AFRICAN DEVELOPMENT BANK GROUP

potential for the fourth industrial revolution in Africa
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BENCHMARK CASE STUDY
South Korea

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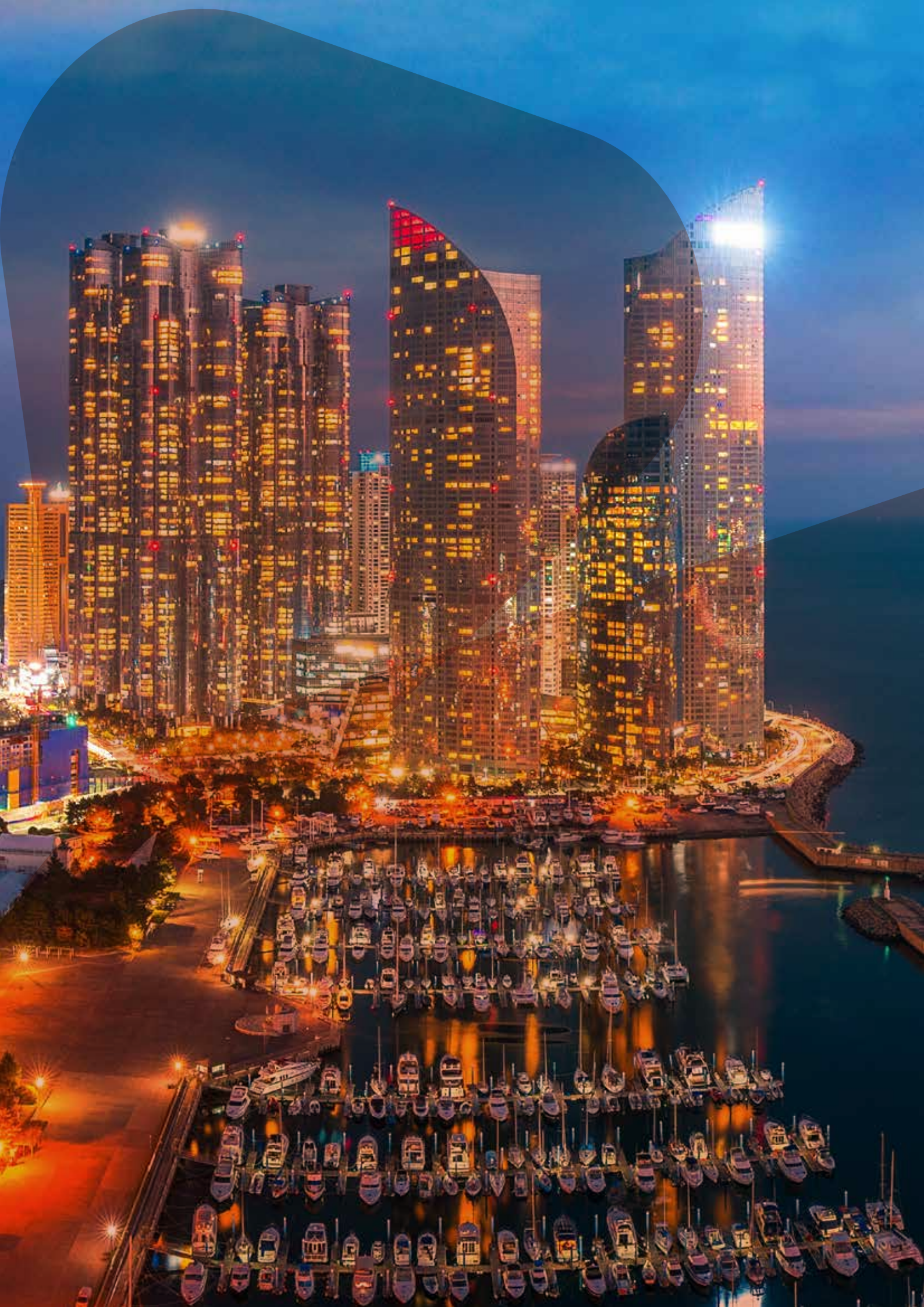


