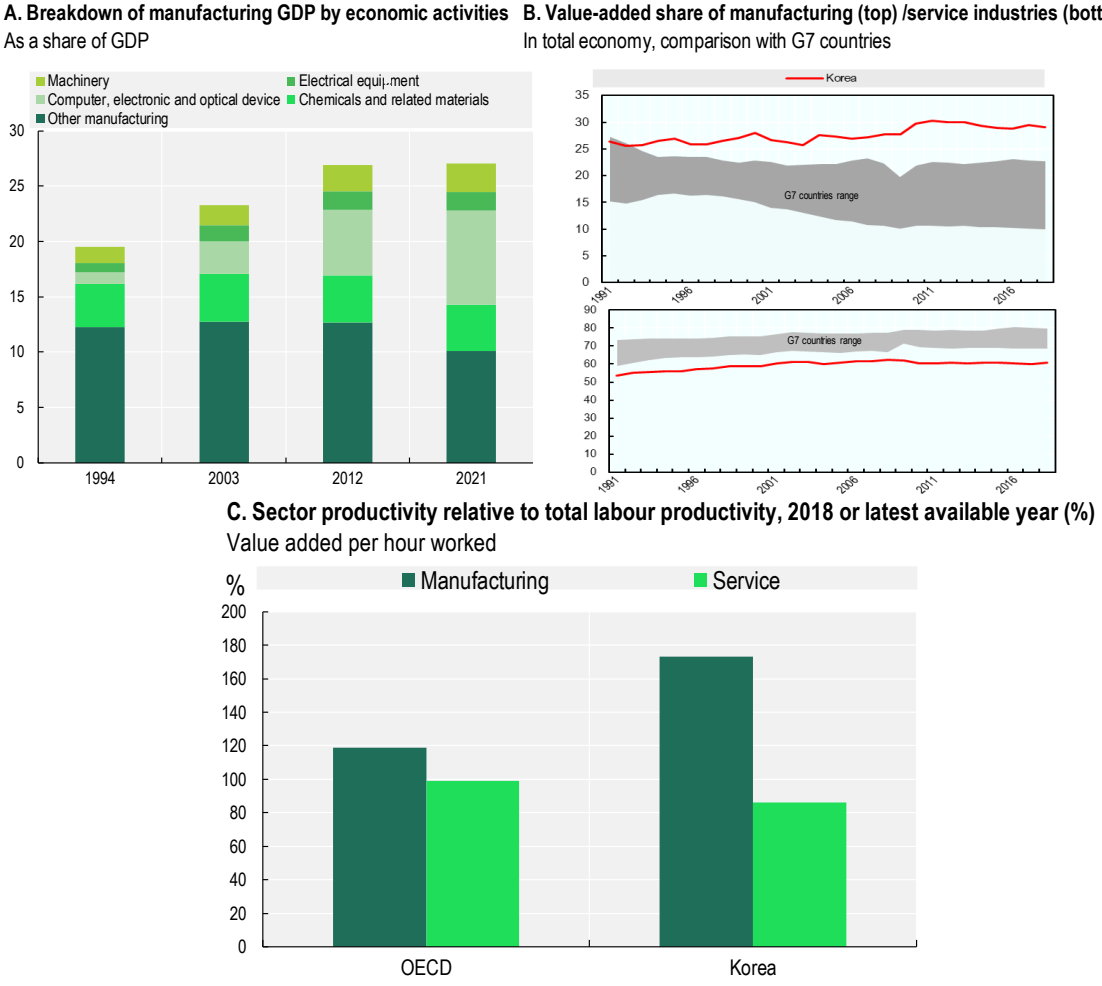
Korea's high economic complexity is manifested in its relative strength and specialisation in highly advanced manufacturing industries, which accounted for 27% of real GDP in 2021, the second-highest share among OECD countries, while the services sector generated 56%. In comparison with Group of Seven (G7) economies, manufacturing has contributed a considerably higher share of value-added with 29.1%, even compared to Germany (22.7%), which is generally considered a manufacturing powerhouse (Figure 2.13, Panel B). In terms of labour productivity in manufacturing, Korea is also above the OECD average (Figure 2.13, Panel C).

The highest share of both GDP and value-added of the manufacturing sector comes from the complex ICT industries, generating 8.5% of GDP, followed by chemicals (4.2%) and electrical equipment (1.7%) (Figure 2.13, Panel A). These constitute a resilient and fast-growing sector of the Korean economy whose high value-added has remained constant since the global economic crisis in 2007 (OECD, 2017[51]).

On the other hand, the service sector's relative underperformance has been lowering the overall productivity of the Korean economy, although it should be noted that some services may be embedded within manufacturing. The service sector's share of value-added has been below the G7 countries' range for three decades (Figure 2.13, Panel B) and its productivity below the OECD average (Figure 2.13, Panel C). By the same token, a comparison with the ICT industry in Ireland, for instance, shows how ICT services could be expanded to a much higher level than today. Both countries generate large value-added

shares from their ICT industries (Korea first, and Ireland third, in the OECD), whereas in Korea, 31.4% came from ICT services; the share for Ireland was 66.4%.

Figure 2.13. Performance of Korea's manufacturing and service industries

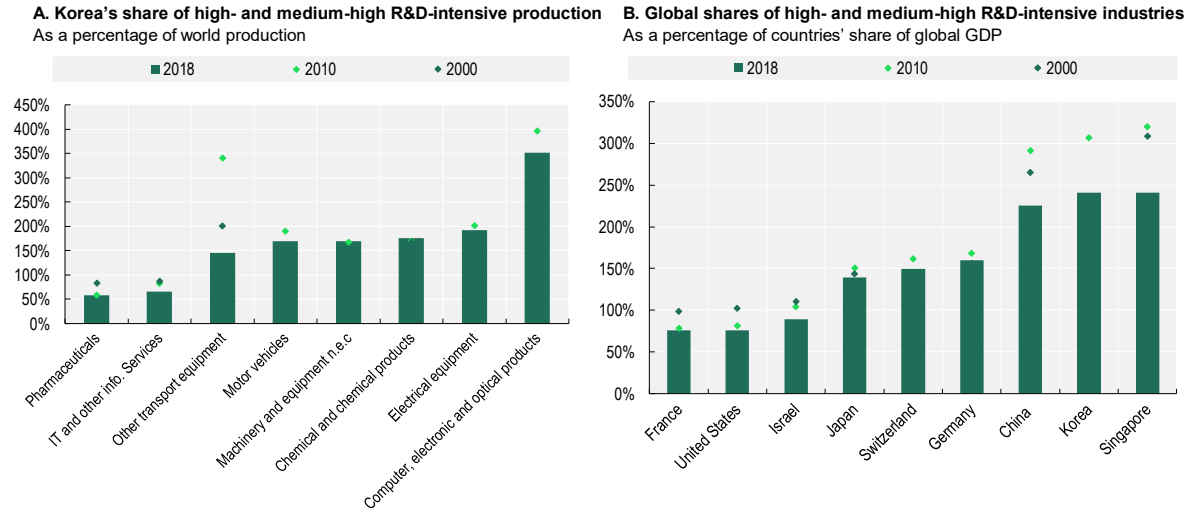


Note: Panel B: Reference years are 2018 for France, Germany, Italy, Japan, Korea, United Kingdom and the United States; 2017 for Canada. Panel C: Average of 32 OECD countries calculated for manufacturing and 34 for services. Per hour worked – total engaged. Calculation is value-added (current prices) per hour worked (- total engaged) for total manufacturing/services over total economy. Productivity of business sector services excluding real estate is 74% for Korea.
Source: Panel A: OECD calculations based on information from the Korean Statistical Information Service, https://kosis.kr/eng/. Panel B and C: OECD (2022[55]), *Structural Analysis (STAN)* (database), oe.cd/ds/4Bj, June 2023.

Furthermore, relative to the global share of advanced output in medium-high and high-technology-intensive sectors, Korean industry is strongly concentrated in the manufacturing-intensive sectors of computer electronic and optical products, electrical equipment and chemical products, showing a strong comparative specialisation (Figure 2.14, Panel A). In 2010, the relative specialisation to the global market reached a high of close to 400% in 2010 and has since subsided. In terms of international comparison, the cumulative share of all technology-intensive industries is above those of other innovation leaders and on par with China and Singapore, which further underscores the high degree of industry specialisation in advanced knowledge-intensive products (Figure 2.14, Panel B). Korea's strong specialisation indicates its strong leadership in these industries, although this does not come without risks. For example, with regard to smartphones, Samsung held its highest global market share in five years in April 2022, with around 24%

of smartphones sold (Canalys, 2022[52]). Similarly, Samsung was the market leader in semiconductors in 2021, with a share of 12.3% (Gartner, 2022[53]). This closely resembles Nokia's past success in Finland, which once was the dominant market leader for cell phones before failing to compete with new market entrants, notably Apple. Nokia's decline left the Finnish economy with a dramatic impact, causing one-third of Finland's drop in GDP and one-fifth of its loss in employment between 2008 and 2014 (OECD, 2017[54]).

Figure 2.14. Share of high- and medium-high R&D-intensive production in Korea and selected countries, 2000, 2010 and 2018



Note: ISIC 4.0 Revision definitions of high- and medium-high R&D intensity. World production refers to the world region as used in the OECD TiVA Database. N.e.c. – not elsewhere classified.
Source: OECD (2023[55]), "Trade in value added", *OECD Statistics on Trade in Value Added* (database), https://doi.org/10.1787/data-00648-en, May 2022.

In contrast to manufacturing, the share of technology-intensive services is below expected, based on Korea's weight in the global economy, and has shown a downward trend since 2000. Therefore, mainly due to its strengths in manufacturing, Korea shows strong aggregate output of advanced industries when compared internationally – being on par with China and Singapore – with the latter's performance significantly driven by a strong specialisation in high-value-added services.

2.2.3. Service sector growth can help realise Korea's untapped innovation potential

The reasons for Korea's relatively weak performance in the service sector are multi-fold. Historically, Korea's traditional export-led growth model siphoned capital, human and other resources away from services and towards manufacturing, resulting in relatively lower capital intensity in the former (OECD, 2016[11]). Park and Shin argue that while employment in the services sector has grown exceptionally fast, labour reallocation from manufacturing to services did little to contribute to productivity growth (Park and Shin, 2012[56]). In other words, according to Eichengreen, Perkins and Shin, this has created the "within effect" where the economy experienced productivity increases, but the sectoral shares remained constant (Eichengreen, Perkins and Shin, 2012[57]). Low productivity of senior employees in micro-enterprises in services sectors has become a common phenomenon in Korean industry and is a direct effect of rapid deindustrialisation.

Government regulations and restrictions to service sector growth

Insufficient competition has prevented the services sector from advancing in terms of growth and productivity (Jones, 2009[58]). In terms of industry structure, as Korea became more integrated into the global economy, conglomerates that are dominant in the manufacturing industry have shown a tendency to perform services in-house rather than contracting them out. In addition, relatively high levels of regulation also weigh on the service sector's growth and hinder newcomers' entry into the market. Competition encourages existing companies to become more innovative and increase investment, thereby contributing to economy-wide productivity growth. However, according to the product market regulation (PMR) index, which covers both manufacturing and services sectors, Korea is one of the least competition-friendly countries in the OECD (sixth-most stringent at 1.7)[6] compared to the OECD average (1.4) (OECD, 2018[59]) (Figure 2.15, Panel A). Korea is more restrictive than the OECD average for four sub-indices, particularly regarding barriers to market entry in service and network sectors[7] (Figure 2.15, Panel B), where Korea imposes more stringent regulations than other OECD countries in almost all sectors except for air and water transport.

Regulations in all six categories of professional services and retail distribution are stricter than the OECD average, with higher entry requirements and distortive business conduct regulations. However, since 2019, in an attempt to allow new firms to enter the services sector without being subject to prevalent legal requirements, the government has launched regulatory sandboxes in ICT convergence, industrial convergence, financial innovation, regulation-free special zones, special R&D zones and "smart city" (Office for Government Policy Coordination, 2022[60]).

Business enterprise R&D in services

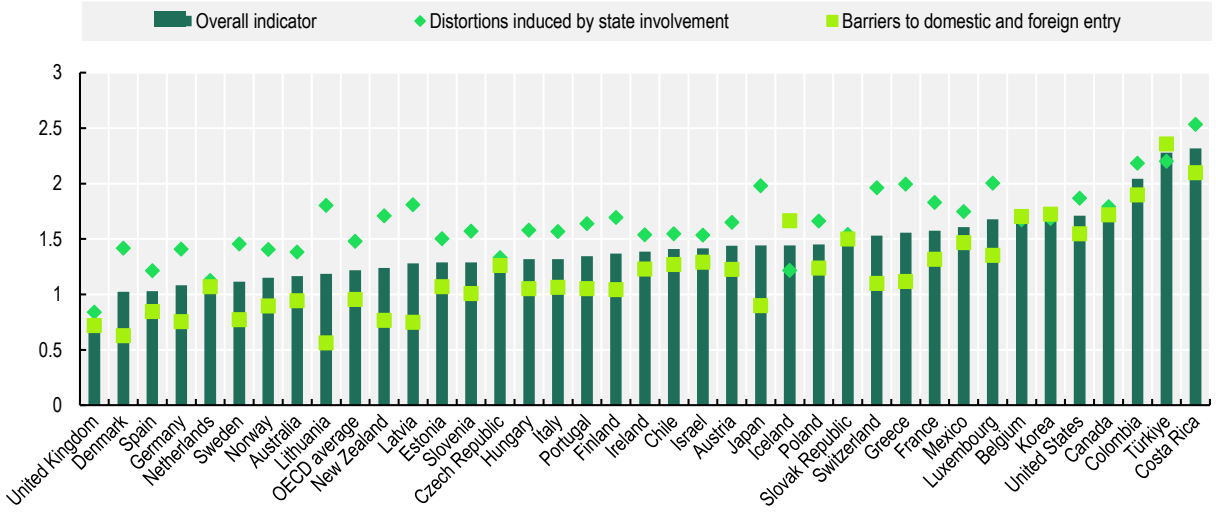
Low levels of BERD in services have been noted as another limiting factor for the sector's growth. BERD in services is at 0.4% of total GDP, far below the best-performing countries of Israel and Sweden (Figure 2.16). It is worth noting that similarly manufacturing-intensive Germany has an even lower share of 0.3%. Limited investment in services R&D can stifle innovation and hinder expansion into high-value-added services, which holds particular importance as Korea's manufacturing sector matures and increasingly faces competition with developing economies (Park and Noland, 2013[61]).

