Fourth Industrial Revolution and FDI from SMEs: The Case of the Republic of Korea*

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Abstract

The impact of Fourth Industrial Revolution (4IR) technologies on enterprises' internationalization strategies is ambiguous. Although digital technologies lower information and transaction costs and facilitate international coordination of overseas activities, automation technologies can push enterprises to reshore foreign operations. This paper analyses the impact of 4IR technologies on the foreign investment decisions of small and large enterprises in one of the most technologically advanced countries in the world: the Republic of Korea. The results indicate differential impact across enterprise sizes and technologies. The propensity of SMEs to invest overseas upon the adoption of 4IR technologies, especially digital technologies, increases relatively more than that of larger firms. The results have important implications for investment and development policies in the region. The findings highlight the key role of FDI by Korean SMEs in the technological development of neighbouring Asian economies, calling for increased attention to smaller players in investment promotion.

Keywords: digital economy, foreign direct investment (FDI), Fourth Industrial Revolution (4IR), multinational enterprises (MNEs), small and medium-sized enterprises (SMEs), technology

JEL classification codes: C43, F23, H25, L86, O31

* Received: 5 September 2022 – Revised: 15 December 2022 – Accepted: 16 December 2022

The authors are grateful to the Journal's editors and referees for useful comments. The views presented herein do not represent those of UNCTAD or Member states of the United Nations. The paper was prepared as background research for the forthcoming UNCTAD policy report on foreign direct investment and small and medium-sized enterprises. The financial support of the Kingdom of the Netherlands for the development of the project on FDI by SMEs is gratefully acknowledged.

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1. Introduction

Small and medium-sized enterprises (SMEs) are important contributors to the economies of many nations, particularly in developing economies. On average, across sectors and geographies, SMEs represent more than 90 per cent of businesses and generate 7 out of 10 formal jobs.[1] Yet relatively few SMEs engage in international trade, and even fewer invest abroad. International trade and investment activities benefit productivity and can bring gains for both home and host economies, including the achievement of the Sustainable Development Goals (SDGs), notably inclusive and sustainable economic growth, employment, and decent work for all (SDG 8), as well as sustainable industry and innovation (SDG 9).

Compared with larger companies, SMEs face considerable – longer-term – barriers to internationalizing. Owing to their limited size, SMEs do not benefit to the same degree from economies of scale, face more difficulties accessing financial resources as well as managerial and technical skills, and are often more affected by bureaucracy and poor infrastructure than larger firms. In addition, relative to large firms, SMEs have less bargaining power, relatively higher compliance costs and smaller networks. These specific challenges hamper SME growth and, in particular, their internationalization process (UNCTAD, forthcoming).

Over the last decades, Korean companies have been increasing their participation in the global economy, first through exports and then gradually through increasing outward FDI (Buckley et al., 2022; Kim et al., 2018; Moon, 2016). In recent years, the Republic of Korea obtained a position among the top 10 investor countries worldwide. In 2021, it reached a record high of over $60 billion in outward FDI, or 4 per cent of global flows (UNCTAD, 2022). Small and medium-size enterprises (SMEs) made a significant contribution to these investments. According to the Korean Statistical Office, SME investments accounted for 8–9 per cent of Korean outward FDI in 2012–2014, growing to about 25 per cent in 2019–2021.

Since the 1970s, the Korean Government has invested in technologies and research. Nowadays the country is, alongside Israel, the biggest spender on R&D worldwide, at more than 4 per cent of its GDP. In 2017 the Government introduced a new five-year

[1] The definition of what constitutes an SME varies significantly across national and international sources. Some definitions are exclusively based on the number of employees of a firm, or its annual turnover (UNCTAD, forthcoming). The number of employees is the most common criterion, yet the maximum thresholds differ across countries or regions. For example, the Organisation for Economic Co-operation and Development (OECD) uses the 250-employee threshold to define SMEs; in the World Bank Enterprise Surveys, the sample is limited to enterprises with fewer than 100 employees. In the European Union and the United Kingdom, an SME is defined as an enterprise that employs fewer than 250 people and has an annual turnover not exceeding €50 million, and/or an annual balance sheet total not exceeding €43 million (European Commission, 2020). In the United States, the threshold is 499 employees (USITC, 2010).

plan, called the Fourth Industrial Revolution (4IR), aimed at mobilizing all players in the Korean economy to work towards become a leading country in 4IR technologies. These technologies distinguish themselves from the digital revolution of previous decades in terms of velocity, scope and systems impact and include the Internet of Things (IoT), cloud computing, big data, 5G, artificial intelligence, blockchain, 3D printing, robotics and virtual or augmented reality. Focus areas of the five-year plan were the education of the workforce and making SMEs the technological foundation of the country.[2] As a result, in 2019, Korean SMEs could rely on the best information and communications infrastructure across OECD countries and a relatively high uptake of 4IR technologies (Bianchini and Kwon, 2021).

Technology adoption can have an important role in fostering outward FDI. Information and communication technologies (ICT) have been shown to facilitate exports, especially of SMEs (Aspelund and Moen, 2008; Hagsten and Kotnik, 2017). The use of ICT allows new channels for marketing as well as for sales and may reduce distance, entry-related, and more generally information costs, thereby lessening SMEs' networking disadvantage – factors that are particularly crucial for smaller firms with limited resources (Lohrke et al., 2006; Martens, 2013; Morgan-Thomas and Jones, 2009). There is little research analysing the specific impact of the 4IR on SME internationalization, aside from a few studies analysing a special type of SMEs – the so-called "born globals" – which in contrast to other firms do not internationalize incrementally but compete globally from inception (Bell et al., 2004; Rialp et al., 2012; UNCTAD, 2017). Not surprisingly, born global SMEs are typically high-tech or digital companies, supporting the idea that 4IR can help the internationalization process.

Yet, not all 4IR technologies are expected to promote internationalization. Automation technologies including the Internet of Things, robotics and 3D printing increase labour productivity, lower production costs and in turn weaken the drive for efficiency-seeking FDI (UNCTAD, 2020). Empirical evidence on the relation between the adoption of 4IR technologies and foreign investment is scarce. This relationship is likely to vary across industries, the specific technologies used and possibly also the size and or productivity of firms.

This paper analyses how the adoption of 4IR technologies can affect SMEs' decision to invest abroad. The paper contributes to two underresearched streams of literature: It addresses the impact of 4IR technologies on international production across different technologies, and it looks at the differential impact on SMEs. We analyse how the probability of investing abroad and the intensity of the investment relates to the adoption of 4IR technologies, using the Republic of Korea's Survey of Business Activities over the period 2017–2020.

[2] Schwab, Klaus (2016). "The Fourth Industrial Revolution: What it means, how to respond", 14 January, www.weforum.org.