A list of acronyms

4IR	Fourth Industrial Revolution
AI	Artificial Intelligence
AMI	Advanced Metering Infrastructure
CHAMP	HRD Ability Magnified Programme
CPI	Corruption Perception Index
DAS	Data Acquisition Systems
DER	Distributed Energy Sources
ETRI	Electronics and Telecommunications Research Institute
EMR	Energy Management System
ESS	Energy Storage System
EV	Electric Vehicles
LNG	Liquid natural gas
LTE	Long Term Evolution
GDP	Gross Domestic Product
HDI	Human Development Index
ICT	Information and Communication Technologies
IoT	Internet of Things
IP	Intellectual Property
IT	Information Technology
KAIST	Korean Advanced Institute for Science and Technology
KERI	Korea Electrotechnology Research Institute
KICT	Korea Institute of Civil Engineering
KIPO	Korean Intellectual Property Office
KISTEP	Korean Institute for Science and Technology Evaluation and Planning
MAGRA	Ministry of Agriculture, Food and Rural Affairs
MOTIE	Ministry of Trade, Industry and Energy
MOLIT	Ministry of Land, Infrastructure and Transport
MSIP	Ministry of Science and ICT
NIA	National Information Society Agency
OECD	Organisation for Economic Cooperation and Development
PCFIR	Presidential Committee on the Fourth Industrial Revolution
POSTECH	Pohang University of Science and Technology
PPP	Purchasing Power Parity
R&D	Research and Development
SCADA	Supervisory control and data acquisition systems
SME	Small and Medium Sized Enterprise
STEAM	Science, Technology, Engineering, Arts and Mathematics
STEM	Science, Technology, Engineering and Mathematics
U-City	Ubiquitous City
US	United States
WEF	World Economic Forum
WIPO	World Intellectual Property Organization

1 introduction

this document is one of the two benchmark case studies drafted in the frame of the Study to unlock the potential of the fourth industrial revolution (4IR) in Africa.

The overall study aims at i) understanding the preconditions for adoption of 4IR technologies, challenges and drivers, positive and negative effects; ii) describing the technologies for knowledge dissemination, including domains of application; iii) benchmarking emerging countries; iv) demonstrating applications in Africa; v) in order to conclude on a business case and vi) recommend interventions and vii) design specific ICT components to AfDB projects which will show case the feasibility of supporting 4IR in Africa.

The present case study thus looks in depth at the structural socioeconomic features of Korea which are drivers or obstacles to adoption of key 4IR applications and identifies lessons learnt and replicable public policies to support Africa's endeavour to tackle the 4IR:

- It reviews the socioeconomic situation of the country and the implications for technological readiness for 4IR;
- It reviews key applications in key economic sectors of the country, from the High 5 AfDB priority fields being agriculture, energy supply, industry manufacturing, regional integration, well-being (including financial inclusion, smart cities, education and healthcare);
- It assesses policies and readiness for 4IR;
- It identifies lessons learnt of interest for African policy makers and international donors.

Our team collected data drawing on existing research and public policy documents, and by consulting local stakeholders. This was done either through telephone or in a written form.

The document is structured around 7 chapters. It shall be enriched and finalised thanks to a workshop with stakeholders to be held early June 2019.

2
country presentation

2.1 ECONOMIC, SOCIAL DEMOGRAPHIC AND INDUSTRIAL PROFILE

With 51.7 million people, South Korea has one of the highest population densities worldwide: 81.5% of the total population lives in urban areas and cities. Nevertheless, South Korea has managed to be among the highest-ranked countries on the Human Development Index, which ranks countries by their level of living standards. It is also one of the world's 15 largest economies. South Korea has a GDP of 32.770 U.S. dollar per capita resulting and a total GDP of 1.7 trillion dollars. South Korea's GDP per capita at equal purchasing power ($38,335 PPP in 2017) is about ten times as high as that of Sub-Saharan Africa ($3,830 PPP in 2017).