Since 2010, the Korean government has prepared and implemented policy measures to boost firms' service R&D investments. Starting from the first Service R&D Promotion Plan,[8] national investment strategies, such as the Service Economy Development Strategy (2016),[9] the Mid- to Long-term Promotion Strategy, the Promotion Plan on Service R&D (2017),[10] and the Service Industry Innovation Strategy (2019)[11] include specific measures aimed at boosting BERD in services. In 2017, the government increased the R&D tax credits for firms by expanding the scope of private companies authorised to establish corporate R&D centres from 19 industries to all and by including novel technologies with growth potential as possible recipients. As a result, the share of services sector firms with R&D centres out of total service firms increased from 26.2% in 2011 to 34.1% in 2019, and the share of those with in-house R&D departments more than doubled from 11.8% to 26.8% during the same period (KITA, 2020[63]). Also, the Ministry of SMEs and Startups selected the Korea-Engineering Service Provider (K-ESP) in six designated industry fields to match with SMEs for R&D projects (KOSI, 2018[64]). Despite such positive developments, however, the impact of government policies has not yet fully materialised, leaving considerable room for improvement.

Figure 2.15. Stringency in product market regulation: Korea and selected countries, 2018

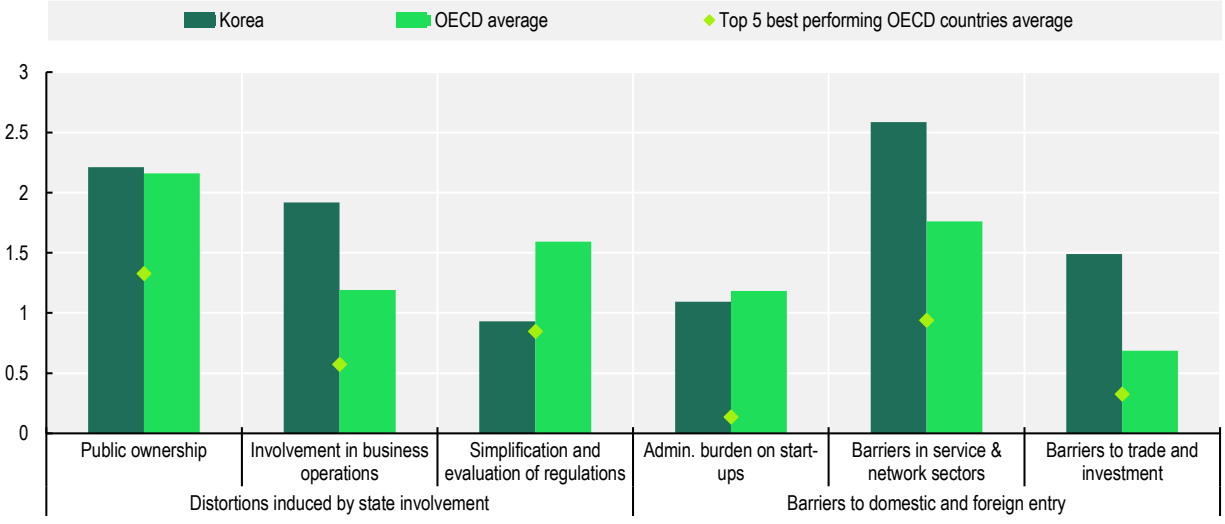
A. Economy-wide values of product market regulation and two high-level indicators, 2018

Scale of 0 to 6 from least stringent to most stringent



B. Korea compared with the OECD average and top five best performers on six medium-level indicators, 2018

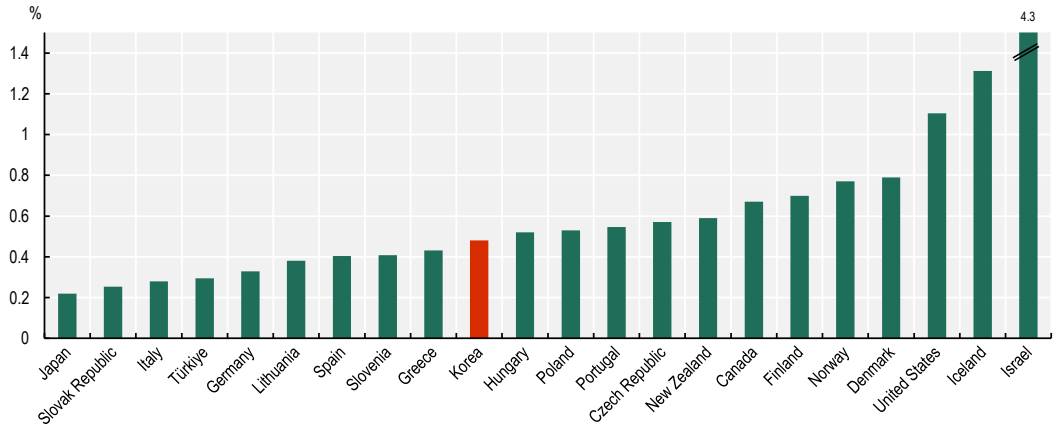
Scale of 0 to 6 from least stringent to most stringent



Source: OECD (2022[62]), *Indicators of Product Market Regulation*, oe.cd/54P, May 2022.

Figure 2.16. BERD in services, Korea and selected countries, 2020 or latest year available

As a percentage of GDP

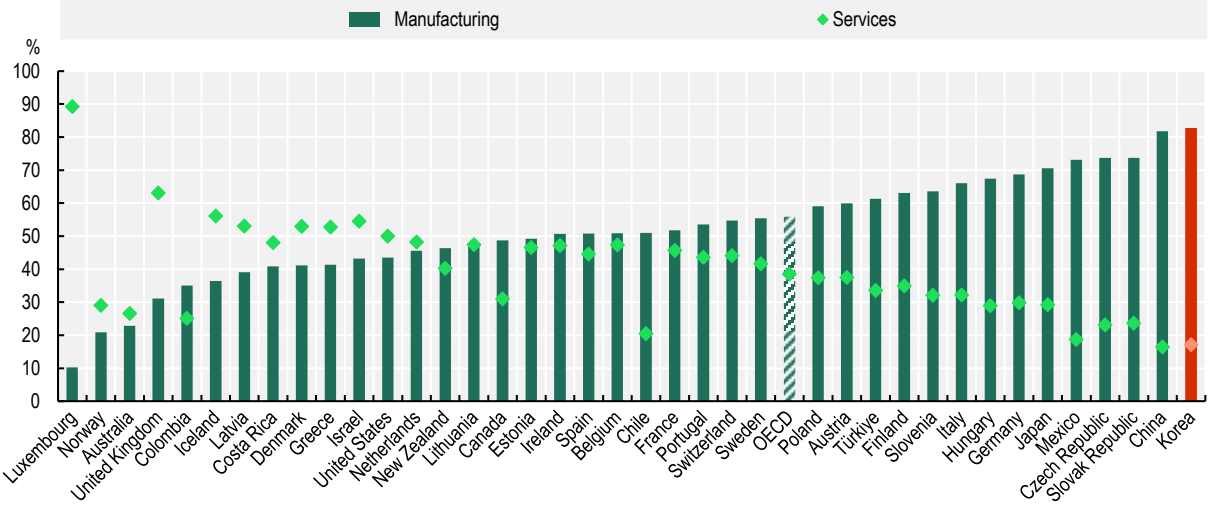


Note: Data correspond to 2021 for Korea
Source: OECD calculations based on OECD, ANBERD Database, http://oe.cd/anberd

2.2.4. Export-led growth continues to be driven by high-tech products with large room for expansion into knowledge-intensive services

The stark concentration of the Korean economy in manufacturing is apparent in its trade flows, with manufacturing accounting for 83% of exports, in contrast to only 16.4% for services, the strongest gap among OECD countries and higher than many other countries in Asia (Figure 2.17).

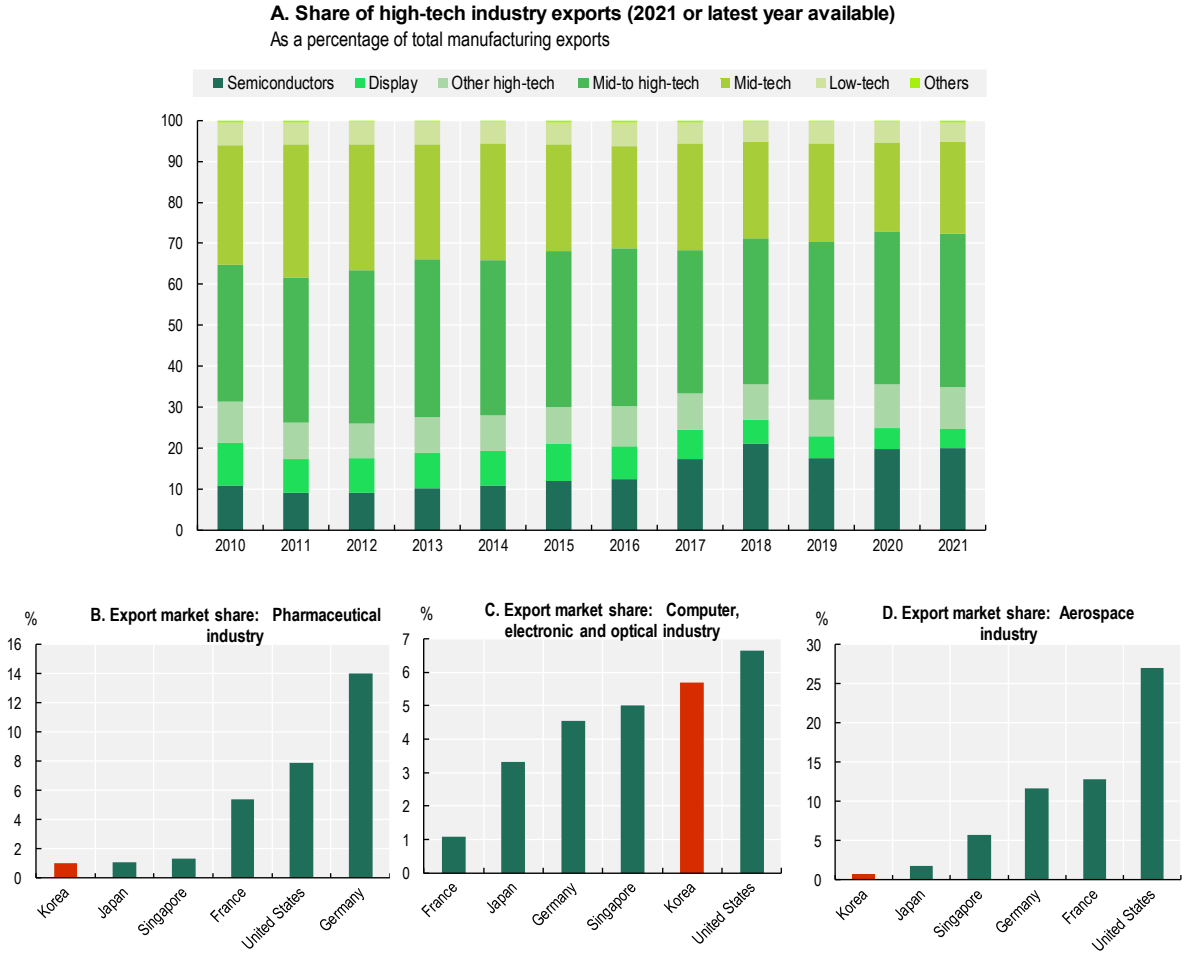
Figure 2.17. Share of manufacturing and services of gross exports in Korea and selected countries, 2018



Source: OECD (2023[55]), "Trade in value added", *OECD Statistics on Trade in Value Added* (database), https://doi.org/10.1787/data-00648-en, April 2022.

Since the 1990s, Korea's industrial strategy has become more technology-focused, and greater emphasis has been placed on the promotion of R&D and innovation (OECD, 2014[31]), which has led to the development of higher value-added tech products and exports. Considering R&D intensity, the share of mid-to-high-tech and high-tech exports has increased throughout the 2010s to nearly 70% of total manufacturing exports (Figure 2.18, Panel A). Among the three categories of high R&D intensity manufactured industries based on the OECD taxonomy (Galindo-Rueda and Verger, 2016[65]), Korea shows an unparalleled performance in computer, electronic and optical products (24% of total exports), which is almost triple the OECD average of 8.1% (Figure 2.18, Panel C), compared to the relatively negligible share of both aircraft and pharmaceuticals, although the latter has strongly increased since 2010 (Figure 2.18, Panels B and C). The strong performance in computer, electronic and optical products is mainly due to exports of semiconductors accounting for 20.1% of total exports in 2021. This followed the initial drop from 21.1% in 2018 to 17.6% in 2019 when semiconductor sales faltered globally, before recovering to 19.7% of total exports in 2020 as the global demand for at-home electronic gadgets increased. In 2021, the value of exports of semiconductors increased by 29% compared to 2020 (Statistics Korea, 2022[66]).