The empirical results confirm that the adoption of technology had different and contrasting effects on SMEs and on larger, more established MNEs. 4IR technologies facilitated FDI by SMEs, but they had a dampening effect on the growth of international production networks of larger firms. Smaller companies quickly adopted digitalization technologies and leveraged this technological advantage in laggard economies to gain market presence, in particular in the services sector. At the same time, their smaller size slowed the adoption of automation technologies. As a consequence, their growth strategy has been to search for neighboring low-cost production economies. Despite having different motivations, both manufacturing and services SMEs have become key actors in regional integration processes, with much of their investments flowing to developing economies in South-East Asia and other less advanced economies.

The results have relevant policy implications. The findings confirm UNCTAD's predictions about declining trends in international investments in large manufacturing projects while highlighting the potential for SMEs to become a valuable alternative for the development of emerging economies (UNCTAD, 2022).. In the case of the Republic of Korea, SMEs have accounted for almost three quarters of projects (opening of subsidiaries; data from the National Statistics Office), mostly in neighboring, less advanced economies. Against this backdrop, trade and investment promotion agencies would do well to increase their attention to smaller players and to provide support services that lower the barriers for SMEs to internationalize.[3]

The findings of the paper also provide support for the idea that digitalization technologies can facilitate internationalization by lowering information costs and easing the coordination of foreign operations. For countries to reap the benefits, key elements are adequate digital infrastructure and platforms to enable smaller players to join regional and global value chains.

The paper is structured as follows. Section 2 describes the data and presents key stylized facts. The empirical model and results are presented in section 3. The final section concludes and briefly discusses policy implications.

2. Data and stylized facts

2.1 Data

The paper uses the Republic of Korea's Survey of Business Activities, which covers the period from 2006 to 2020. The survey has several major advantages in studying the effect of FDI on 4IR technology adoption. First, the data covers

[3] For in-depth policy recommendations, see UNCTAD (forthcoming).

all firms that have more than 50 employees and have capital stock larger than ₩300 million Korean won (approximately $250,000) and contains questions related to the adoption of each of the specific technologies included in the 4IR definition. Second, it allows for tracking individual firms through time without concerns about dropouts, other than the shutdown of businesses. Finally, the data set includes several variables on foreign subsidiaries (host country, total stock of capital invested and functionality of subsidiaries).

Throughout this paper, we define "SME" on the basis of the following criteria, as per the official definition by the Ministry of SMEs and Start-ups. In our analysis, we apply these criteria depending on the sector and year.

1. *Independence*: No more than 30 per cent of the shares is owned by a parent company, whose value of total assets exceeds ₩500 billion (about $380 million) either in the Republic of Korea or abroad. Also, a firm should not be a part or a subsidiary of companies belonging to enterprise groups that are subject to the limitations on mutual investment.
2. *Size*:
    - Number of employees: less than 300[4]
    - Total capital stock less than ₩8 billion[5] (about $6 million)
    - Total asset value less than ₩500 billion (about $380 million)
    - Total yearly turnover less than ₩150 billion (about $110 million)

Table 1 presents summary descriptive statistics on 12,900 firms for the year 2019 in the data set. We focus on the overall distribution of size indicators and patterns of outward FDI by looking at the subsidiaries abroad, and we disaggregate the sample by SME status to compare the size difference and FDI destinations. SMEs and larger firms differ in many dimensions other than size. On average, large enterprises hire 6 times more employees; they have 15 times larger yearly turnover and have 30 times larger value of total assets. SMEs and large enterprises also exhibit significant differences across sectors. SMEs are more concentrated in manufacturing (54 per cent versus 39 per cent), where the main difference is driven by the greater number of large enterprises in the finance/insurance and retail/wholesale sectors. In relation to FDI, on average, SMEs have 0.42 foreign subsidiaries, as compared with the 1.13 in large enterprises.

[4] The number of employees applies to firms in the data set before 2015. This data is for the manufacturing sector only. Depending on the sector, the benchmark for the number of employees varies from 50 to 300.

[5] For manufacturing, construction, transportation and mining sectors prior to 2015. The threshold varied from ₩8 billion to ₩3 billion across sectors.

Table 1. Descriptive statistics

	SMEs			Large enterprises		
	Count	Mean	Standard deviation	Count	Mean	Standard deviation
Firm size						
Total employees	7 586	105.59	63.63	5 314	619.47	2 414.38
Yearly turnover (millions of dollars)	7 586	26.07	23.84	5 314	407.91	2 314.16
Total assets (millions of dollars)	7 586	35.11	43.01	5 314	1 079.21	11 332.40
Subsidiaries						
Number of foreign subsidiaries	7 586	0.42	1.03	5 314	1.13	3.24
Sector						
Agriculture	7 586	0.00	-	5 314	0.00	-
Mining	7 586	0.00	-	5 314	0.00	-
Manufacturing	7 586	0.54	-	5 314	0.39	-
Energy	7 586	0.00	-	5 314	0.01	-
Water/sewage	7 586	0.01	-	5 314	0.01	-
Construction	7 586	0.05	-	5 314	0.04	-
Retail/wholesale	7 586	0.08	-	5 314	0.16	-
Transportation	7 586	0.06	-	5 314	0.05	-
Food/lodging	7 586	0.03	-	5 314	0.03	-
Information/telecommunication	7 586	0.08	-	5 314	0.09	-
Finance/insurance	7 586	0.01	-	5 314	0.06	-
Real estate	7 586	0.02	-	5 314	0.02	-
Science/technology	7 586	0.05	-	5 314	0.04	-
Facility maintenance	7 586	0.03	-	5 314	0.07	-
Public affairs	7 586	0.01	-	5 314	0.01	-
Education	7 586	0.00	-	5 314	0.00	-
Health care	7 586	0.02	-	5 314	0.02	-
Arts and sports	7 586	0.01	-	5 314	0.00	-
4IR technology use						
Internet of things	7 508	0.03	-	5 586	0.04	-
Cloud	7 508	0.05	-	5 586	0.08	-
Big data	7 508	0.03	-	5 586	0.08	-
Mobile	7 508	0.02	-	5 586	0.04	-
Artificial intelligence	7 508	0.03	-	5 586	0.05	-
Blockchain	7 508	0.01	-	5 586	0.01	-
3D printing	7 508	0.01	-	5 586	0.02	-
Robotics	7 508	0.01	-	5 586	0.02	-
Augmented or virtual reality	7 508	0.01	-	5 586	0.02	-

Source: Republic of Korea, Survey of Business Activities, 2019.

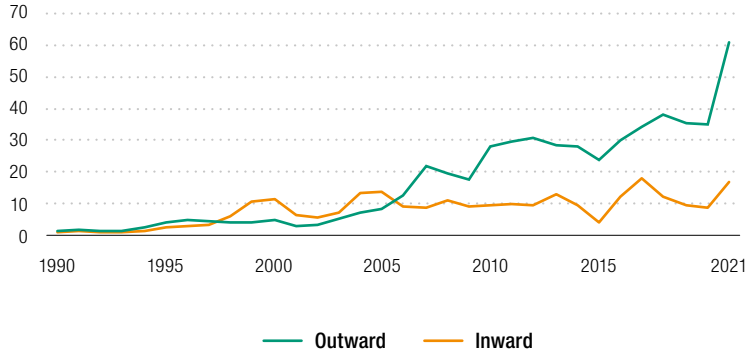
Note: The number of observations includes all observations in the panel that the data set spans. The dummy variables for technology usage (4IR technology use) are constructed for each type of technology if a firm is utilizing the technology during the survey year for (i) company operation (e.g. marketing, sales, organization management) or (ii) product/service development.