South Korea is known for its spectacular rise from one of the poorest countries in the world receiving aid to a developed, high-income country in just a few generations. The country has almost no natural resources but has adapted to an export-oriented economic strategy that has proved successful. In 1957, South Korea's economy used to be the size of Ghana's. The rapid economic growth that followed afterwards implies that South Korea holds lessons for African countries in terms of economic development. Sometime after the Korean War, around 1960, the government orchestrated financial sector investments in several dozen family-owned business groups. These grew into large family-controlled conglomerates like Samsung, Hyundai, LG, Lotte and SK Holdings that are known as chaebols and that dominate the South Korean economy. The top five chaebols account for more than 60% of South Korea's economy. Between 1962 and 1994, GDP growth in South Korea averaged on 10% annually. Next to the large chaebols, SMEs account for more than 80% of the country's jobs.

South Korea's experience in sustainable development, providing better services and infrastructure to improve the lives of people and its transition to a knowledge economy, provides lessons that can benefit African countries. In terms of demographics, South Korea is very different from Africa. The country is facing a demographic decline with a low fertility rate of 1.2 and a median age 40.8 years, while sub-Saharan Africa faces a demographic growth with a fertility rate is 4.8 and a much younger median age of 19 years. South Korea's unemployment rate is 3.7% and relatively steady.

South Korea still remains one of the fastest growing developed economies in the world following the Great Recession, with its GDP growth percentage remaining steady at around 3% a year. However, apart from Samsung and the electronics sector, profits of the chaebols have gone down and several crises and corruption scandals have hit various industries, in particular shipbuilding, steel and construction. Rising wages in the manufacturing industry combined with stagnating productivity have led to a rise in youth unemployment. For young people aged between 20 and 29 the unemployment rate is 9.9% – a problem shared by many African countries despite the different demographics.

This trend of stagnation has sparked an ongoing effort to restructure the economy and find alternative sources of long-term growth. The government is shifting attention towards emerging technologies of the fourth industrial revolution (4IR) (e.g. smart technology, big data and artificial intelligence) to create business opportunities and to overcome the stagnant growth of the industry.

The country has a strong innovation ecosystem on which to refurbish its economy. South Korea is, alongside Israel, worldwide the highest spender on R&D, with more than 4% of its GDP. The country's emphasis on science and technology has been an element of its success and South Korea is highly ranked in innovation indexes. It can draw on well-developed existing research infrastructure, including a network of highly connected industrial science hubs comprising 26 research institutes, seven universities, more than 1,400 firms and 26,000 researchers. Furthermore, the country has high rates of STEM graduates (32% of tertiary graduates in South Korea are in natural sciences and science and engineering disciplines) and ranks fourth globally in the number of patents filed.

South Korea's main research strengths are in the natural and engineering sciences. An analysis of field-weighted citation impact of academic publications published by the

European Commission (2018) shows that the main research strengths are in chemistry and chemical engineering, materials science (incl. surfaces/interfaces), building and mechanical engineering and renewable energy. Apart from research, South Korea's R&D seems to be specialised in ICT and nanotechnology – as shown by an analysis of patent applications published by the European Commission (2018).18 The country has many patents in these areas, with quite a lot patent families in specifically Internet of Things, Big Data and quantum computing. This indicates a strong high-tech industry and related R&D institutions. When it comes to added value of ICT to the economy, most added value is provided by ICT manufacturing industries producing hardware technologies. Korea scores a lot lower on added value of ICT service industries providing software and IT services.

Since the 1970s the Korean government has invested in the creation of government research institutes to favour the development of domestic capabilities. Top institutes in South Korea are the Electronics and Telecommunications Research Institute (ETRI), the Korean Advanced Institute for Science and Technology (KAIST), the Korean Institute for Science and Technology Evaluation and Planning (KISTEP) and the three big universities, collectively known as SKY (Seoul National, Korea and Yonsei).

ETRI is a government funded agency under the ministry of science and has about 1,800 scientists, engineers and technicians, including a whole division for intellectual property (IP) commercialisation.

KAIST focuses on basic and applied research, with emphasis on the former. Annually, it has around 1,800 domestic patents and 20,000 commercial licensing agreements. It tries to foster more entrepreneurship and innovation by launching its own incubators.