Figure 2.18. R&D industry exports in Korea and selected countries, 2010-20/21



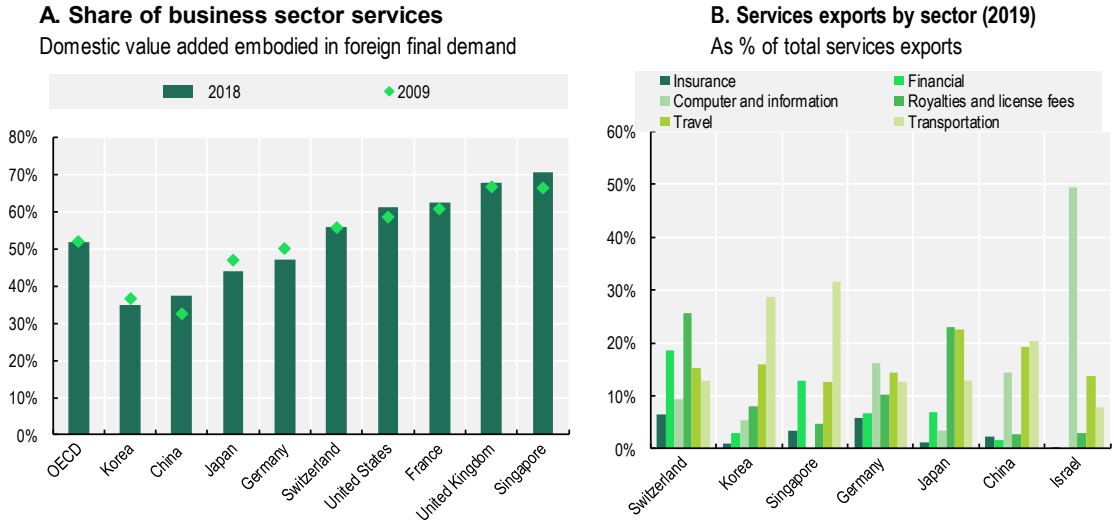
Note: Semiconductor and display industries in the first panel are singled out for significance. Other high-tech industries include pharmaceuticals, computers, telecommunication equipment, home appliances, precision instruments, batteries and aerospace.
Source: OECD calculations based on MOTIE Industrial Statistics Analysis System (ISTANS); OECD (2022[67]), *Trade in goods and services*, oe.cd/dp/4Bn; OECD (2023), Main Science and Technology Indicators (database), oe.cd/msti, (accessed on 23 June 2023).

On the other hand, Korea's exports of display panels gradually decreased from 10.4% in 2010 to 4.5% in 2021 (Figure 2.18, Panel A). During the same period, Korea's global market share diminished from 50.7% to 33.2% in 2021, mainly due to stiffening competition with Chinese manufacturers, whose share increased to 41.5% in 2021 (Korea Display Industry Association, 2022[68]). The TV set production supply chain has rotated among East Asian economies, whereby the market dominance has shifted from Japan to Korea, then again to China. China increased its dominance in liquid crystal display (LCD) panel production (63% of total production worldwide) over Chinese Taipei (21%), Japan (8%) and Korea (8%) (S&P Global, 2021[69]). As display panel producers are transitioning from LCD technology to organic light-emitting diode (OLED) technology driven by rising sales of smartphones and high-end televisions, Korea still excels on the technological front with 82.3% of global OLED market shares, followed by China (16.6%) (Omdia, 2022[70]) However, as the technological gap between Korea and China narrows, it may become increasingly difficult for Korea to secure its competitive advantage in the OLED display market (BusinessKorea, 2021[71]).

Despite rising competition, Korea's overall performance in the high-tech sector has been resilient, supported by the government's proactive policies and interaction with industry. In 2021, the government announced the National Strategy for Selection and Protection of National Critical Technologies[12] at the National Science and Technology Policy Coordination meeting presided over by the Prime Minister (Ministry of Science and ICT, 2021[72]). It lists ten core technologies[13] for which the government committed to establishing a proactive nurture and protection system to prevent the leakage of core skills and to strengthen inter-ministerial co-operation in both aligning strategies and integrating policies to be implemented. The strategy is backed by the government's pledge to increase R&D investment in these technology areas to KRW 3.3 trillion, its provision of a new Act on Special Measures for Strengthening and Protecting the Competitiveness of National High-tech Strategic Industries[14] in 2022 and by an amendment to the Special Taxation Act[15] to increase tax benefits for the firms' R&D costs and investment in infrastructures (Korea Law Information Centre, 2022[73]; Ministry of Government Legislation, 2022[74]). Furthermore, the Ministry of Trade, Industry and Energy (MOTIE) organised the first roundtable discussion with industry stakeholders in the semiconductor industry in an effort to establish a permanent communication platform with the industry. The discussion will likely be expanded to other sectors, such as automobiles, batteries and steel (Ministry of Trade, Industry and Energy, 2022[75]).

When considering service exports, the general trend among OECD countries since 2009 is that their share of domestic value-added embodied in foreign final demand has remained largely stable, around 52% (Figure 2.19, Panel A). Although largely stable when considering the average, a growing disparity emerges as countries that already had a larger share of value-added service exports, including the United States and Singapore, saw an increase between 2009 and 2018. Countries with a low share of business services in value-added exports, including Korea, but also Japan and Germany, have seen a further decline. Korea's share, with 35%, significantly lags that of countries leading in knowledge-intensive services, such as Singapore (70.5%) and other manufacturing-intensive economies, including Germany (47%) and Japan (44%). Moreover, despite employment growth in service sectors,[16] the share of value-added services has fallen, which implies that this growth occurred mainly in sectors with lower knowledge intensity, which is in line with findings from previous research (Park and Shin, 2012[56]).

Figure 2.19. Service exports in Korea and selected countries, 2009 and 2018



Source: Panel A: OECD (2023[55]), "Trade in value added", *OECD Statistics on Trade in Value Added* (database), https://doi.org/10.1787/data-00648-en, April 2022; Observatory of Economic Complexity (n.d.[50]), *Economic Complexity Rankings*, https://oec.world/, May 2022.
Panel B: Services classification follows United Nations Statistics Division (2021[76]), *Trade Statistics*, https://unstats.un.org/unsd/tradeserv/datacollection.htm.

The majority of service exports are in sectors with relatively low knowledge and technology intensity, such as transportation and travel, which, combined, account for almost 45% (Figure 2.19, Panel B). STI-related services that are being commercialised through royalties and licence fees are significantly lower (8%) than in other countries leading the innovation frontier. Royalties and licence fees constitute, for instance, a significant share of Swiss (25.5%) and Japanese (23%) service exports. Similarly, other knowledge-intensive services, such as financial as well as computer and information services, account for only 3% and 5.3%, respectively. These differences show that although Korea's economy belongs to the world's most complex ones, the country stands to benefit immensely from further diversification by expanding into knowledge-intensive services whose contributions to innovation through various channels are well documented (OECD, 2006[77]). Nevertheless, in some respects, knowledge-intensive service exports are growing in some areas, for instance, related to AI training and education. Knowledge-intensive services can carry a functional role as sources of innovation – where they are directly linked to innovation, such as in R&D or operational management – and act as facilitators of innovation, for instance, by helping a firm in the innovation process itself. In addition, they can serve as carriers for innovation in aiding knowledge transfer within and across organisations, networks and industries.

2.3. Korea can leverage its global position to strengthen its innovation performance

2.3.1. The reorganisation of global value chains holds implications for Korea

The analysis of global value chains (GVCs) is a useful tool for policy makers to comprehend the interconnectedness of economies. Analysing a country's embeddedness in GVCs allows the attribution of its export competitiveness to the sourcing of efficient inputs and access to final producers and consumers abroad (De Backer and Miroudot, 2013[78]). Active participation in GVCs allows countries to expand international specialisation and pursue economies of scale by reaching a larger customer base and

allowing inter-regional knowledge spillovers. However, it also increases their vulnerability to supply and demand shocks.

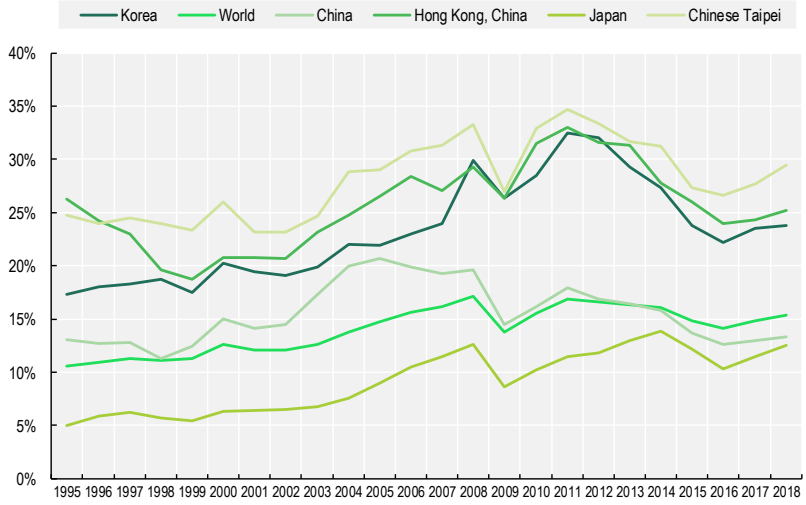
Recently, due to the disruptions in supply chains caused by the COVID-19 pandemic, the question of whether the gains from the embeddedness in GVCs outweigh the associated risks resurfaced (OECD, 2021[79]). During the crisis, firms temporarily stopped production at sites directly affected by the presence of the virus, and the economic shock was propagated along the value chains. A recent OECD report finds specific features that may determine the degree of exposure to shocks, which are: high reliance of sales on foreign demand; high dependence on foreign value-added in production; and high centrality of some "hubs" in GVCs (OECD, 2021[79]). However, these are the very characteristics that drive the benefits from GVCs by allowing the economies to specialise in their comparative advantage. No conclusive analysis exists of how GVCs will be reshaped in response to shocks, but the recent analysis suggests that GVCs are more likely to evolve further than to shut down (WTO, 2021[80]). Therefore, as the initial shocks caused by the pandemic recede, it is important to explore the policy options for Korea to minimise the shocks while continuing to reap the economic benefits from its GVC embeddedness.

Korea's participation in global value chains

Korea benefits from its active integration into GVCs. Three notable aspects of Korea's participation are its manufacturing industry's high reliance on foreign inputs and market demands, proximity to the global hub of China, and relative underperformance in the service sector trade. The first two are interlinked since GVCs, by nature, have a strong regional dimension.[17] For Korea, the short geographical distance to one of the world's biggest suppliers and buyers shapes the country's involvement along the value chains. The foreign value-added (FVA) content of gross exports[18] measures how much foreign inputs a country uses for exports. For Korea, the share declined from 39.7% in 2008 to 32% in 2018, which is, however, still higher than the OECD average and G7 economies' shares (Figure 2.20, Panel A). A high level of FVA is common for smaller countries and for countries engaging in high R&D manufacturing exports since they are dependent on intermediate inputs.

Figure 2.20. Foreign inputs for production in Korea and selected East Asian economies, 2008-18

Share of foreign value-added (FVA) content of gross exports



Note: The FVA content of gross exports measures how much foreign inputs a country uses for exports, while the global import intensity (GII) indicator measures the fragmentation of production by focusing on the imports needed to produce goods or services, whether exported or consumed in the domestic economies (Timmer et al., 2016[81]).
Source: OECD (2023[55]), "Trade in value added", *OECD Statistics on Trade in Value Added* (database), https://doi.org/10.1787/data-00648-en, April 2022; OECD (2022[82]), *OECD Inter-Country Input-Output (ICIO) Tables*, http://oe.cd/icio, April 2022.

This point becomes more evident on the regional level since Korea shows an import intensity comparable to small-sized economies such as Hong Kong (China) and Chinese Taipei and higher than Japan and China (Figure 2.20, Panel B). The global import intensity (GII) indicator measures the fragmentation of production by focusing on the imports needed to produce goods or services, whether exported or consumed in domestic economies (Timmer et al., 2016[81]). Miroudot (2020[83]) finds that all East Asian economies have witnessed a decreasing import intensity since the global financial crisis. However, the phenomenon is much stronger in Korea, where specific policies were implemented to encourage reshoring. Starting in 2013, subsidies and tax reductions were offered for relocating production to Korea, and in 2016, this was reinforced by a five-year tax exemption even for partial reshoring. Eleven sectors were defined as priority sectors, including robotics, self-driving cars, biotech and health-related products. In June 2020, the government went on to offer additional incentives to relocating high-tech companies, including subsidising relocation expenses, robotisation and automation of processes, tax exemptions and facilitation of visa requests by highly skilled immigrant workers. Such a reshoring policy focused on firms in specific sectors can be contrasted with policies focusing on the entire value chain in the home country, such as the French policy, and a policy of building a resilient value chain put in place as the "Supply chain resilience initiative" by Japan, India and Australia, which aims to reduce the dependency of value chains on China by creating alternate value chains based on trust and stability (Elia et al., 2021[84]).

Recent OECD findings on GVCs suggest a more comprehensive picture of Korea's position within the GVCs. Foreign input reliance (FIR) and foreign market reliance (FMR) are useful indicators that measure, respectively, the country's involvement in upstream activities and downstream activities. An upstream supplier exports intermediate goods, so the FIR index tends to be higher for the manufacturing industry, followed by services (Figure 2.21, Panel A). As a smaller and highly open economy, Korea relies to a larger extent on imported intermediates than large diversified economies. A majority of this intermediate depends on intra-regional trade, which confirms the findings from the above discussion on import intensity. On the other hand, Korea's reliance on foreign markets is higher than in other economies, such as Germany, the United States and China (Figure 2.21, Panel B). As mentioned, the size of the economy matters, which explains Korea's higher sensitivity to foreign demand than larger economies, but the level is found to be even higher when compared to those of country aggregates by regions. Also, Korea's export destinations are largely centred in Asia and Oceania, and most notably, in China.