Companies from the Republic of Korea are important investors in neighbouring economies, benefitting from several trade agreements with investment provisions. The Republic of Korea joined fourteen other Asia-Pacific countries in signing the Regional Comprehensive Economic Partnership (RCEP), which by some measures, is the biggest regional trade and investment agreement in the world. The RCEP entered into force on 1 January 2022, strengthening Asia-Pacific economic integration. The investment provisions in the agreement mostly consolidate existing market access as contained in a myriad of bilateral agreements. Importantly, the provisions related to market access and disciplines in trade, services and e-commerce are highly relevant for regional value chains and market-seeking investment.

The country is signatory to 18 other free trade agreements with ASEAN, Australia, Canada, Central America (Partial), Chile, China, Colombia, the European Free Trade Association, the European Union, India, New Zealand, Peru, Singapore, the Republic of Türkiye, the United Kingdom, the United States and Viet Nam. It is also a signatory of over 100 investment treaties (bilateral, regional, multilateral), with substantive provisions on technology and measures friendly to FDI.

The Republic of Korea has become a key global investor over the years, ranking among the top 10 such investors (UNCTAD, 2022). Korean outward FDI started increasing since 1995 and boomed after 2005, when the country became a net outward investor (figure 1). The main destinations and drivers have also changed over the years, with more FDI driven by market-seeking motives towards large developed and emerging economies and less by efficiency-seeking in low-cost neighbouring economies (Buckley et al., 2022; Kim et al., 2018).

Figure 1. Republic of Korea: outward and inward FDI (Billions of dollars)

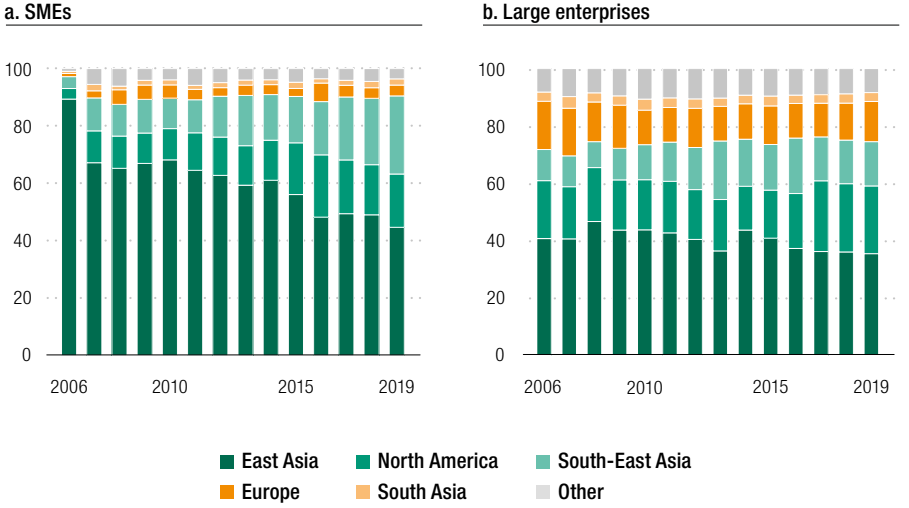


Source: UNCTAD.

Preferred locations for investments are determined by different drivers across firm sizes. In recent years, most of the FDI by SMEs from the Republic of Korea was efficiency-seeking and into South-East Asia. Motivated by the increasing production costs in the Republic of Korea, manufacturing SMEs invested in cheaper neighbouring locations in the region, first in China and more recently in Viet Nam and Indonesia. In contrast, FDI by large enterprises was relatively more motivated by network- and market-seeking drivers (figure 2). The difference in the pattern of FDI is mainly attributed to the difference in industry sectors between SMEs and large enterprises. As shown in table 1, over half of Korean SMEs are manufacturing firms. Their main motivation for internationalizing to South-East Asia has been rising costs for domestic production and labour (see also Kwak et al., 2017). The largest manufacturing sectors among SMEs are electronics (13 per cent), machinery and equipment (13 per cent) and vehicle parts (11 per cent). This explains the distinct geographical patterns of FDI between SMEs and large enterprises.

The data allows the measurement of the effect of 4IR technologies, including IoT, cloud computing, big data, 5G, artificial intelligence, blockchain, 3D printing, robotics and augmented/virtual reality. In the data set, the dummy variable for technology use is constructed for each type of technology if a firm is utilizing the technology during that survey year for (i) company operation (e.g. marketing, sales, organization management) or (ii) product or services development.

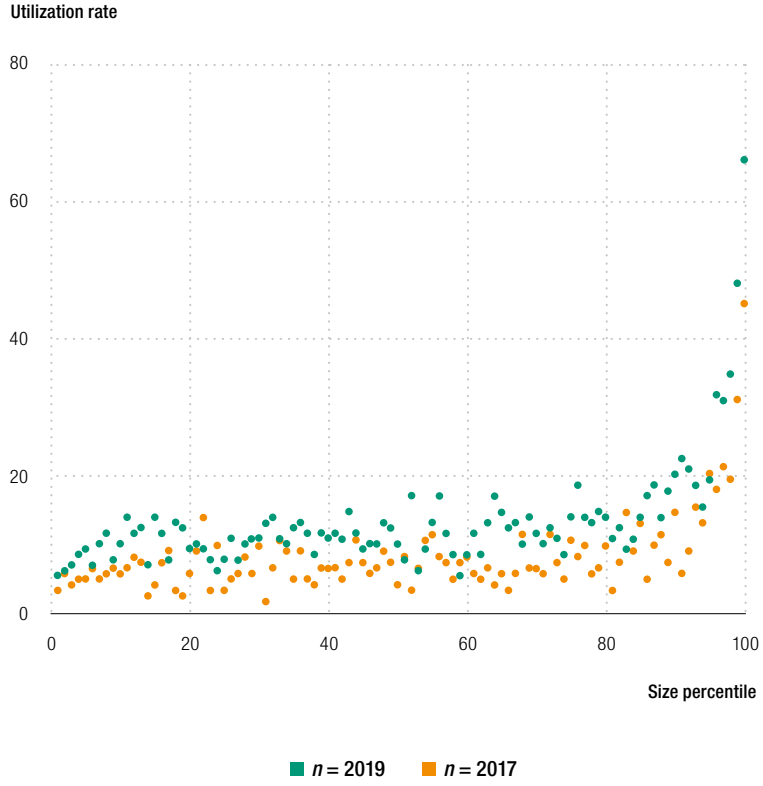
Figure 2. Share of FDI stock by region (Percentage)



Source: Republic of Korea, Survey of Business Activities, 2006–2019.