KISTEP assesses technology trends and sets the research agenda and budget priorities for the South Korean government. Furthermore, it evaluates science and technology outcomes.

The latter, KISTEP, is appointed by the Korean government to shape its fourth industrial revolution initiative. Next to the focus on technological innovation, the government is also including a focus on human resources. Re-education at universities and other entities should address the existing talent shortage and improve the South Korean economy.14 The government-sponsored research institutes in South Korea have played an important role in Korea's economic development.

In South Korea the largest economic sectors are services and industry – agriculture is in comparison small. Most revenues and profits are obtained from the manufacturing industry, followed by wholesale and retail trade and financial and insurance activities. In terms of employment the manufacturing industry is by far the largest, followed by retail trade and accommodation and food service activities – in the financial and insurance sector far less people are employed. The number of companies is largest in wholesale and retail trade, followed by accommodation and food service activities. The number of manufacturing companies is only third and much lower – indicating the existence of quite some large manufacturing firms in South Korea.

South Korea is in many aspects different from most African countries, but the country provides some lessons for policy makers in Africa. South Korea's approach to the 4IR is interesting as it has successfully developed its economy from a poor country to a high-income – and high-tech – country in just a few generations during the last century, even while the country cannot count on significant natural resources. Now South Korea is much more developed than most African countries. This transition has been attributed to the government's financial investments in family owned businesses resulting in growing business of which some became well-known multinationals. Investments in the private sector has been at the basis of the economic development model of South Korea.

2.2 BROAD POLICY OBJECTIVES

Every five years, the Korean government decides on a cross-cutting theme that impacts all spheres, whether economic, social or cultural. Previous topics were the economy of well-being, the green economy, the intelligent economy and the creative economy.

In 2017, the South Korean government introduced a new five-year plan called The Fourth Industrial Revolution that should again mobilise all players in the Korean economy. The government has the ambition to become a leading country for the 4IR. As part of the five-year plan, the South Korean government has set up a fourth industrial revolution steering committee in October 2017, which falls under the direct control of the president. Focus points for the 4IR are education, i.e. the nurturing of highly skilled human resources that the country considers vital for the fourth industrial revolution and "hidden stars"; small and medium-size enterprises that should form the technological foundation of the country. Specific objectives that are part of the plan are that the 4IR by 2030 should:

- generate 430 trillion won ($378 billion) of economic benefits; and
- create 800,000 ICT jobs, including software engineers and data analysts.
- South Korea has started to invest in Intelligent IT (AI, IoT, Big Data, Mobile, Cloud) for industry and society in 2016. This has led to the "Mid- to Long-Term Master Plan in Preparation for the Intelligent Information Society Managing the Fourth Industrial Revolution". In this plan the impacts and opportunities of Intelligent IT on South Korea are outlined:
- an economy that is free and competitive with added value
- new economic opportunities
- better technological competitiveness
- more companies on intelligent IT (e.g. AI)
- more opportunities for all people in society
- personnel that is more creative
- less working time, more spare time
- better social security by increasing public and social spending
- more safety and happiness to people in their daily life
- less work on householding due to automation
- increased health and age
- less traffic accidents

South Korea is clearly positive about the potential opportunities of 4IR for the Korean economy and society. To reap these benefits, South Korea intends to reform the labour market to educate more creative personnel, create more convergence between intelligent IT and current industry, enhance intelligent IT capabilities and improve existing data-infrastructure.

In 2017, the national government set up the Presidential Committee on the Fourth Industrial Revolution (PCFIR) to coordinate national policies pertaining to the development of new science and technology, including AI and data tech, and of new industries and services to facilitate the country's adaptation to the 4IR. Specifically, the Committee organises public campaigns related to 4IR, prepares the groundwork for public-private partnerships and fosters both ecosystems for new industries and the integration of intelligent technologies into existing industries related to, for example, smart city, healthcare, environment, or energy – sectors that are also high on the agenda of decision makers in Africa. The PCFIR's approach is to build consensus among policy makers and stakeholders in the country to make the necessary changes to benefit from 4IR. The holistic approach is reflected in the organisation of the Committee's work in three subcommittees dealing with science and technology, industrial economy (focusing on creating new industries and high-quality jobs), and social institutions (focusing on solving chronic social problems). The Committee also organises hackathons to drive regulatory and institutional reform.