Moreover, trade in certain service sectors remains restricted. Overall, the OECD finds that Korea's GVC income,[19] i.e. the sum of value-added generated by Korean firms along the global production chain from most service sectors, has significantly increased over the past 15 years. This shows the growing prominence of trade in services. However, this is driven by domestic demand rather than technological upgrades (OECD, 2021[85]). By the same token, when looking at the revealed comparative advantage[20] index by industry sector, other business services and information technology (IT) services show values above 1 (showing comparative advantage). Other sectors, such as finance and insurance, and telecoms, have values below 1 (showing no comparative advantage). Innovation and technology adoption relies on easier access to knowledge and networks of people, goods and services to share knowledge (OECD, 2021[86]). A clear identification of trade barriers in some services sectors deserves further policy attention for Korea to benefit more from open markets for services trade. Korea has made significant progress in service trade liberalisation, allowing its servicification to catch up with other OECD economies. However, barriers remain, such as foreign equity limits and complex registration procedures to establish a local presence (OECD, 2021[87]).

Policy objectives for Korea and the role of innovation policy

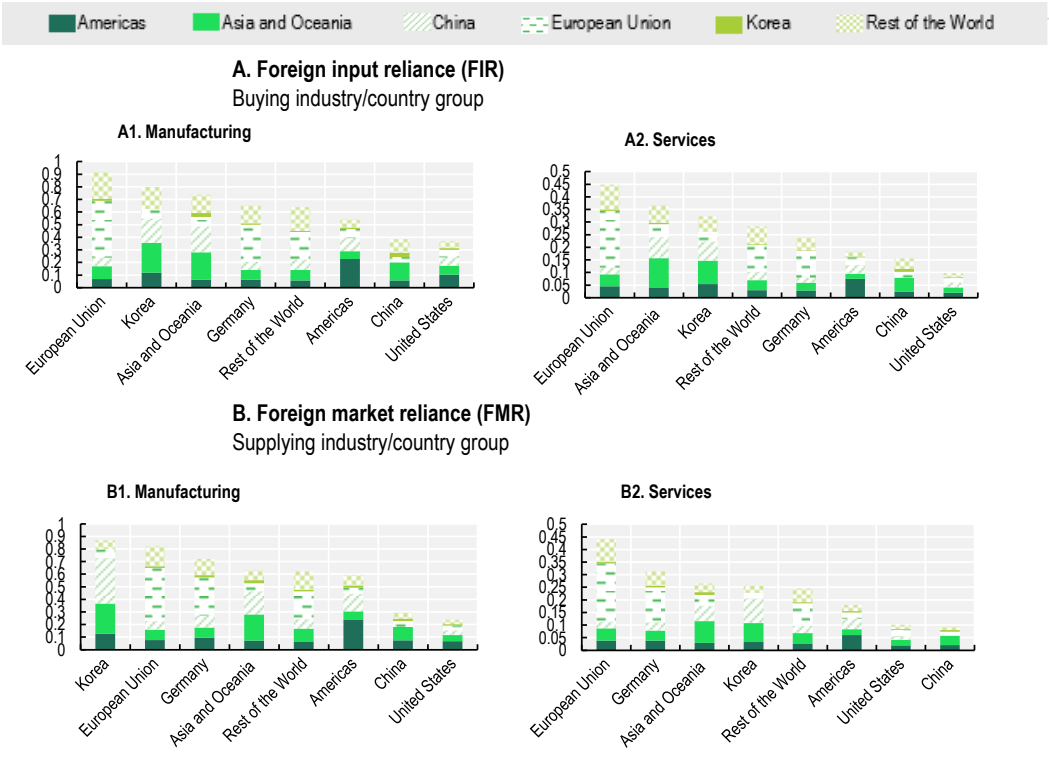
A range of public policies can be considered to enhance industry resilience against potential shocks. Although corporate decisions predominantly shape changes in GVCs, public policies can help align private and public interests and provide timely information to private companies to better estimate risks (Cadestin et al., forthcoming[88]). In this regard, the OECD (2021[85]) has recommended that Korea design a more

inclusive GVC strategy to help it mitigate the impact of rising protectionism, reduce productivity gaps and promote business dynamism. Three policy objectives were proposed, namely:

- diversification of exports
- rebalancing productivity growth towards services
- mitigating the impact of protectionism and facilitating the reorganisation of GVCs.

These objectives still hold significance for Korea and other countries actively engaging in global trade. According to a more recent study by Cadestin et al. (forthcoming[88]), the first two objectives can be interpreted as an "adaptation strategy" since the government employs trade,[21] industrial, innovation and skills policies to help the economy rebound if a value chain shock materialises. These objectives can also be achieved by unilateral reforms in Korea rather than depending on the willingness of other trade partners (OECD, 2021[85]). The last objective, mitigation of the rise of protectionism and consolidating current trade agreements, can be seen as a "mitigation strategy"[22] since it aims to reduce the risk that a shock may occur in the first place.

Figure 2.21. Foreign input reliance and foreign market reliance in Korea and selected economies and regions, 2018



Note: In Panel A, each horizontal panel denotes a buying country (group), each bar a buying industry group, and the coloured stacks the contribution of the supplying country (group) to the FIR. In Panel B, each horizontal panel denotes a supplying country (group), each bar a supplying industry group, and the coloured stacks the contribution of the buying industry country (group) to the FMR. The contributions to the FIR are computed by: 1) aggregating to the level of the buying industry group *J* (agriculture, mining, manufacturing, services and total) in each country ($FIR_c^J = \sum_{j \in J}^{n}(FIR_{c,j} * W_{c,j}^{GO})$, where $W_{c,j}^{GO} = GO_{c,j} / \sum_{j \in J}^{n} GO_{c,j}$); and then 2) by aggregating to the level of the buying country (group) *C* (Americas, Asia and Oceania excl. China and Korea, China, Korea, the European Union and Rest of the World) as $FIR_J^C = (\sum_{c \in C}^{n} FIR_{c,J}) / n$. A similar procedure is used to compute the contributions to the FMR.
Source: Schwellnus, C., et al. (2023), "Global value chain dependencies under the magnifying glass", https://doi.org/10.1787/b2489065-en.

Both supplier and buyer diversification and reshoring of selected production activities present interesting options for highly industrialised countries, including Korea. Diversification means redistributing trade links across countries without significantly modifying the overall value chain integration, therefore increasing the substitutability of inputs and export destinations. High diversification reduces global economic losses in response to disruptions and also lowers GDP volatility following productivity shocks (OECD, 2021[79]; Lan et al., 2022[89]). Korea has diversified its trade partners since the late 1990s, as is evident from its decreasing Herfindahl-Hirschman Index (HHI),[23] but the market remains relatively concentrated in selected countries compared to those of other economies (IIT, 2018[90]).[24] Overdependence on one trade partner may constitute a long-term risk, and diversifying export destinations, thereby increasing the substitutability of intermediate inputs, can ensure an economy's greater flexibility and resilience. In fact, Korea has been replaced by the Association of Southeast Asian Nations (ASEAN) economies in terms of high-tech intermediate goods exports as the internal demand of the Chinese market started to change rapidly (KITA, 2022[91]). In parallel, Korea can benefit further from trade preferences and common standards by joining mega-regional trade agreements (OECD, 2021[85]). Korea has already established a network of free trade agreements, but a majority of them are bilateral under different sets of rules. The new Yoon administration has established as one of the 110 national tasks to join new and benefit from existing multilateral trade regimes, such as the Comprehensive and Progressive Agreement for Trans-Pacific Partnership and the Regional Comprehensive Economic Partnership (Government of Korea, 2022[92]). As opposed to bilateral agreements, these regimes would facilitate the creation of networks, help upgrade the GVCs and increase Korean firms' capacity (OECD, 2021[85]).

Meanwhile, disruptions wrought by the COVID-19 pandemic led many firms, mostly in the manufacturing sector, to become increasingly keen to alleviate the shocks in their supply chains by bringing back essential input production. Essential input production is also considered an alternative route – as opposed to diversification – since diversified trade linkages can increase the length and complexity of value chains. Despite the saliency and attractiveness of this option, however, the economic cases for reshoring GVCs are still relatively weak, and using a range of government policies to better structure firm production processes presents a better option (OECD, 2021[79]).

In terms of encouraging productivity growth towards services, Korea could consider more actively adopting disruptive technologies in the production process and strengthening the SME and start-up sector through innovation policies. Successful absorption of new technologies has been proven to increase productivity and encourage structural transformation. (OECD, 2017[38]). The set of cutting-edge technologies is broadly referred to as Industry 4.0, and their impacts vary across industries. More labour-intensive industries are less vulnerable to changes, whereas mid-to-high-tech industries (e.g. electrical and electronics and machinery sectors) are likely to be affected to a greater extent. In advanced, industrialised countries with a strong manufacturing base, such as Korea, such changes, therefore, have great implications. As the average population age and labour costs increase, the capital intensity of the production process is expected to grow (Frederick et al., 2017[93]).

Furthermore, adopting new technologies is generally an investment-intensive process that stretches far beyond capital input. Therefore, it needs to be complemented with relevant expenditures, such as through firms' investments in technologies and by ensuring the well-functioning of tertiary-level educational institutions in science, technology, engineering and mathematics (STEM) disciplines. Overall, Korea's high R&D intensity, high level of educational attainment and strong emphasis on STEM disciplines show that it is well-positioned to adapt to such changes. However, firms' absorptive capacities for new technologies need to be enhanced. In parallel, in order to ensure economy-wide resilience, it is critical to promote the growth of innovative SMEs and start-ups. Innovation policies can encourage the emergence of innovative firms in strategically important sectors in the wake of sudden demand surges and supply shortages (Cadestin et al., forthcoming[88]). Currently, the ratio of innovative firms in Korea is the lowest among OECD countries (Figure 2.11), and SMEs' overall low productivity may signal their lack of innovative capacities.

2.3.2. Foreign direct investment restrictions remain relatively high in some sectors

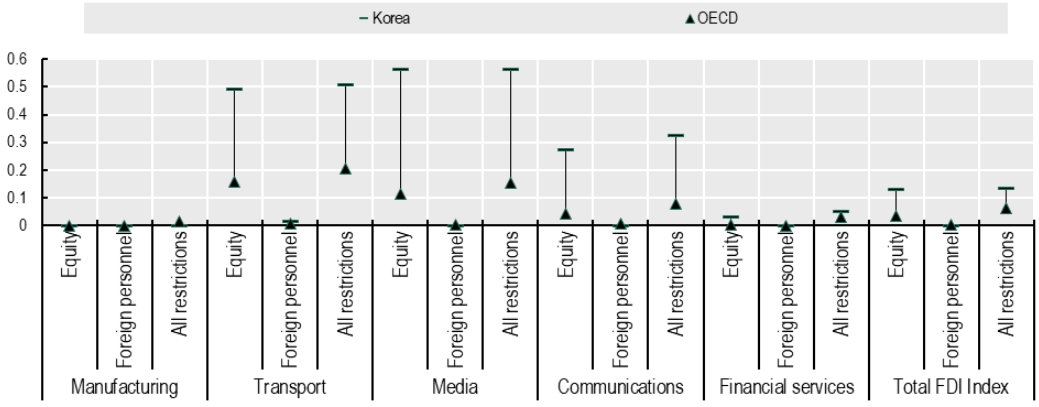
Foreign direct investment (FDI) by multinational corporations (MNCs) has various benefits for the host economy, including productivity growth, knowledge spillovers, industry diversification and service sector growth (Xiaolan, Emesa and Hou, 2021[94]). It allows new technology to be diffused, especially by SMEs with high absorptive capacity and if a country is attracting investment into knowledge-intensive sectors. A proactive STI policy can also be a powerful driver of FDI by knowledge-intensive firms wishing to benefit from local knowledge. Indeed, a strong local STI system can provide specific knowledge inputs to knowledge-intensive firms.

Korea demonstrated a particularly strong commitment to market liberalisation in the 1990s. The corresponding reforms entailed the reduction of trade barriers as well as fewer restrictions on FDI. Following its accession to the OECD in 1996, Korea has driven the most transformative FDI liberalisation progress among OECD countries, as measured by the OECD FDI Regulatory Restrictiveness Index.

Nevertheless, in 2020, Korea was still the sixth-most restrictive OECD country when it came to FDI. While hardly any trade and investment restrictions apply to the manufacturing sector, some service industries, such as telecommunications, pose conditions including foreign equity limits of 50% (Figure 2.22). Moreover, public procurement regulation in some ICT services allows for preferential treatment in favour of Korean small and medium-sized businesses and requires foreign companies to create a local presence to provide their services, subject to a costly company registration, thus creating a barrier to foreign suppliers.

Figure 2.22. FDI Regulatory Restrictiveness Index, Korea, 2019

For a selection of restrictions and a selection of sectors



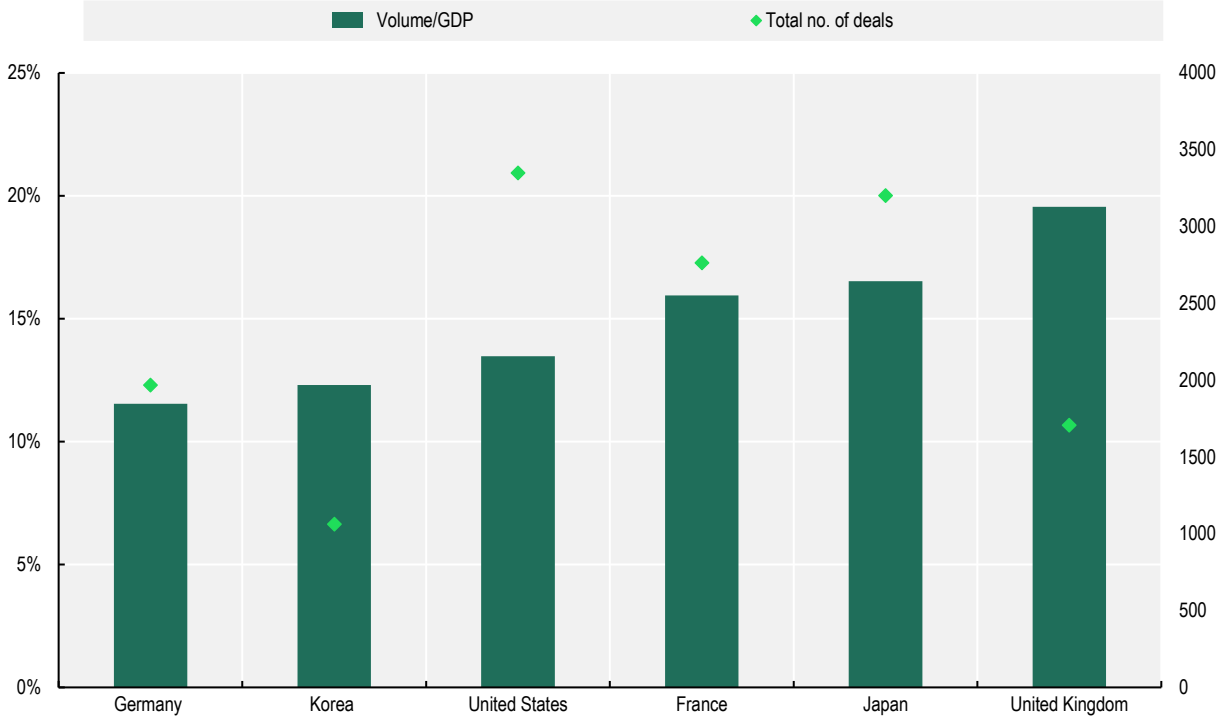
Source: OECD (2022[95]), *FDI Regulatory Restrictiveness Index*, https://www.oecd.org/investment/fdiindex.htm.