Figure 3 shows the significant disparity between larger and smaller firms in adoption of 4IR technology. In the figure, the share of firms that have adopted 4IR technology is plotted with respect to each size percentile, by turnover. Whereas firms below the 80th percentile in turnover remain overall homogeneous in adoption rate, large firms (above the 95th percentile in turnover) have adoption rates that are substantially higher than smaller firms. Moreover, although the average rate of adoption has increased over time for firms in all size percentiles, the increase in adoption rate has been bigger for firms in the top percentiles. To sum up, not only are large firms more likely to adopt 4IR technologies, but they are also faster to adopt technological innovation.

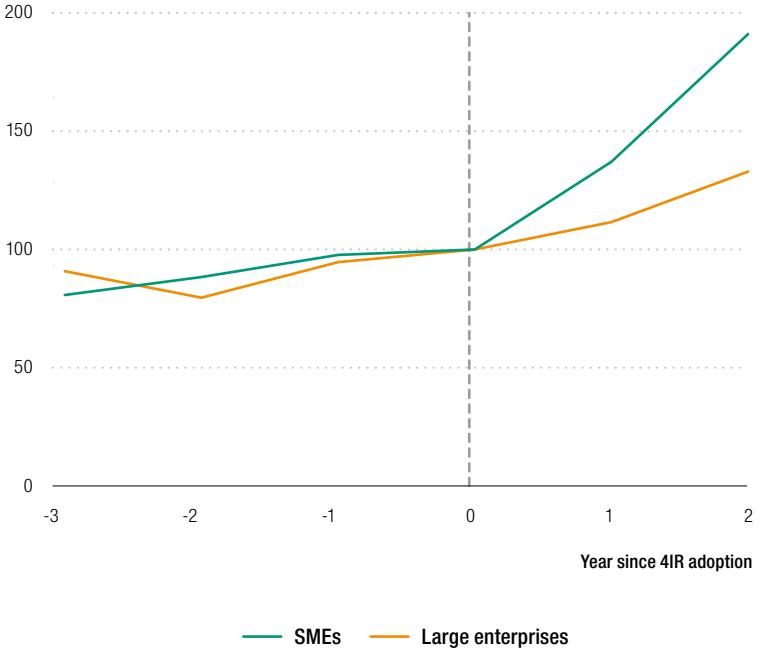
Figure 3. Share of firms adopting 4IR technologies, by size (Percentage)



Source: Republic of Korea, Survey of Business Activities, 2017 and 2019.

Note: Utilization rate refers to the percentage of firms utilizing 4IR technology (IoT, could computing, big data, artificial intelligence, blockchain, 3D printing, robotics, augmented or virtual reality) in each percentile. Size percentile is based on yearly turnover reported in the Survey of Business Activities.

Figure 4. 4IR technology adoption and FDI stock, index (year 0 = 100)

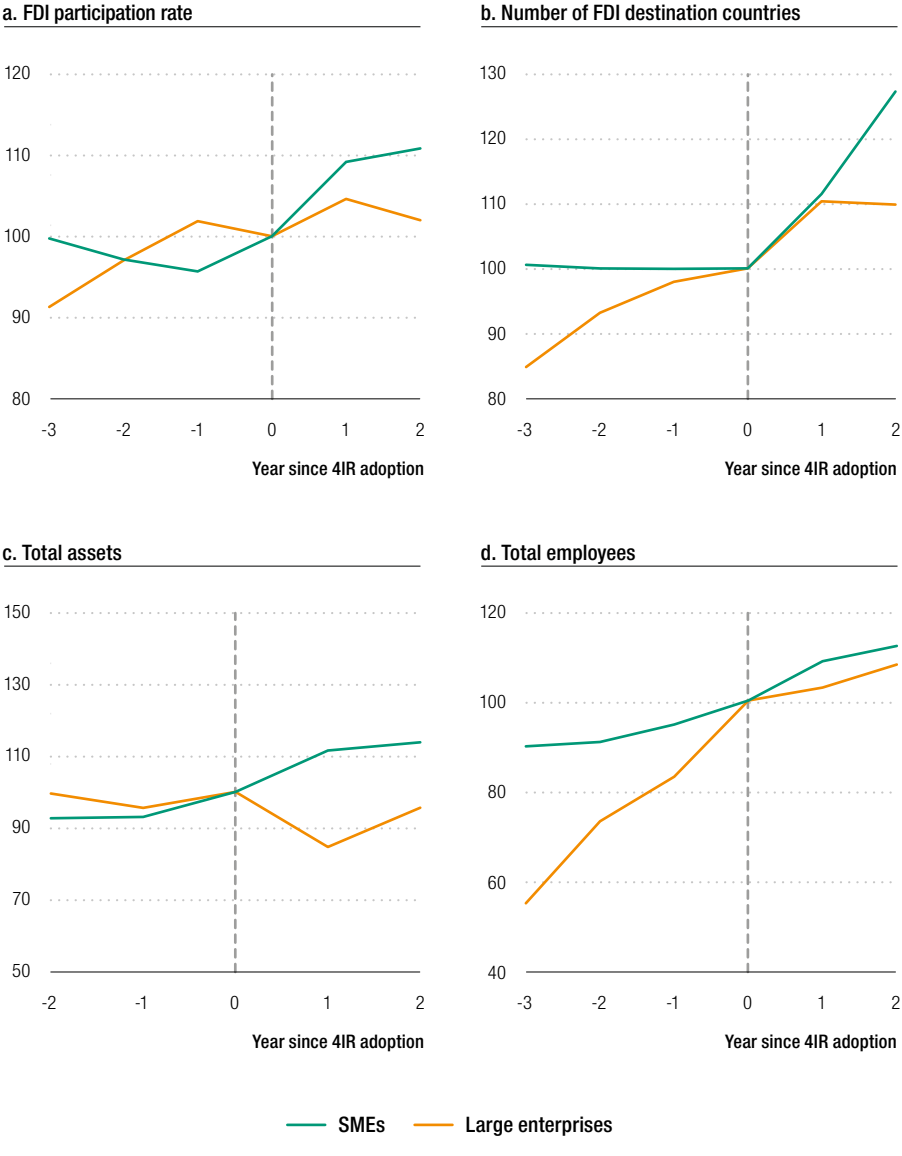


Source: Republic of Korea, Survey of Business Activities, 2015–2020.

Note: The vertical dashed line represents the period when firms started using 4IR technologies (Internet of things, cloud computing, big data, artificial intelligence, blockchain, 3D printing, robotics, virtual or augmented reality). Total stock of FDI is normalized to year 0 level (i.e. year 0 = 100).