Nurturing skills vital to taking advantage of 4IR is another pillar of South Korea's strategy. This includes re-education of employees at universities, done by the Korea Software Technology Association for example. Another aim of the Korean government is to support the development of smart factories – with the aim of having 20,000 smart factories in place by 2020. Next to this, the government seeks to improve regulation to foster 4IR industries and raise social benefits.28

Other investments of the Korean government go to eight innovative fields (smart factories, smart farms, fintech, smart cities, future cars, new energy industries, drones and health) and three platforms around AI, hydrogen and data. It aims to develop five new industries (energy, future cars, IoT-based household appliances, bio & healthcare, semiconductors & displays) and also allocated separate (extra) budgets for basic research, encouraging pioneering efforts in the bio-economy and hydrogen-based economy and developing core technologies in new industries such as quantum technology.

Next to this, the Korea Productivity Centre conducts activities to spread social awareness of the 4IR, to stimulate the application and dissemination of 4IR technologies and to nurture talent.

The Korean Intellectual Property Office (KIPO) has introduced new IP policies geared toward 4IR technologies by developing new patent examination guidelines helping to classify 4IR innovations in fields such as AI, Big Data, IoT, 3D printing, etc, and has expedited the process for patent application for 4IR-related innovations. The revised guidelines reflect the nature of many 4IR innovations which are more about connecting existing technologies in new ways than creating new technology altogether. This may constitute a good practice of modernising IPR policy to facilitate the development and take-up of 4IR innovations.

2.3 POLICIES RELATED TO SPECIFIC 4IR TECHNOLOGIES

South Korea has recently recognised the importance of the fourth industrial revolution and AI and adopted measures accordingly.

The 2016 "Mid- to Long-Term Master Plan in Preparation for the Intelligent Information Society Managing the Fourth Industrial Revolution" recognises the important role of AI alongside other technologies like the Internet of Things, big data analysis, cloud computing and mobile technologies. Regarding AI, the Korean government plans to invest $2 billion to create six new AI research institutes by 2020 and educate more than 5,000 high quality Korean engineers. Its AI efforts are mostly concentrated on the activities of the South Korean technology incumbents and on building the necessary AI capabilities and skills through its education system. The focus is on human resources, technology and infrastructure.

The Korean government is also encouraging companies to innovate themselves by developing technologies using 3D printing. The Ministry of Trade, Industry and Energy (MOTIE) has for example funded the development of 3D printing technologies for ship building and several Korean institutes are developing 3D printing techniques, for example for the electronics sector (KERI), construction (KICT) and the medical and bio sector (POSTECH). The technology is, however, still in an early stage of development, most of which is being done by knowledge institutes. On the other hand, South Korea is known for its high-level industrial robotics technology. The country has the highest number of industrial robots, a number of 710 robots per 10,000 employees. Robotics are used mostly in the automotive and electronics industry.

Other 4IR technologies the South Korean government is investing in are big data and the Internet of Things, that are also part of the Master Plan of the Intelligent Information Society and collectively named "IntelligentIT". In previous years, the Korean government has invested in Big Data for Development, by erecting institutes like the Big Data Strategy Centre that is part of the NIA and the Big Data Institute that is part of Seoul National University. Currently, it is investing in 5G networks, promoting the application of these technologies in all industries, innovating education and strengthening the social security net, laws and ethical regulations.