In the years following the Asian financial crisis leaving many firms in need of capital, inward FDI has more than quadrupled, notably in the form of mergers and acquisitions (M&As) and joint ventures. This has been a positive development for Korea since firms and industries with larger FDI inflows show higher average labour productivity, wages and R&D spending. FDI was found to have contributed significantly to the country's trade surplus, employment generation and manufacturing sector (OECD, 2021[87]). Furthermore, international linkages, such as joint ventures, tend to foster knowledge transfer from foreign to domestic firms. However, FDI inflows have since stagnated in recent years, reaching 0.6% of Korea's GDP in 2019 compared to 1.2% for the OECD average.

Among OECD innovation leaders, Korea had the lowest total number of M&A deals between 2012 and 2022. In contrast, measured in terms of total volume as a percentage of GDP, Korea's share of M&A deals is 12.3%, slightly higher than Germany (11.54%) and considerably lower than other comparator countries,

including Japan (16.52%) and France (15.95%) (Figure 2.23). More specifically, Korea's M&A deals took place mostly in established industries, notably in industrial materials. In all other countries, there was a more even share of existing and emerging sectors, with the latter including healthcare and communications. A key restriction with regard to M&A applies to emerging SMEs, which are acquired by or incorporated into conglomerates, as these consequently become subject to holding company regulations and lose access to affiliate support (FKI, 2022[96]).

Figure 2.23. Total volume and number of merger and acquisition deals in Korea and selected countries, 2012-22



Source: Federation of Korean Industries (2022[97]), *M&As slow in Korea due to tight regulations: FKI*, https://www.koreaherald.com/view.php?ud=20220210000704.

2.3.3. Despite a relatively open policy on attracting international students, Korea's appeal as a migration host destination is low

International mobility of students, researchers and skilled workers can contribute positively to a country's innovation system in various ways, such as a higher population size increasing the prevalence of innovative talent, complementary skill composition, which reduces labour market mismatches, and more diversity spurring creativity. Moreover, knowledge spillovers from foreign, high-skilled labour, as well as tacit knowledge, which returning nationals "carry" back to their origin country, are common drivers of innovation (Xiaohui Liu, 2010[98]).

Korea has committed to a comparatively open talent immigration system with numerous initiatives to promote inflows of foreign researchers and students. For instance, it has introduced the following ongoing initiatives:

- BrainKorea21 entails a scholarship programme for international students.
- The Gold Card Visa programme offers visas with longer durations for skilled labour in advanced technology.

- The Global Korea Scholarship programme is a fully-funded scholarship programme for international undergraduate and graduate students to study in Korea.

These initiatives were launched in 1999, 2000 and 1967, respectively, to attract international researchers and students to foster Korea's shift to a knowledge-based economy. As a result, the share of foreign tertiary student inflows as a percentage of total enrolled students increased by 80% between 2010 and 2019 (Figure 2.24, Panel A). Nevertheless, in 2021, more than two-thirds of foreign students came from either China with 44% (down from 71% in 2010) or Viet Nam with 24%. Furthermore, these increases occurred from relatively low levels; Korea still has one of the lowest shares of foreign students among OECD countries. On the other hand, a relatively high share of Korean students opts to go abroad for their studies, with a share of 3.4%[25] of outflows of all domestic students, much higher than Japan (0.9%) or the United Kingdom (1.8%) and just below Germany (4%) and France (4.1%).

In addition, the inward mobility of foreign researchers remains low. The share of international scientific authors' net inflows as a percentage of total authors is 1.6%, among the lowest in the OECD (Figure 2.24, Panel B). This prevents Korea from tapping into other sources of inspiration and new ideas for innovation, which skilled foreign labour and international research co-operation can offer. Inflows of foreign researchers and professionals remain low despite historically open immigration policies and reductions in barriers for skilled employees in recent years. Very few foreigners choose the path towards permanent residence even though Korea has one of the most generous job-search visas among OECD countries (OECD, 2019[99]).

In 2003, Korea launched one of the largest temporary employment permit systems in the OECD, both in absolute terms and relative to the labour force, one of whose objectives was to better meet SMEs' needs for semi-skilled employees as well as to create a points-based system that allows entry for foreign talent based on the fulfilment of criteria as pertains to education, age, Korean language skills and income. Furthermore, MOTIE launched a global recruitment service, Contact Korea, in 2008 to recruit foreign workers for SMEs. Other initiatives, including job fairs abroad and contests to appeal to high-skilled international professionals, in particular for start-ups, have been undertaken under various schemes (OECD, 2019[99]).

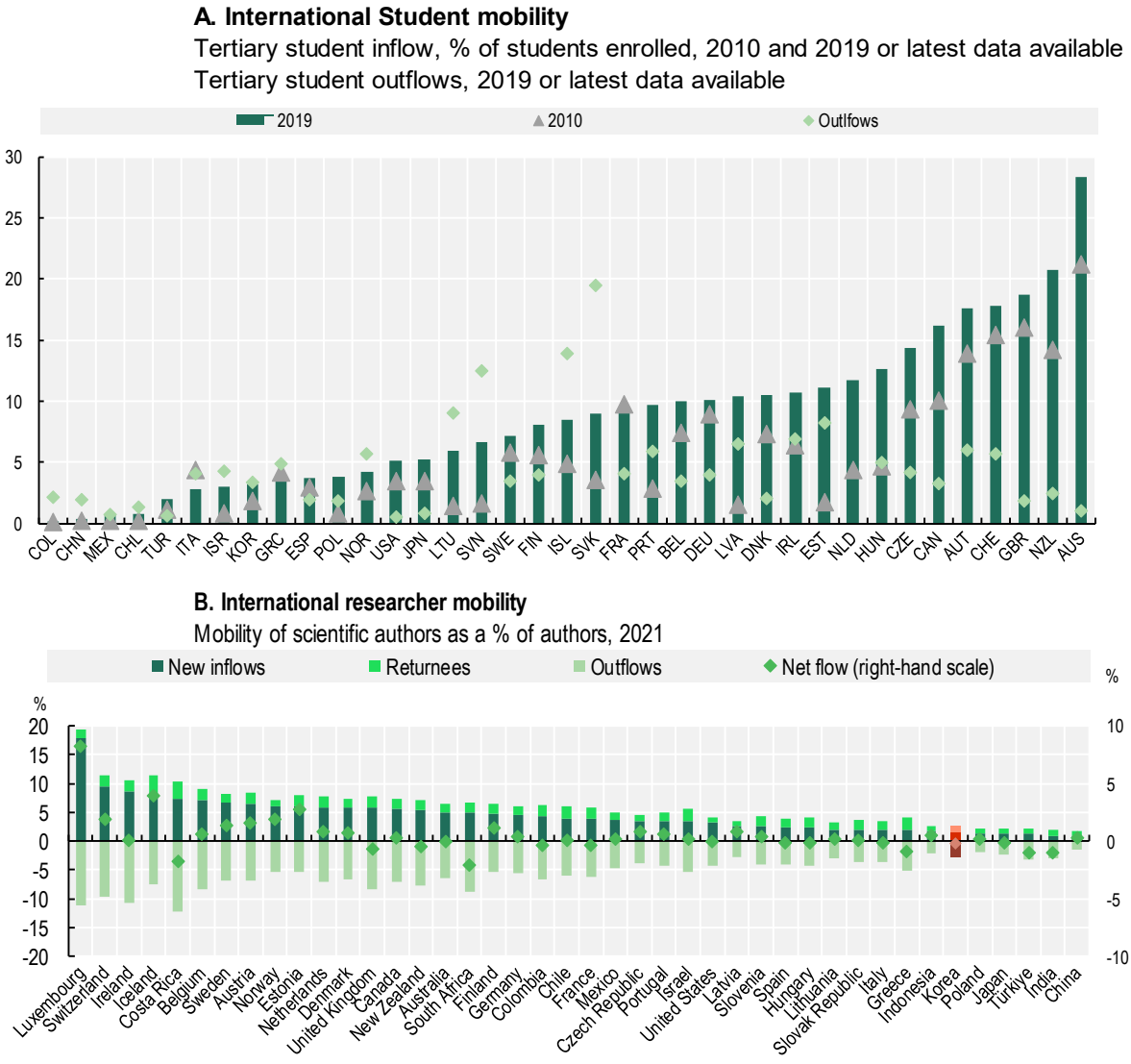
Overall, the migration framework has been continuously adapted to welcome foreigners; however, crucial factors prevent foreigners from wanting to stay for the long term, including working conditions and strong hierarchies, gender disparity, a highly competitive tertiary job market, difficulties in enrolling their children in the education system as well as closed social networks (Kraeh, Froese and Park, 2015[100]; Shin and Choi, 2015[101]). In order to appeal to foreign skilled immigrants, change needs to occur in culture rather than policy (Herting, 2016[102]). For instance, there was a strong increase in foreign professors joining Korean universities until 2012, which was largely interpreted as a commitment to and success of highly skilled immigration. However, while increasing the number of Western faculty members does well for rankings, in practice, they are often deprived of power and marginalised, frequently being positioned in isolated colleges with low impact, as pointed out in stakeholder interviews. In some cases, missing or minimal socialisation with Korean colleagues has also meant that expatriate professors were not asked to serve on faculty committees. The absence of such faculty activities, in turn, has resulted in the rejection of their applications for tenure (Park, 2018[103]). This lack of integration has resulted in many professors leaving after their period of assignment only to be replaced with new recruits. This is particularly detrimental in view of foreign professors being more productive than domestic ones, thereby inhibiting harnessing the full potential internationalisation can offer.

Having skilled immigrants join the local labour force could spark new ideas, knowledge diffusion and the creation of new businesses as they tend to be bigger risk takers. Moreover, immigrants provide a culturally diverse view on business models and value propositions, which could help Korean start-ups internationalise rather than remain local players. In addition, Korean SMEs that face serious technical skills shortages could leverage skilled immigrants' tech savviness and entrepreneurial spirit to promote

productivity through the scale-up of digital technologies. Current policy requires foreigners without university degrees to have at least five years of work experience.

Immigration will become all the more relevant in light of population ageing and the decline of the labour force of the Korean economy. This demographic change is one of the critical societal challenges set to affect Korea going forward.

Figure 2.24. International student and researcher mobility in Korea and selected countries, 2019



Source: Panel A: OECD (2022[104]), *Education Statistics* (database), oe.cd/dp/4Bt, May 2022. Panel B: OECD (2022[24]), *Main Science and Technology Indicators* (database), oe.cd/msti,, May 2022.

2.4. Societal challenges put Korea's innovation system under pressure

The 2030 Agenda for Sustainable Development was adopted in 2015 and set out an ambitious action plan with 17 Sustainable Development Goals (SDGs). By 2021, Korea had achieved 28 of 128 targets related to securing basic needs and implementing necessary policy tools and frameworks mentioned in the 2030

Agenda. As one of the best-performing countries in industry and innovation, Korea's strengths lie in the goals of the Prosperity category (Goals 8, 9, 11),[26] where they are also above the OECD average (OECD, 2022[105]). On the other hand, Korea faces challenges in promoting inclusion and equality in society (Goals 1, 5, 10).[27] This reflects the high relative income poverty, under-representation of women in workplaces and existing legal and financial frameworks not being able to adequately tackle the issues of inequality.