As the first step, we explore whether the firms that adopt 4IR technologies are also more likely to invest abroad. A basic analysis of the data describes positive trends of firms' foreign investment associated with the adoption of 4IR technologies. Figure 4 shows a sharp increase in outward FDI stock following the adoption of 4IR technologies, which is especially sizeable for SMEs. In other words, technology adoption contributes more to outward FDI by SMEs than by large firms. In addition, further analysis of alternative performance indicators reveals that adoption of 4IR technologies is positively correlated with extensive margins of FDI (i.e. numbers of investments and destinations) by SMEs and in general with company productivity. Panels a and b in figure 5 present the FDI participation rate and the number of FDI destinations countries by SMEs and large enterprises. Not only do the extensive margins of FDI increase substantially following the adoption of 4IR technologies, but the growth is faster among SMEs. It is also worth noting that these changes are accompanied by growth in firm size (total assets and employees, panels c and d).

Figure 5. 4IR technology adoption and firm performance indicators, index
(year 0 = 100)



Source: Republic of Korea, Survey of Business Activities, 2015–2020.

Note: The vertical dashed line in each graph represents the period when firms started using 4IR technologies (Internet of things, cloud computing, big data, artificial intelligence, blockchain, 3D printing, robotics, virtual or augmented reality). FDI participation rate, number of invested countries, total assets and FDI participation rate are normalized to year 0 level (i.e. year 0 = 100).

2.2 The Fourth Industrial Revolution and SMEs

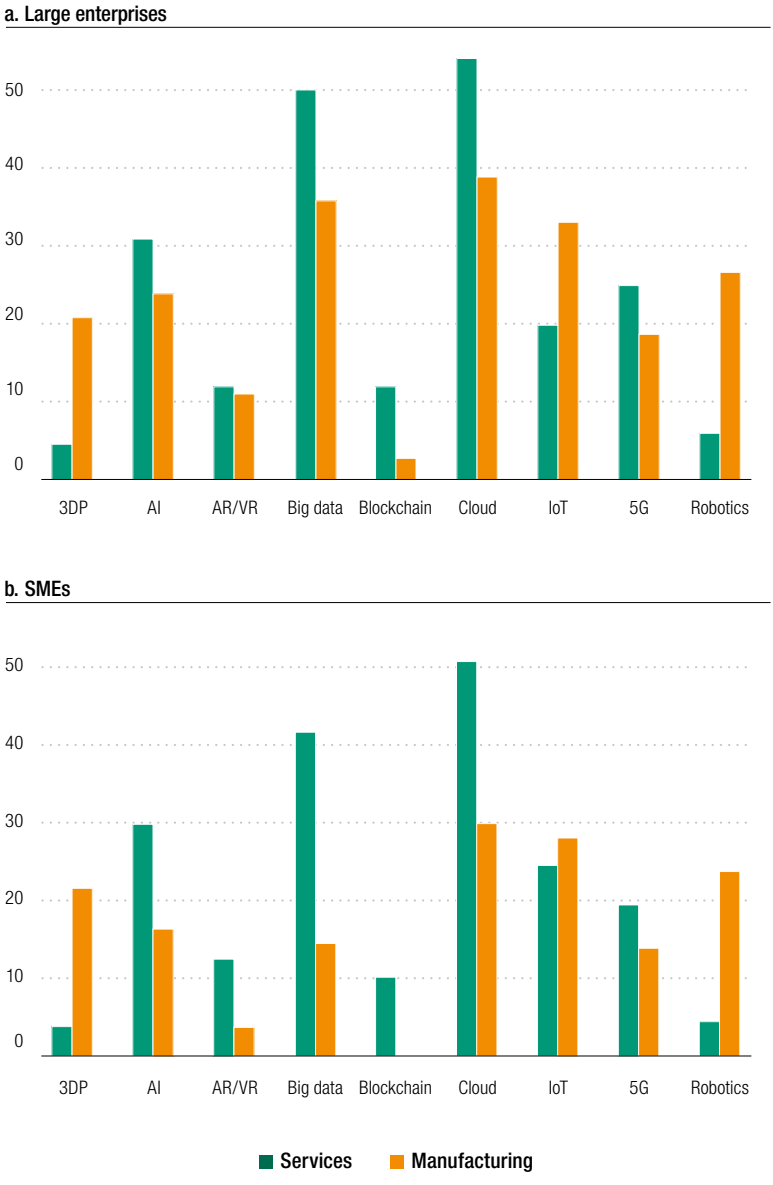
In this section, we further explore the 4IR technologies adopted by SMEs and large enterprises, to identify which type of technologies are most likely to be driving the changes in investment decisions. In figure 6, we consider only firms that are utilizing 4IR technology, and compare the adoption of each technology by firm size) and (services and manufacturing sectors). The graphs depict two clear patterns. First, there is a clear distinction in the type of technologies adopted by firms in the services and manufacturing sectors. The most widely used type of technology among manufacturing firms are IoT, robotics and 3D printing. IoT is used to optimize production processes, improve workplace safety and predict potential malfunctions with predictive maintenance.[6] Robotics and 3D printing are at the heart of the process of automation of manufacturing. Automation reduces the competitive advantage of low-cost manufacturing locations, lowering the incentive for efficiency-seeking FDI. Because of technical and economic feasibility, not all industries are affected in the same way (UNCTAD, 2020). For example, in textiles and apparel, the application of robots and 3D are not yet technically feasible.

In the services sector, a larger share of firms are using big data, cloud computing and artificial intelligence. These technologies are part of what is called digitalization. The application of digital technologies results in more integrated production processes, a reduction in governance and transaction costs, and improved access to foreign markets for SMEs, especially in the services sector (UNCTAD, 2017 and 2020). Although these latest technologies are grouped under the term "Fourth Industrial Revolution", figure 6 shows the impact of the different technologies on the firms' investing decisions may vary across sectors. In addition, there is a distinctive pattern of technology adoption across sizes. In the manufacturing sector, SMEs' utilization rates are significantly lower than larger firms. For instance, robotics is used by 36 per cent of firms among large enterprises, whereas only 14 per cent of SMEs use robots. In the services sector, not only do SMEs exhibit higher adoption rates than SMEs in the manufacturing sector, but the gaps in the rate of technology adoption are smaller for nearly all types of technology.

In figure 7, we present the rate of utilization of each technology *among all firms* in the data. We disaggregate the data by FDI engagement: (i) "FDI firms" (firms with at least one foreign subsidiary) and (ii) "non-FDI firms" (those that do not have any foreign subsidiary.) The overall pattern of technology use is similar between FDI and non-FDI firms: Cloud computing, big data, artificial intelligence and IoT are the popular technologies that are adopted by firms. FDI firms are in general more technologically advanced; however, the disparity in the adoption rates between

[6] *Forbes*, "How IoT is playing a key role in production uptime", 10 October 2022.

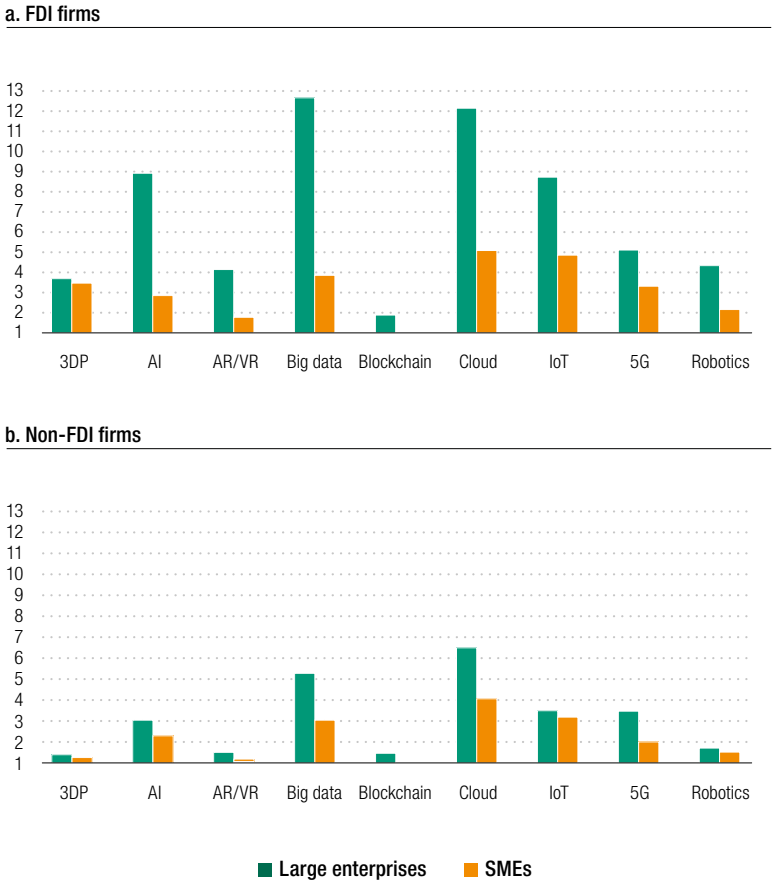
Figure 6. 4IR technologies adopted: share of firms using each technology among firms adopting any 4IR technology, by sector (Percentage)



Source: Republic of Korea, Survey of Business Activity, 2019.
Note: 3DP = 3d printing, AI = artificial intelligence, AR/VR = augmented or virtual reality, cloud = cloud computing, IoT = Internet of things.

SMEs and large enterprises are higher for FDI firms. For instance, the utilization gap between big data, artificial intelligence and cloud computing are noticeably larger among FDI firms, which are most often adopted among the services firms (as in figure 6). This is not only a representation of the existing technology gap between SMEs and larger firms in the services sector, but also an indication that there is much greater room to grow for firms in the services sector. As we will see in section 3, this is in line with larger benefits for firms in the services sector that use 4IR.

Figure 7. 4IR technologies adopted, by firm size and FDI participation (Percentage)



Source: Republic of Korea, Survey of Business Activity, 2019.

Note: 3DP = 3D printing, AI = artificial intelligence, AR/VR = augmented or virtual reality, cloud = cloud computing, IoT = Internet of things. FDI-firms refers to firms that had at least one foreign subsidiary in 2019. Non-FDI firms refers to firms that did not have any foreign subsidiaries in 2019.

3. Specification and regression results

To analyse the growth in FDI stock upon the adoption of 4IR technologies, we perform a set of linear regressions with various fixed effects and firm characteristics as controls. We propose the following specification, in which the various measures of FDI are regressed on a set of dummy variables (SME and 4IR utilization) and additional explanatory variables:

$$Y_{it} = \beta_1 + \beta_2 SME_{it} + \beta_3 4IR_{it} + \beta_4 SME_{it} \cdot 4IR_{it} + X_{it}\gamma + \alpha_t + \alpha_i + \alpha_k + \varepsilon_{it} \quad (1)$$

where Y_{it} is a measure of FDI at the extensive (a 0-1 variable if the firm invests abroad or not) or intensive (log of FDI) margins, SME_{it} is a dummy variable to indicate SME status (as per legal definition in the Republic of Korea) in year t by firm i, $4IR_{it}$ is a dummy variable to indicate the adoption status in year t by firm i, X_{it} is a vector of firm characteristics to control for additional variations in firm sizes (number of employees, turnover, total assets) and α_t, α_k and α_i refer to time, adoption year-[7], and firm-fixed effects, respectively.

Table 2 shows the basic regression results, which look at the extensive margin of FDI – firms' decision to invest and the number of countries with outward investment. First, the decision to adopt any 4IR technology is negatively associated with the decision to participate in FDI: In table 2, the estimated coefficients of 4IR utilization are negative and especially so in the manufacturing sector (columns 3 and 4). This is in line with the empirical evidence that looks at the relationship between automation and reshoring, and finds that automation increases the pace of reshoring (Artuc et al., 2019; Faber, 2018). In contrast, for SMEs such negative effects are cancelled out. The estimated coefficients of the interaction term (4IR utilization × SME) are as large as the coefficients of 4IR utilization, which means that SMEs did not adopt automation to lower domestic costs and reshore production. In the services sector, the 4IR technology even promoted the internationalization of SMEs to more countries (column 6).

In table 3, we investigate the effect of 4IR utilization on the intensive margins. To further disentangle the main drivers for FDI we distinguish FDI stock by the level of technology of FDI destination countries. In order to classify countries into two groups – technologically "advanced" economies (in terms of 4IR technology) and "lagging" economies – we use the Readiness Index from Readiness for the Future of Production by the World Economic Forum (WEF, 2018). Using this taxonomy, 16 countries fall in the advanced group and 83 in the lagging group (appendix table A.1). Along the internal margins of FDI, we also observe similar patterns:

[7] *n* year following the adoption (= Current year (*t*) – Technology adoption year).

The decision to use 4IR technologies is negatively associated with the size of the FDI stock. Yet, the estimated coefficient of the interaction term 4IR utilization × SME is positively significant to the extent that the negative correlation is cancelled out for SMEs. Although these positive effects are observed regarding different types of FDI stock – whether the destination countries are technologically more advanced or lagging – the additional positive effects on SMEs are more strongly associated when the destination is technologically lagging. This clearly indicates the main motivation of manufacturing SMEs investing abroad is efficiency seeking.