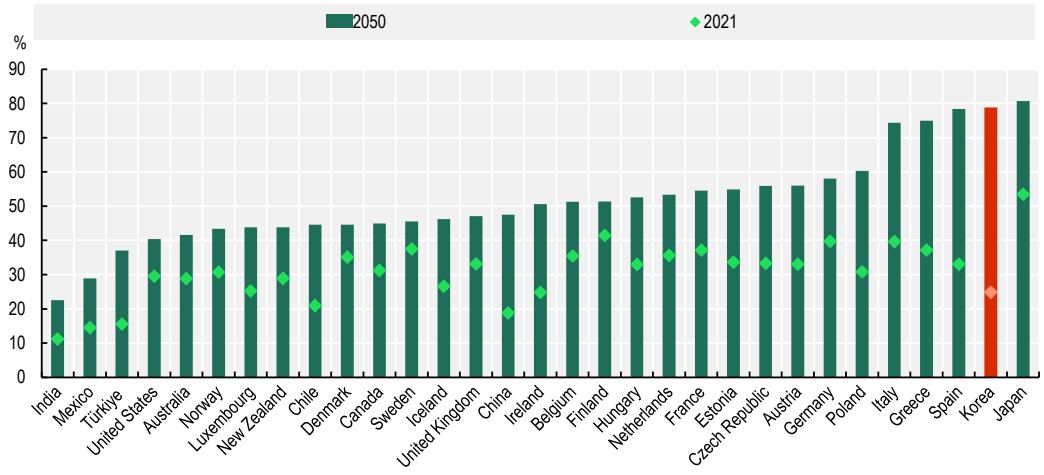
Korea has continued its efforts to incorporate the SDGs into its national development plans. The first Framework Act on Sustainable Development dates back to 2006, which led to the first Basic Plan on Sustainable Development (2006-11; hereafter, the "SD Basic Plan"). The legal basis for the SD Basic Plan was changed to the Framework Act on Low Carbon Green Growth, which was adopted in 2010. Since 2011, the SD Basic Plan was renewed twice every five years until 2020. In 2018, the national SDG goals ("K-SDGs") were established in 17 fields (goals), with 122 specific targets and 214 indicators (currently amended to 119 targets and 236 indicators) as complementary to the United Nations SDGs (Ministry of Environment, 2022[106]). Setting the K-SDGs was largely a bottom-up process, and more than half (57%) of the 122 targets address societal concerns specific to Korean circumstances. The fourth SD Basic Plan covers a longer period of 20 years (2021-40). Under the vision of "building a sustainable nation through inclusiveness and innovation", it establishes four thematic strategies (people, prosperity, environment, peace and co-operation) supported by 17 goals. For the last decade, special attention has been given to incorporating SDGs into national policies and plans to make them more compatible with the existing framework conditions in Korea on issues such as ageing, gender equality and environmental protection (United Nations, 2016[107]).

2.4.1. Korea is expected to have the steepest rise in old-age dependency by 2050

As is the case for many industrialised economies, Korea faces a significant increase in its old-age population outside the labour force. By 2050, it is expected to have the second-highest dependency ratio after Japan, which means that its old-age population above the age of 65 relative to the population in the labour force supporting the pension systems will be very high, with about 80% of the labour force, which is roughly on par with Japan (Figure 2.25). More specifically, however, the rise is expected to be the highest among OECD countries from 2021 levels of 23%, compared to 53% for Japan, for instance, where the rise will be slower, allowing policies and the economy to adjust more gradually. For Korea, the drastic shift has vast implications for the labour market, its national innovation system and the economy more generally. The impact on the talent pool is already visible, with a lack of young people leading to fewer student enrolments at some universities, notably in regions outside the metropolitan areas, potentially forcing some to close down. Moreover, this will pressure firms, especially SMEs, to secure talent for their business operations from a shrinking pool of available candidates.

This further underlines the importance of leveraging the prevalent skills-based immigration system in line with the needs of businesses, thus compensating for the increasing lack of human capital. Since the policy framework is largely in place, efforts to better integrate immigrants so as to increase Korea's appeal as a migration host destination will be of particular relevance.

Figure 2.25. Old-age dependency by 2050, Korea and selected countries

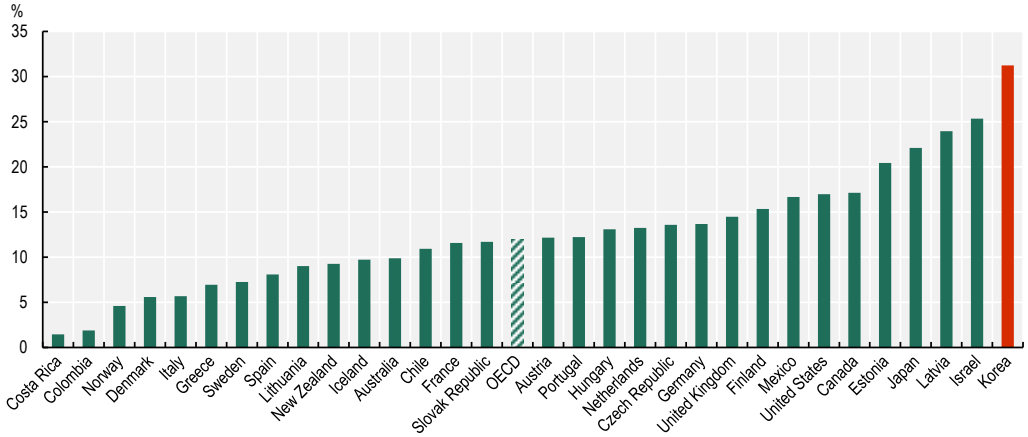


Note: The old-age to working-age demographic ratio is defined as the number of individuals aged 65 and over per 100 people of working age, defined as those aged 20-64.
Source: OECD (2023), "Old-age dependency ratio" (indicator), https://doi.org/10.1787/e0255c98-en (accessed on 23 June 2023).

In addition, Korea has the highest gender wage gap among OECD countries (Figure 2.26). A major reason for this is the high opportunity cost of having children. Long working hours, concerns over the quality of childcare and societal norms around gender roles contribute to the cost for women in combining having children and a career. In addition, hiring practices are heavily based on seniority, meaning that career breaks for child-bearing purposes significantly hamper women's employment trajectories. More specifically, women re-entering the labour market after parental leave often do so as non-regular employees in jobs with considerably lower wages. Moreover, many women may be reluctant to have children in the first place due to perceived difficulties in returning to work afterwards. Such behaviour may further lower overall fertility. To increase mothers' rates of returning to work after a career break and to decrease the opportunity cost of having children, the government is providing vocational and other education and training programmes through specific job centres and training by the Ministry of Employment and Labour and the Ministry of Gender Equality and Family.

Figure 2.26. The gender wage gap in Korea and selected countries, 2022

2022 or latest data available



Source: OECD (2022[108]), *Employment and Labour Market Statistics* (database), oe.cd/dp/4WZ, May 2022.

Other judicial and policy initiatives to address the issue of population ageing have been established to alleviate social and economic insecurities for people across the various stages of life. They include the Plan for Aging Society and Population (2015), the Framework Act on Low Fertility and Population Aging (2014), and the Law for Promoting Elderly-Friendly Industries (2013).

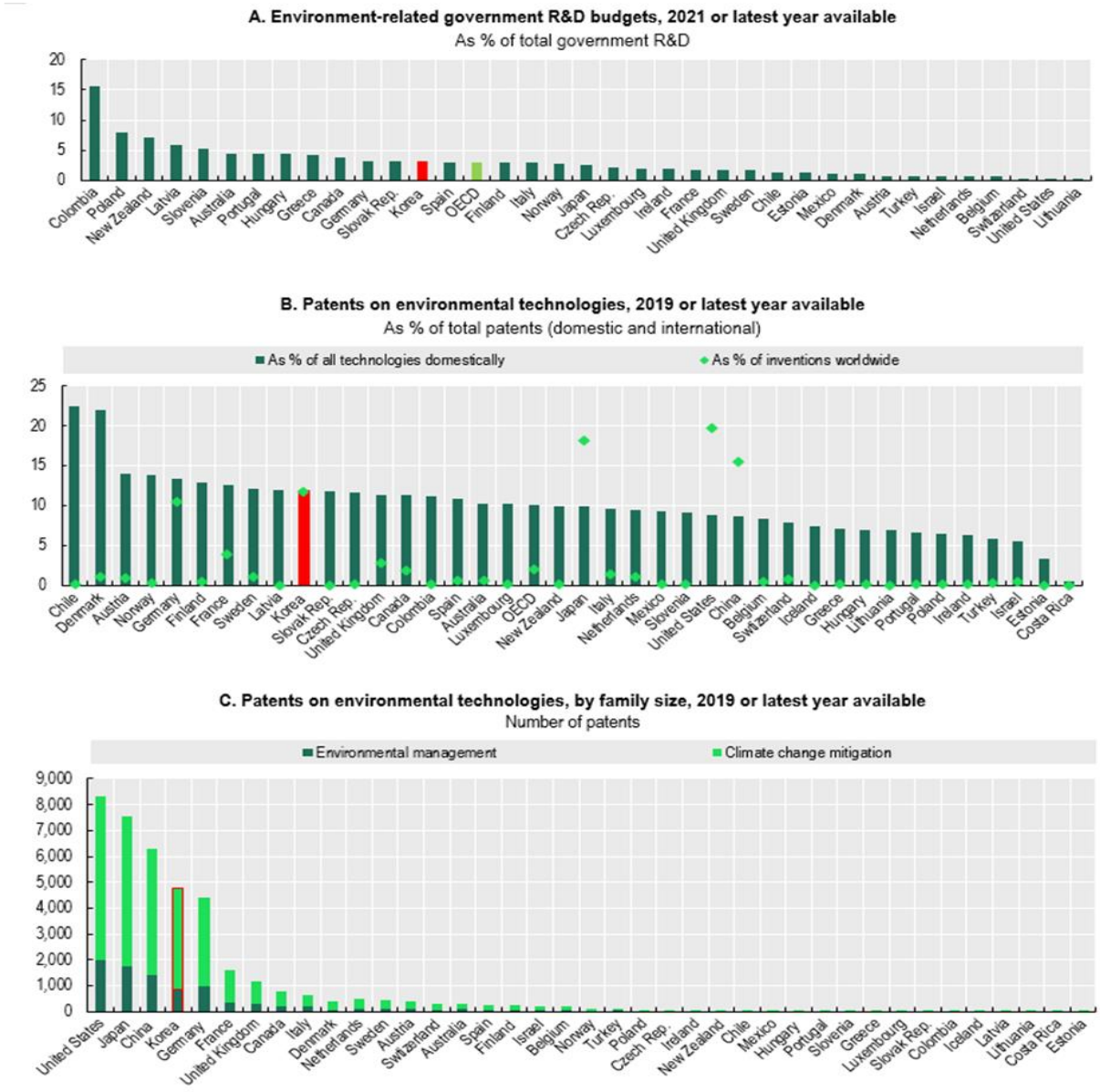
2.4.2. Following previous efforts, which leave room for improvement, Korea has adopted policies to tackle climate change, but implementation will depend on wider participation from both society and industry

Climate change is a global concern that affects ecosystems and diversity and generates considerable socio-economic consequences. Globally, apart from a few countries, there has been a decoupling of greenhouse gas (GHG) emissions from GDP and population growth, and emission intensities per GDP have decreased since 2007 across most OECD economies (OECD, 2022[109]).

Korea is working towards its climate neutrality target. Korea ratified the Kyoto Protocol and the Paris Agreement as an expression of commitment to join international efforts in fighting climate change. The government recently revised its reduction target to 40% of the 2018 level by 2030 from its previous goal of 26.3% submitted in 2020. The new administration supports this goal and plans to expand nuclear power generation to accelerate the country's goal of zero emissions. It has also anchored several policies that propel nationwide green transition, such as the National Green Growth Strategy (2009-2050), Five-year Plans for Green Growth (third in 2020) with detailed investment plans and tasks for the ministries and local governing entities, and the Framework Act on Low Carbon, Green Growth (2010). In 2015, Korea introduced the third-largest emission trading scheme (K-ETS) after the European Union's Emission Trading System (EU ETS) and China. Currently, Korea has one of the widest (73%) sector coverage in terms of types of economic activities[28] (International Carbon Action Partnership, 2022[110]). However, carbon prices are much lower than in other countries. The auctioning revenue from emission trading as a source of government revenue is rather modest at USD 199.4 million since 2019, compared to USD 8 497 million in Germany and USD 5 928 million in the United Kingdom since 2021. Furthermore, innovation is considered a key pillar in leading Korea's green transition. High investment levels in R&D place Korea in a favourable position for transforming itself into a carbon-neutral economy. The government allocates a higher R&D budget for environment-related programmes and projects than the OECD average (Figure 2.27, Panel A). Korea is one of the most innovative countries in developing environmental technologies, particularly climate change mitigation technologies (OECD, 2017[111]) (Figure 2.27, Panels B and C).

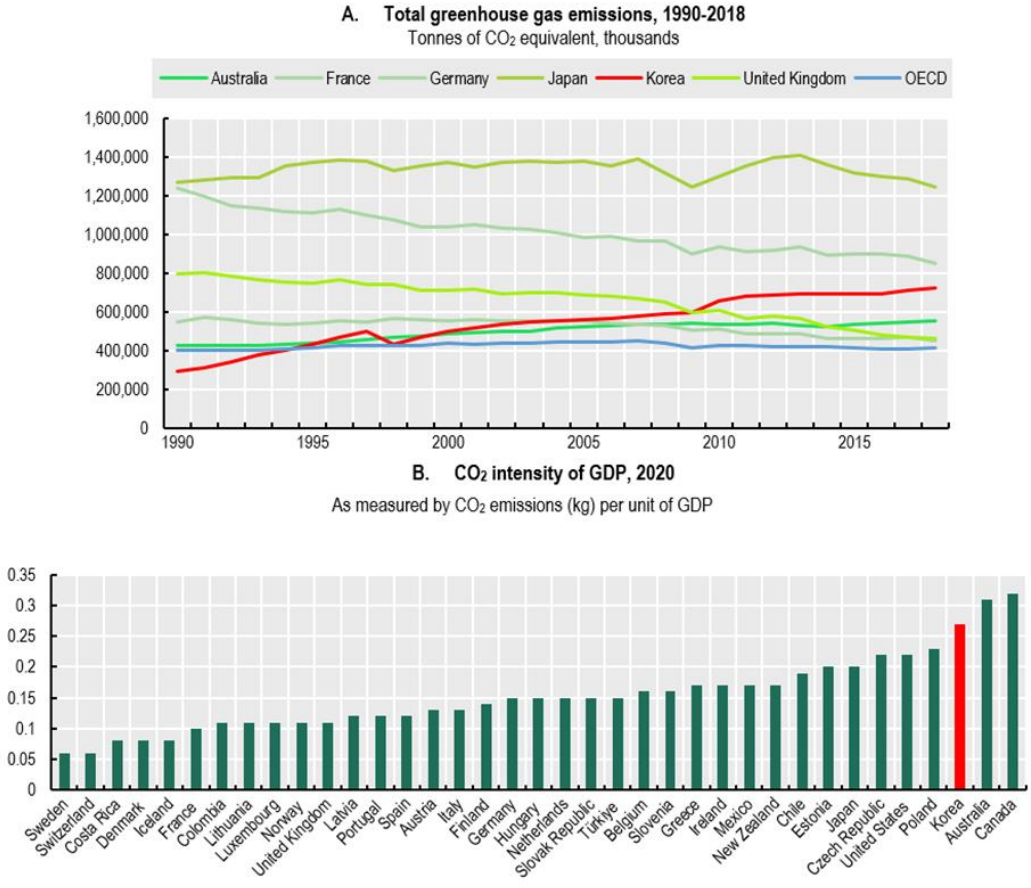
However, total emissions (Figure 2.28, Panel A) indicate that past and current policy initiatives, as well as Korea's innovation performance, have been insufficient to generate the needed structural changes. After incurring the steepest rise in GHG emissions between 1990 and 2005, the government made the commitment to reduce its emissions by 30% below the "business as usual" (BAU) baseline by 2020. *De facto,* this would imply a 4% reduction from 2005 levels; however, actual emissions have risen from 560 million to 728 million tonnes in the given period, an increase of 30%. A study by Kalinowski concludes that despite ambitious green growth policies being implemented, "Korea's legacy as a developmental state characterised by strong corporatist links between state and business as well as a weak civil society" explain the underperformance in emissions mitigation. The ambition was amended in 2015 to a reduction of 37% below BAU while extending the deadline to 2030 (Kalinowski, 2021[112]). In addition, Korea's carbon dioxide intensity of GDP remains one of the highest among OECD countries (Figure 2.28, Panel B).