We investigated if the different technologies affected firms differently in the manufacturing and the services sectors. In this analysis, we define sector-specific 4IR technologies as follows: Manufacturing-specific 4IR technologies include IoT, robotics, and 3D printing, which are the most popular types of technology, typically adopted by manufacturing firms for automation (see figure 6a). Services-specific 4IR technologies include big data, cloud and artificial intelligence (see figure 6b). Table 4 shows the results of alternative regression specifications, where we consider only the impact of manufacturing-specific 4IR technologies

Table 2. Regression results, extensive margin

	All		Manufacturing		Services	
	(1) FDI dummy	(2) Number of countries	(3) FDI dummy	(4) Number of countries	(5) FDI dummy	(6) Number of countries
SME	-0.13*** (0.04)	-0.22 (0.14)	-0.17*** (0.05)	-0.25 (0.17)	-0.06 (0.09)	-0.13 (0.28)
4IR utilization	-0.05* (0.02)	-0.22** (0.11)	-0.07** (0.03)	-0.25* (0.13)	-0.06 (0.04)	-0.16 (0.13)
4IR utilization × SME	0.04** (0.02)	0.19*** (0.07)	0.07* (0.03)	0.19** (0.09)	0.04** (0.02)	0.23** (0.08)
Constant	0.40*** (0.02)	1.20*** (0.14)	0.49*** (0.03)	1.53*** (0.28)	0.31*** (0.04)	1.05*** (0.15)
Observations	5 567	5 567	2 988	2 988	2 369	2 369
R^2	0.734	0.759	0.751	0.779	0.720	0.750
Year fixed effects	yes	yes	yes	yes	yes	yes
Firm fixed effects	yes	yes	yes	yes	yes	yes
Adoption year fixed effects	yes	yes	yes	yes	yes	yes
Controls	yes	yes	yes	yes	yes	yes

Source: Authors' estimation based on Survey of Business Acitvities, Republic of Korea.

Note: All regressions include firm characteristics (yearly turnover, total assets, total number of employees) as explanatory variables. Statistical significance is indicated by *($p < 0.1$), **($p < 0.05$), ***($p < 0.01$). Standard errors are clustered at industry level.

Table 3. Regression results, intensive margin

	All			Manufacturing			Services		
	(1) ln(FDI total)	(2) ln(FDI advanced)	(3) ln(FDI lagging)	(4) ln(FDI total)	(5) ln(FDI advanced)	(6) ln(FDI lagging)	(7) ln(FDI total)	(8) ln(FDI advanced)	(9) ln(FDI lagging)
SME	-2.94***	-0.41	-2.70***	-3.90***	-0.49	-3.54***	-1.37	-0.17	-1.15
	(0.83)	(0.56)	(0.69)	(1.04)	(0.73)	(1.05)	(2.02)	(1.90)	(1.41)
4IR utilization	-1.19**	-0.85*	-1.05**	-1.74***	-1.24**	-1.56***	-1.36	-0.38	-1.40**
	(0.50)	(0.43)	(0.45)	(0.60)	(0.50)	(0.50)	(0.90)	(0.65)	(0.60)
4IR utilization × SME	1.09***	0.61***	1.17***	1.61**	0.80	1.66***	1.03**	0.54**	1.09***
	(0.24)	(0.14)	(0.24)	(0.68)	(0.49)	(0.54)	(0.38)	(0.20)	(0.33)
Constant	8.98***	4.40***	7.37***	11.18**	4.74***	9.65***	7.07***	4.34***	5.49***
	(0.48)	(0.40)	(0.41)	(0.75)	(0.51)	(0.76)	(0.81)	(0.73)	(0.72)
Observations	5 567	5 567	5 567	2 988	2 988	2 988	2 369	2 369	2 369
R^2	0.740	0.712	0.734	0.757	0.717	0.750	0.728	0.714	0.721
Year fixed effects	yes	yes	yes	yes	yes	yes	yes	yes	yes
Firm fixed effects	yes	yes	yes	yes	yes	yes	yes	yes	yes
Adoption year fixed effects	yes	yes	yes	yes	yes	yes	yes	yes	yes
Controls	yes	yes	yes	yes	yes	yes	yes	yes	yes

Source: Authors' estimation based on Survey of Business Acitvities, Republic of Korea.

Note: All regressions include firm characteristics (yearly turnover, total assets, total number of employees) as explanatory variables. Statistical significance is indicated by *($p < 0.1$), **($p < 0.05$), ***($p < 0.01$). Standard errors are clustered at industry level.

for manufacturing firms (column 1 – column 3) and for firms in the services sector (column 4 – column 6). The results show that manufacturing-specific technologies did not lead manufacturing SMEs to internationalize: the estimated coefficients of Manufacturing 4IR utilization × SME are not significantly positive at the 5 per cent significance level. SMEs' degree of adoption of automation technologies is not advanced enough to allow them to substitute foreign low-cost labour with in-house production.

Table 4. Regression results, manufacturing sector-specific technology

	Manufacturing			Services		
	(1) ln(FDI total)	(2) ln(FDI advanced)	(3) ln(FDI lagging)	(4) ln(FDI total)	(5) ln(FDI advanced)	(6) ln(FDI lagging)
SME	-3.24*** (0.88)	-0.23 (0.56)	-2.77*** (0.93)	-0.51 (0.88)	0.049 (0.91)	-0.35 (0.80)
Manufacturing × 4IR utilization	-1.00* (0.51)	-0.14 (0.51)	-0.48 (0.56)	-2.43* (1.20)	-1.06 (1.38)	-1.69* (0.95)
Manufacturing 4IR utilization × SME	1.41* (0.79)	-0.21 (0.59)	1.05 (0.65)	1.25 (2.26)	-0.05 (2.77)	1.57 (1.38)
Constant	9.52*** (0.58)	3.83*** (0.45)	8.11*** (0.62)	4.83*** (0.53)	3.15*** (0.42)	3.61*** (0.50)
Observations	3 423	3 423	3 423	3 395	3 395	3 395
R^2	0.757	0.717	0.750	0.728	0.714	0.721
Year fixed effects	yes	yes	yes	yes	yes	yes
Firm fixed effects	yes	yes	yes	yes	yes	yes
Adoption year fixed effects	yes	yes	yes	yes	yes	yes
Controls	yes	yes	yes	yes	yes	yes

Source: Authors' estimation based on Survey of Business Acitvities, Republic of Korea.

Note: All regressions include firm characteristics (yearly turnover, total assets, total number of employees) as explanatory variables. Statistical significance is indicated by *($p < 0.1$), **($p < 0.05$), ***($p < 0.01$). Standard errors are clustered at industry level.

Conversely, table 5 shows that services sector-specific technologies helped SMEs in both the manufacturing and the services sectors to internationalize, especially in economies that lag technologically. This is consistent with the theories that digitalization facilitates firms' presence in foreign markets, especially services ones. Companies offering automated services on the cloud can easily penetrate foreign markets with a little investment, probably only as a sales office. Also, manufacturing companies benefit as these technologies reduce information costs and provide SMEs with a tool to deal with local procedures and administration rules.