Figure 2.27. R&D budgets for environment-related programmes and patents on environmental technologies in Korea and selected countries, 2021 and 2019



Source: OECD (2022[116]), *Green Growth Indicators*, oe.cd/ds/4BK, June 2022; OECD (2022[117]), *Intellectual Property (IP) Statistics and Analysis*, oe.cd/4BL, June 2022.

Figure 2.28. Greenhouse gas emissions (1990-2018) and CO_2 intensity of GDP (2020) in Korea and selected countries



Note: Panel A: Total emissions excluding land use, land-use change and forestry. Panel B: 2019 data for Costa Rica.
Source:
Panel A: OECD (2022[118]), Environment Statistics (database), oe.cd/dp/4BM, June 2022.
Panel B: OECD (2022[116]), Green Growth Indicators, oe.cd/ds/4BK, June 2022.

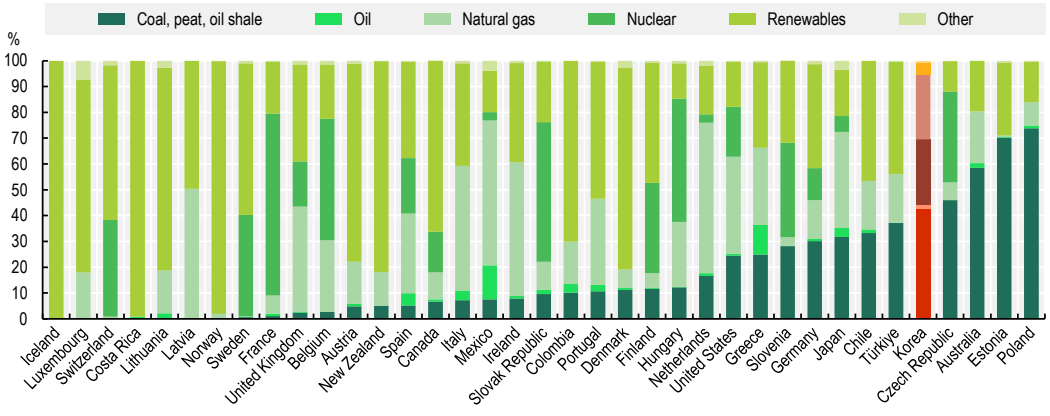
One bottleneck may be the lack of public engagement. Achieving a climate neutrality goal depends on whether or not a government can attract and incentivise broad-based participation from society and industry. In fact, Korea benefits from a relatively high level of public awareness around the need for the green transition (Dechezleprêtre et al., 2022[113]) (OECD, 2022[17]). According to the OECD Economic Survey (OECD, 2022[17]), most Koreans agree that climate change is an important problem and will negatively affect their personal lives. Concrete policy measures receive moderate support; for instance, only around half of a surveyed group supports a tax on fossil fuels. However, Korea outperforms Germany in this regard, on par with the United Kingdom and Denmark. Accumulation of knowledge on climate change needs to be paired with society's acceptance of laws and a co-operative attitude among citizens to bring substantive impact (Willems and Baumert, 2003[114]). Benefiting from a high level of public awareness around climate policies, Korea can bolster further engagement from its citizens to materialise its policy ambitions. For instance, the 2017 Green New Deal initiative is the largest policy package (KRW 114 trillion) in Korean history to make the economy greener (see Chapter 5). However, according to a survey conducted by the Korea Environment Institute (KEI) under the Ministry of Environment, over half (58.5%) of respondents stated that they are neither knowledgeable nor have heard of the concept of the Green New Deal, and 41.6% considered the policy "unrealistic" (KEI, 2021[115]).

Another bottleneck may be that Korea aims to reduce GHG emissions in a cost-effective way (IEA/KEEI, 2022[119]) but does not fully leverage the emission trading system. The power sector, i.e. the generation of electricity and heat, is the largest source of emissions in many OECD economies, including Korea (58% of total carbon emissions), and the International Energy Agency (IEA) Net Zero 2050 Roadmap designates it as the first sector to decarbonise (IEA, 2021[120]; International Carbon Action Partnership, 2022[110]). Currently, the electricity market in Korea is highly coal-intensive (fifth among OECD countries), generating 38.7% of the country's electricity from coal (Figure 2.29, Panel A). From 2010 until 2020, coal's share decreased by 5.2%, but gas rose by approximately the same margin (5.2%), meaning that the total generation from fossil fuels changed very little (-2.8%). In the meantime, the growth of renewable sources was rather muted, indicating that Korea's energy market has remained invested in non-renewable sources for the past decade (Figure 2.29, Panel B). Carbon pricing can be a very effective policy to make low- and zero-carbon energy more competitive (OECD, 2021[121]) by sending the right signals to the demand side.

Figure 2.29. Electricity generation by source and share of renewable energy in Korea and OECD countries, 2020

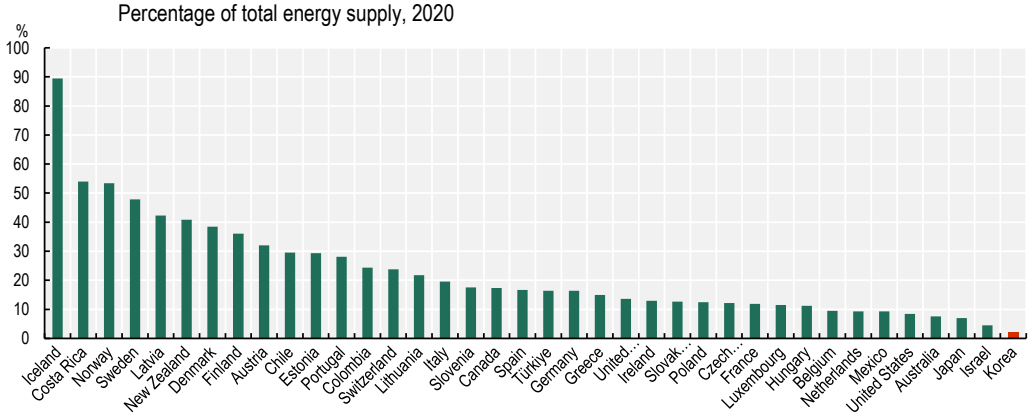
A.Energy mix in electricity production

Shares in total electricity production, 2020 or latest year available



B. Renewable energy supply

Percentage of total energy supply, 2020



Note: Panel A: In the legend, "Hydro, bioenergy and other renewables" is an aggregate of biofuels, hydro, waste, tide, geothermal and other sources, and "Wind and solar" is an aggregate of solar PV, wind and solar thermal. All are based on the IEA classification. Panel B: Renewable energy is defined as the contribution of renewables to the total primary energy supply (TPES). Renewables include the primary energy equivalent of hydro (excluding pumped storage), geothermal, solar, wind, tide and wave sources. Energy derived from solid biofuels, biogasoline, biodiesels, other liquid biofuels, biogases and the renewable fraction of municipal waste are also included.

Source: Panel A: IEA, "World energy statistics", *IEA World Energy Statistics and Balances* (accessed on 27 June 2023).

Panel B: OECD, "Green growth indicators", *OECD Environment Statistics* (database), https://doi.org/10.1787/data-00665-en (accessed on 27 June 2023).

However, the explicit carbon price in Korea (approximately USD 10.5/tonne)[29] has remained far below the level required by 2020 to be consistent with the Paris Agreement (USD 40-80/tonne). In 2030, the European Commission estimates that the price should reach USD 50-100, provided that a supportive policy environment is in place, meaning complementary action needs to be taken through other policy instruments, e.g. adjusting the cost of transition and increasing political and social acceptability of the carbon price. Apart from the price of carbon emissions, the overall effectiveness of the K-ETS system has been unclear to date. Narassimhan et al. (2018[122]) find that by international comparison, Korea's 100% free allowance allocation approach[30] at the firm level and the minimal increase in auctioning compromise the credibility of K-ETS. Generally, the marginal costs of carbon dioxide tend not to be taken into account by private actors when deciding how much to produce or consume (Butner et al., 2020[123]). Within the European Union, industry sectors facing carbon leakage tend to receive higher shares of free allowances[31] (European Commission, 2022[124]), in part to secure industry competitiveness. Furthermore, in Korea, the ETS cap has been questioned for relying too heavily on a bottom-up approach where the manufacturers derived the abatement targets, whereas the societal and environmental aspects have been relatively disregarded (Kim, 2015[125]).

Some criticise the Green New Deal for laying out the net-zero carbon emission target by 2050 without specific responsibilities, targets or actions to follow to that effect. The only emission target mentioned of a reduction by 16.2 million tonnes is below the "2030 National Greenhouse Gas Reduction Implementation Plan" introduced in 2018. This stands in contrast to the European Union Green Deal, which sets out near-time and binding objectives and monitors compliance by private entities (Woo, 2020[126]). While the Green New Deal and other government initiatives reflect Korea's aspirations to become a green leader and show strong investments in green technologies, the path dependencies of the developmental state involving strong business-government affiliation hinder progress when it comes to reducing emissions and, therefore, imposing higher costs onto businesses. In combination with a relatively restrained civil society, this enables the private sector leeway to assert their mostly near-term profit-oriented interests (Kalinowski, 2021[112]). In fact, carbon emissions in Korea are estimated to have been around 679.6 million tonnes in 2021, according to recent data, which is a 3.5% increase over the previous year. Emissions by the top 30 private companies have increased by 4.2%, reaching a new all-time high (Ministry of Environment, 2022[127]).

Nevertheless, co-operation with and buy-in from the private sector is essential in mobilising resources, knowledge and innovation for addressing climate change (OECD, 2016[128]). Business practices are often associated with environmental pollution and degradation, and possibly to a greater extent in Korea, considering the country's larger coal-intensive industries. Private firms can also, however, play a critical role in promoting green behaviour across supply chains, increasing investments in clean infrastructures and leading innovation in clean technologies. Given the policy trend, conglomerates in Korea have announced their commitments to emission-reduction targets by 2030 and joined global initiatives, such as RE100 (Kim, 2020[129]; RE100, 2021[130]). In 2021, 10 conglomerates[32] formed a hydrogen alliance, vowing to provide an additional 1 500 hydrogen-powered electric cars; expand hydrogen charging infrastructures; and establish a hydrogen energy council in the private sector (IT Chosun, 2021[131]). Hyundai-KIA is gaining global market share in electric cars (KATECH, 2022[132]), and offshore wind power installations also have proved a promising business opportunity for the top three firms in the Korean shipbuilding industry (Hankyung Economy, 2022[133]). Moreover, Korea's steel group, POSCO, also the biggest carbon emitter, committed to replacing coal with hydrogen in its steel production system by 2027 (The Korea Times, 2022[134]). POSCO is also co-operating with the world's biggest steel manufacturers, such as Nippon Steel of Japan and SSAB/LKAB/Vattenfall of Sweden, to develop new technologies that are not yet proven at scale.

However, it is unclear whether this private sector push will materialise in a breakaway from the traditional profit model, given that the highest-emission industries in Korea are the most successful ones. Private sector resistance has been strong, and already before the introduction of the K-ETS system in 2015, the

Federation of Korean Industries (FKI), a non-profit organisation that consists of Korea's major conglomerates and associated members, expressed grave concern about the possible compromise of industry competitiveness (FKI, 2014[135]). Since then, the K-ETS system has demonstrated encouraging results in this respect, as carbon-intensive industries have increased their corporate carbon productivity at the firm level[33] (Jung et al., 2021[136]). However, the recently announced K-ETS Phase 3 allocation plan (2021-25) is likely to face a similar level of headwinds from industry since it contains stricter provisions, such as a tightened power sector benchmark, updated allocation provisions (e.g. a rise of the share of auctioning from 3% to 10%) and third-party participation (Ministry of Environment, 2020[137]). In order to secure economy-wide momentum for the green transition while preserving industry competitiveness, a clear understanding of private sector needs and a holistic approach to private sector engagement are essential (OECD, 2016[128]). The Fossil-Free Sweden (FFS) Initiative in Sweden offers an interesting benchmark case in this regard (Box 2.1).

Box 2.1. Fossil-Free Sweden (Fossilfritt Sverige): An orchestrator to leverage private sector engagement in building a fossil-free economy

Fossil-Free Sweden (FFS) is a national multi-stakeholder initiative created by the Swedish government in 2015. To date, it has 450 members, including businesses, municipalities, country councils, regions, country boards, civil society, education and research organisations, and industry and trade organisations. Headed by a national co-ordinator, FFS assumes an orchestrator role between the business sector and policies by producing political proposals that are presented to the government ministries and the parliament (*riksdag*).