Table 5. Regression results, services sector-specific technology

	Manufacturing			Services		
	(1) ln(FDI total)	(2) ln(FDI advanced)	(3) ln(FDI lagging)	(4) ln(FDI total)	(5) ln(FDI advanced)	(6) ln(FDI lagging)
SME	-3.43*** (0.84)	-0.47 (0.56)	-2.92*** (0.90)	-0.72 (0.95)	-0.05 (1.03)	-0.56 (0.81)
Services 4IR × utilization	-1.51*** (0.48)	-1.25* (0.66)	-1.18** (0.45)	-0.51 (0.48)	-0.01 (0.33)	-0.80* (0.42)
Services 4IR utilization × SME	2.26** (0.99)	1.33 (0.81)	1.73* (0.88)	0.94* (0.49)	0.37 (0.39)	1.03*** (0.35)
Constant	9.66*** (0.57)	4.00*** (0.43)	8.26*** (0.58)	4.85*** (0.50)	3.11*** (0.42)	3.71*** (0.50)
Observations	3 423	3 423	3 423	3 395	3 395	3 395
R^2	0.757	0.717	0.750	0.728	0.714	0.721
Year fixed effects	yes	yes	yes	yes	yes	yes
Firm fixed effects	yes	yes	yes	yes	yes	yes
Adoption year fixed effects	yes	yes	yes	yes	yes	yes
Controls	yes	yes	yes	yes	yes	yes

Source: Authors' estimation based on Survey of Business Acitvities, Republic of Korea.
Note: All regressions include firm characteristics (yearly turnover, total assets, total number of employees) as explanatory variables. Statistical significance is indicated by *($p < 0.1$), **($p < 0.05$), ***($p < 0.01$). Standard errors are clustered at industry level.

4. Conclusion and policy implications

The Republic of Korea is a leading investor globally and in Asia. Korean firms play an important catalytic role in the Industry 4.0 transformation process as users, technology providers, manufacturers and ecosystem enhancers. They also invest in digitalization of manufacturing, advanced manufacturing solutions, smart factories, and R&D facilities, technology hubs and centres of excellence in the region.

4IR technologies can affect firms' decisions to invest abroad. While automation can push manufacturing companies to reshore production and thus reduce overseas investments, digitalization, in contrast, can facilitate their geographical expansion.

We find empirical evidence supporting this notion for companies based in the Republic of Korea, with an overall negative impact of 4IR technologies on outward FDI by large enterprises. However, SMEs constraints and drivers differ from those of large MNEs (UNCTAD, forthcoming). In general, foreign investment by SMEs is not negatively affected by adoption of 4IR technologies. Lower rates of automation

often do not allow SMEs to substitute low-cost foreign labour with efficient in-house production. In addition, digitalization technologies facilitate internationalization processes in both services and manufacturing SMEs. This is in line with the idea that digital technologies lower the information and transaction costs of overseas operations. Thus, manufacturing SMEs still invest in neighbouring economies, driven by efficiency-seeking motives, whereas services SMEs take full advantage of new digital technologies such as big data and the cloud to penetrate less advanced markets. Both services and manufacturing SMEs have become key actors in regional integration processes.

The empirical findings in this paper have important implications for policy and for future research. In the current global context, with a shrinking pool of productive investment, FDI by SMEs could contribute to boosting investment in sustainable post-pandemic recovery. Small firms could also support resilience-seeking FDI.

The need for multinational enterprises, both large and small, to diversify supply sources and strengthen regional value chains should translate not only to shifting FDI patterns within the region but also to renewed overall growth of international investment in industry. SMEs could help promote investment for development in the context of broader economic integration and cooperation. They can also contribute to closing the investment gap in the least developed countries in the Asia-Pacific region. To unleash the potential of SMEs, policymakers need to refocus their investment promotion and facilitation strategies, paying more attention to smaller players and their specific needs, with support services that facilitate their internationalization.[8]

Finally, regulatory frameworks in both home and host countries of FDI are important factors in enhancing the attractiveness of the investment environment in Industry 4.0. Adequate plans to support the development of digital infrastructure and platforms and a strategic investment policy to support SMEs' digital transition and internationalization are thus key prerequisites for successful SME investment policies.[9]

[8] For further detail on policies, see UNCTAD (forthcoming).

[9] For a policy package and other promotion measures for investment in Industry 4.0 in the ASEAN region, see ASEAN Secretariat and UNCTAD (2021).

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Annex table A.1. Economy classification for regression analysis

	Economy	Score
Economies ranked higher than the Republic of Korea	United States	8.16
	Singapore	7.96
	Switzerland	7.92
	United Kingdom	7.84
	Netherlands	7.75
	Germany	7.56
	Canada	7.54
	Hong Kong, China	7.45
	Sweden	7.40
	Denmark	7.20
	Finland	7.16
	Australia	7.14
	Norway	7.07
	France	6.89
	Ireland	6.85
	Japan	6.82
	Belgium	6.80
	Austria	6.79
	United Arab Emirates	6.76
	New Zealand	6.73
Republic of Korea		**6.51**
Economies ranked equally or lower than the Republic of Korea	Malaysia	6.51
	Israel	6.24
	Spain	6.23
	China	6.14
	Czech Republic	6.01
	Estonia	6.00
	Portugal	5.99
	Qatar	5.96
	Italy	5.90
	Poland	5.83
	Slovenia	5.71
	Cyprus	5.65
	Chile	5.60
	Thailand	5.45
	Saudi Arabia	5.44
	Lithuania	5.42
	Latvia	5.39
	Mauritius	5.37
	Slovak Republic	5.33
	Bahrain	5.31
	Hungary	5.30
	the Russian Federation	5.30
	India	5.24
	Oman	5.13
	Mexico	5.04
	Brazil	5.03
	Bulgaria	5.02

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Annex table A.1. Economy classification for regression analysis (Concluded)

	Economy	Score
Economies ranked equally or lower than the Republic of Korea	South Africa	5.02
	Greece	4.96
	Croatia	4.93
	Romania	4.93
	Viet Nam	4.93
	Georgia	4.92
	Jordan	4.91
	Costa Rica	4.90
	Republic of Türkiye	4.90
	Panama	4.89
	Indonesia	4.89
	Uruguay	4.75
	Kazakhstan	4.74
	Azerbaijan	4.69
	Kuwait	4.65
	Serbia	4.59
	Colombia	4.53
	the Philippines	4.51
	Ukraine	4.47
	Egypt	4.46
	Botswana	4.43
	Armenia	4.43
	Lebanon	4.43
	Tunisia	4.41
	Morocco	4.35
	Sri Lanka	4.26
	Argentina	4.25
	Peru	4.18
	Ghana	4.14
	Albania	4.07
	Bosnia and Herzegovina	4.04
	Dominican Republic	4.02
	Republic of Moldova	4.02
	Paraguay	3.84
	Kenya	3.83
	Mongolia	3.82
	Senegal	3.73
	Guatemala	3.71
	Algeria	3.70
	Nigeria	3.68
	Bangladesh	3.67
	Ecuador	3.66
	Cambodia	3.63
	Honduras	3.61
	Pakistan	3.60
	El Salvador	3.55
	Zambia	3.54
	Kyrgyzstan	3.43
	Uganda	3.31
	Ethiopia	3.29
	United Republic of Tanzania	3.28
	Cameroon	3.24

Source: WEF (2018).
Notes: Economies are listed in order of WEF Drivers of Production ranking.