FFS has three work streams: 1) communicating the identified challenges; 2) building roadmaps for fossil-fuel-free competitiveness; and 3) convening roundtable discussions. Regarding the first work stream, FFS has launched four challenges – transport, solar, internal travel tax and company car – that require concrete climate action, and their aim is to engage actively with their target audience, industry and society in general. The second stream, roadmaps, is the cornerstone of the initiative. As part of FFS, 22 different industries covering the major sectors of the Swedish economy produced their own roadmaps. The roadmaps contain both their commitments and political proposals, and in 2019, FFS issued 54 proposals to help prioritise among the large volume of inputs from industry. In 2021, with the backing of the industries, FFS published a follow-up report reviewing the government initiatives and policies implemented in response to the initially submitted proposals and drawing conclusions on the five most important political decisions and five outstanding challenges (FFS, 2021[138]).

Since the creation of FFS, information sharing among different stakeholder groups has been considered key, and more importantly, the participation of the business sector. There already existed a few voluntary and rather loose industry-led partnerships for climate action in Sweden, but FFS stood out as a state-led initiative to become a facilitator of change rather than a barrier for non-state actors (Nasiritousi and Grimm, 2022[139]). To this end, FFS has adopted key legitimacy-building strategies on the institutional level to focus on the narrative of improving competitiveness. For instance, the Swedish Prime Minister was involved in the initial meetings to increase the initiative's weight as a high-level communication platform.

In the absence of favourable incentives, such as competition, external pressure from reputation and laws, as well as anticipated costs and benefits, the success of this initiative depends on normative factors. In the case of FFS, this hinges on two key factors: 1) the main orchestrator has a non-governmental organisation (NGO) background and also uses language understandable to business, such as business case and competitiveness; 2) the initiative is from government, so the stakeholders know they will capture the attention of relevant ministers. Success is not guaranteed, however, since the FFS has been nominated as one of the top three nominees for Friends of the Earth Sweden's 2021

"greenwash" prize. The NGO says that FFS promotes "business as usual", pointing at unsustainable biomass extraction by the forestry industry as a solution to the climate crisis.

On the positive side, FFS has inspired other decarbonisation initiatives, such as the Leadership Group for Industry Transition, which counts 18 countries and 19 large firms as members, which have committed to national decarbonisation targets, most notably the ambition of achieving net-zero carbon emissions by 2050. In particular, they aim to use the policy window created by COVID-19 to steer economic development onto a more sustainable and inclusive path towards net zero, resisting pressures from carbon-emissions industries to maintain "business as usual" to avoid an increase in costs and job losses (Johnson et al., 2020[140]).

Source: FFS (2021[138]), *Roadmaps for Fossil-Free Competitiveness - Follow-up 2021*, https://fossilfrittsverige.se/wp-content/uploads/2022/01/Roadmaps_follow_up_2021_ENG.pdf; Nasiritousi and Grimm (2022[139]), "Governing toward decarbonization: The legitimacy of national orchestration", https://doi.org/10.1002/eet.1979; Johnson et al. (2020[140]), *Shaping a Sustainable and Low-carbon Recovery that Spurs Industry Transition*, https://view.ckcest.cn/AllFiles/ZKBG/Pages/126/b5e99e6ceca215a50bd7a322d6598b296d448636.pdf.

2.4.3. Leveraging innovation for defence as a response to geopolitical threats

Korea continues to be directly affected by rising geopolitical tensions, in particular by security threats from the Democratic People's Republic of Korea and has thus pledged a record sum of investments for strategic defence purposes. In 2020, Korea had one of the highest government budget allocations for R&D (GBARD) on defence (16.6%), second only to the United States (47.1%) among OECD members (OECD, 2022[24]).

According to the Defense Acquisition Program Administration, the government has set the objective of systematically supporting defence R&D using advancements in innovation as per the Defense Science and Technology Innovation Promotion Act in 2021. More specifically, it is intended to encourage an "open R&D culture" with participation from government research institutes, academia and the private sector, notably also smaller companies (Grevatt, 2021[141]). For this purpose, it seeks to enhance technologies of the Fourth Industrial Revolution that may benefit other sectors through industry linkages. Moreover, this initiative may also set an example for other sectors in terms of inducing deepened co-operation across research institutes, universities and businesses.

2.5. Synthesis

Korea has shown impressive economic and innovation performance. It is among the leading OECD countries in some respects and one of the main laggards in others. The main achievements and challenges discussed in this chapter are listed in Table 2.3.

Table 2.3. Korea's main innovation-related achievements and challenges

Achievements	Challenges
▪ Korea has shown an impressive growth trajectory to high-income status and the innovation frontier. ▪ Strong global leadership in ICT technologies, notably in broadband, 5G and digital government. ▪ Strong economic performance and comparative advantage in manufacturing, notably in advanced products, such as semiconductors and smartphones. ▪ Korea is a leader in spending financial and human resources for R&D. ▪ Korea fares well in investment in green innovation, e.g. in terms of R&D budget and patents for climate mitigation.	▪ Large disparities in industry regarding firm size, between manufacturing and services. ▪ Knowledge-intensive activities are highly concentrated in manufacturing and, in particular, in conglomerates, which holds risks for the overall market. ▪ High productivity gaps across industries and firm size may hinder knowledge diffusion and inclusive growth. ▪ Higher gender equality, e.g. regarding wages and female participation in research, will be critical for inclusive growth and innovation. ▪ Despite FDI regulatory liberalisation efforts, Korea is among the most restrictive OECD countries. ▪ Despite a relatively open migration system, lack of

Achievements	Challenges
	inclusion and working conditions hinder Korea's appeal as a migrant and expat destination. ▪ Korea is expected to have the steepest rise in old-age population by 2050, with structural implications for the economy and innovation system. ▪ Korea's legacy as a developmental state with strong business-state links and weak civil society means carbon emission reduction is sub-par to other leading economies.

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Notes

1. "The concept of national innovation systems rests on the premise that understanding the linkages among the actors involved in innovation is key to improving technology performance. Innovation and technical progress are the result of a complex set of relationships among actors producing, distributing and applying various kinds of knowledge. The innovative performance of a country depends to a large extent on how these actors relate to each other as elements of a collective system of knowledge creation and use as well as the technologies they use. These actors are primarily private enterprises, universities and public research institutes and the people within them. The linkages can take the form of joint research, personnel exchanges, cross-patenting, purchase of equipment and a variety of other channels. There is no single accepted definition of a national system of innovation.” (OECD, 1997[150])

2. Strictness Index on dismissal regulation for workers on regular contracts (both individual and collective dismissals). Range of indicator scores: 0-6. Countries with the lowest and highest score are classified as countries with low and high regulatory protection.

3. SMEs are further subdivided into micro enterprises (fewer than 10 employees), small enterprises (10-49 employees), medium-sized enterprises (50-249 employees). Large enterprises employ 250 or more people.

4. Data on Korean firms' use of IoT technologies are not available in the OECD database for comparison.

5. Product innovation is defined as "a new or improved good or service that differs significantly from the firm's previous goods or services and that has been introduced on the market". This includes significant improvements to one or more characteristics or performance specifications, such as quality, technical specifications, user-friendliness or usability. Business process innovation as "a new or improved business process for one or more business functions that differs significantly from the firm's previous business processes and that has been brought into use in the firm". This includes the various functions within a firm, such as the production of goods or services, distribution and logistics, marketing and sales, information and communication systems, and administration and management.

6. Index scale 0-6 from most to least competition-friendly regulation. See OECD (2018[59]).

7. The indicator measures the level of regulations in three service sectors with sub-categories: energy (electricity, gas); transport (rail, air, road, water); and e-communications (fixed, mobile).

8. In Korean, 서비스 R&D 활성화 방안.

9. In Korean, 서비스경제 발전 전략.

10. In Korean, 서비스 R&D 중장기 추진전략 및 투자계획.

11. In Korean, 서비스산업 혁신 전략.

12. In Korean, 국가 필수전략기술 선정 및 육성 보호전략.

13. Artificial intelligence, 5G/6G, advanced biology, semiconductor/display, rechargeable battery, hydrogen, advanced robot manufacturing, quantum technology, aerospace and cybersecurity.

14. In Korean, 국가첨단전략산업 경쟁력 강화 및 보호에 관한 특별조치법.

15. In Korean, 조세특례제한법; the amendment is to take effect as of 2023.

16. Employment in services as a percentage of total employment has increased from 66% in 2013 to 70% in 2019. Source: International Labour Organization, ILOSTAT database.

17. For instance, see Baldwin (2013[151]), De Backer and Yamano (2012[156]) and Cigna, Gunnella and Quaglietti (2022[152]).

18. The GVC Participation Index indicates the level of integration in the vertically fragmented production process, and it distinguishes the "backward participation", i.e. the use of foreign inputs in exports as measured by foreign value-added (FVA) content of gross exports, and "forward participation", i.e. the use of domestic intermediates in third-country exports as measured by domestic value-added (DVA) content of gross exports. The higher the backward participation is, the more a country relies on the sourcing of foreign inputs, and the higher forward participation, the more it supplies intermediate goods and services to other countries, which are then re-exported.

19. GVC income is the value-added contributed by Korean firms (from any industry) in world sales of products from each industry.

20. RCA is an index used for calculating the relative advantage or disadvantage of a certain industry or country. It is calculated as the share of Korea in world GVC income for a given industry divided by the share of Korea in world GVC income. When a country has a revealed comparative advantage for a given product (RCA >1), it is inferred to be a competitive producer and exporter of that product relative to a country producing and exporting that good at or below the world average.

21. For instance, agile trade policies can help firms to switch to alternative suppliers, and innovation policies can promote the emergence of innovative companies to quickly meet the surging demand of certain products.

22. Mitigation strategy is often used interchangeably with the "robustness strategy" (Baldwin and Freeman, 2021[149]; Miroudot, 2020[154]), which by definition is the ability to maintain operations during a crisis (Brandon-Jones et al., 2014[158]). Possible policy scenarios include supplier and buyer diversification and re-shoring or near-shoring of production. Regarding the latter, some claim that further localised production can alleviate the shocks in supply chains and lower uncertainty. However, such argumentation needs to be taken with caution since greater reliance on domestic production not only limits the economy's ability to cushion the shocks but also slows its recovery from GDP losses in the aftermath of the crises (OECD, 2021[79]; Arriola et al., 2020[155]).

23. The Hirschman-Herfindahl Index measures the dispersion of trade value across an exporter's partners. Depending on the level of concentration of a country's trade (export and import) partners, the index can range from 0 ("unconcentrated") to 2 500 ("highly concentrated"). Over 2 500 is considered "highly concentrated", 1 500~2 500 range as "moderately concentrated" and below 1 500 as "unconcentrated".

24. HHI: Korea (954), Japan (928), Netherlands (852), United States (760), China (659), France (545), United Kingdom (525), Italy (490), Germany (431). IIT finds that Korea's trade model places itself at a "high-growth high-return" model where it faces both a high level of volatility and expected return, while most advanced Western European economies and China follow a "low-risk low-return" model. In general, larger economies are better placed for trade diversification. Nevertheless, Japan follows the "high-growth high-return" model since both countries are largely reliant on the Chinese market for their exports (Korea 22.1% of total exports; Japan 19.9%) (KOTRA, 2022[153]).

25. Calculation based on numbers from the Ministry of Education indicate 3.65% of outflows in 2021.

26. Sustainable Development Goal 8: Decent Work and Economic Growth; SDG 9: Industry, Innovation and Infrastructure; SDG 11: Sustainable Cities and Communities.

27. SDG 1: No Poverty, SDG 5: Gender Equality; SDG 10: Reduced Inequality

28. Sectors include forestry, waste, domestic aviation, transport, buildings, industry and power.

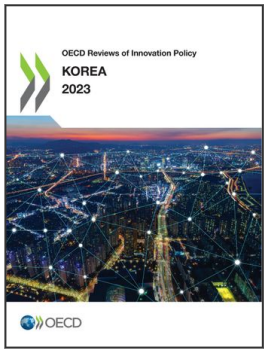
29. Explicit carbon price is about EUR 10 per tonne for most industries. In the electricity generation sector, the price goes up to USD 31.7 per tonne due to excise tax.

30. Sectors that meet one of the following conditions may receive 100% of their allowances for free during a certain phase: 1) sectors whose production cost rate (ratio of total allowance cost among total value-added production, specifically defined in the Presidential Decree to ETS Act) is 30% or more; 2) sectors whose trade intensity level (specifically defined in the Presidential Decree to ETS Act) is 5% or more; or 3) sectors whose production cost rate is 5% or more and at the same time has a trade intensity level of 10% or more.

31. Carbon leakage refers to the situation that may occur if, for reasons of costs related to climate policies, businesses were to transfer production to other countries with laxer emission constraints. This could lead to an increase in their total emissions. The risk of carbon leakage may be higher in certain energy-intensive industries.

32. Hyundai Motors, SK, Lotte, POSCO, Hanwha, Hyundai Heavy Industries, GS, Doosan, Hyosung, Kolon.

33. According to Jung et al. (2021[136]), carbon productivity is measured as a firm-level revenue created per unit of carbon emission. It is calculated as CPi,t=Revenuei.t/Emissioni,t. where CPi,t is the carbon productivity of firm i in year t, Revenuei,t is the annual sales generated by firm i in year t, and Emissioni,t is the level of GHGs emitted by firm i in year t. For clarity, all of the carbon productivity values are multiplied by 1 million. For the top three industries with the highest emission levels – basic metals, chemicals and chemical products and other non-metallic mineral products – the figures increased, respectively, from 7.9 to 10.4 (before ETS and ETS Phase 2), from 4.7 to 8.8, and from 1.8 to 6.3.



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