2.4 PRECONDITIONS FOR FOURTH INDUSTRIAL REVOLUTION TECHNOLOGIES IN THE COUNTRY

In the following, we consider South Korea's track record on a range of preconditions we regard as essential to successful 4IR take-up. As regards South Korea's overall readiness for 4IR technologies, the WEF Global Competitiveness Index 2018 provides a useful indication as it explicitly considers 4IR readiness in its methodology. South Korea ranks 15th out of 140 countries here and is considered a beacon of innovation. The country invests heavily in innovation, with 4.2% of GDP allocated to R&D it is the second biggest spender on R&D.37 The country has one of the highest penetration rates of ICT in the world. Those are important preconditions for innovation in 4IR.

Legal and regulatory, institutional and governance preconditions: A policy framework bringing all stakeholders together can be considered essential to accelerate the development and take-up of 4IR technologies. A couple of indicators can be used to position South Korea's policies vis-à-vis Africa in terms of readiness for 4IR.

Effective government and governance are necessary to create a regulatory environment in which innovations and enterprises can thrive and hence are able to try out new applications of 4IR technologies. The World Bank measures government effectiveness every five years. According to its data, South Korea scored relatively high (82/100) compared to Sub-Saharan Africa (33) in 2017. This indicator captures opinions on the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies. South Korea also scored better than Sub-Saharan Africa on regulatory quality (82 vs 28) and rule of law (86 vs 30) in 2017.

Another index ranking countries according to regulatory quality, amongst other factors, is the Ease of Doing Business Index, also compiled by the World Bank. This index measures regulatory performance Several aspects of the index are particularly relevant in terms of preconditions for 4IR technologies: ease of starting a business, getting electricity, and getting credit. On this index, South Korea scores 84 out of 100 compared to 51 for Sub-Saharan Africa. This shows that in principle, African countries may learn something from South Korea in terms of how to shape their regulatory environment to facilitate the take-off of 4IR technologies.

Apart from regulatory quality and government effectiveness, the innovation capabilities of a country are in part also a reflection on the effectiveness of its related policies. In the WIPO Innovation Index 2018 South Korea ranks 14th out of 124 countries, with a rather high score of 63. The index is a composite of sub-indices looking at aspects of innovation capability from institutions, human capital, infrastructure, market and business sophistication, to knowledge and technology outputs and creative outputs.

Finally, the regulatory quality on paper may deviate from reality when there is widespread corruption in a country. By nature, corruption is very hard to measure and to compare internationally. The most ambitious attempt of doing so is Transparency International's Corruption Perception Index (CPI), which is updated annually and attempts to measure the level of corruption in the public sector of countries. In 2018, South Korea received a score of 57/100, ranking 45 out of 180 countries. This is comparable to the scores of Rwanda (56) and Cabo Verde (57) and only slightly above Namibia (53). This quite low position of South Korea on the CPI is likely due to the importance of a limited number of large cheabols in South Korea – the World Economic Forum (2018) suggests structural measures to enhance competition and to avoid collusion and trade practices that can be considered unfair.

A first precondition relates to infrastructure: This relates in particular to the ready availability of broadband and mobile internet. South Korea leads the ICT adoption pillar of the WEF Global Competitiveness Index, boasting some of the world's highest penetration rates of ICTs.

South Korea's ranking in terms of ICT infrastructure can be further assessed when looking at some individual components of the WEF's Competitiveness Index:

- electrification rate: 100% of population (rank 1/140)
- mobile-broadband subscriptions: 112.8% of population (rank 17/140)
- fixed-broadband subscriptions: 41.6% of population (6/140)
- fibre Internet subscriptions: 30% of population (1/140)
- internet users: 92.8% of population (9/140)

These figures show that the South Korean ICT infrastructure is of high quality. This is a prerequisite to take full advantage of many of the technologies that the Fourth Industrial Revolution brings.

Another observation of interest in aforementioned figures is the fact that South Korea has far more mobile broadband subscriptions than fixed broadband subscriptions and fibre internet subscriptions – this shows that fast mobile internet is more important for most people than land lines are in South Korea. Many 4IR applications use the Internet, but this could be wireless as long as the bandwidth allows sufficient speeds and data retention. Africa focuses mainly on mobile internet, which could be sufficient for most people and applications, although for some applications faster internet connections are still needed. With the introduction of 5G, mobile internet will be sufficient for 4IR and the need for traditional broadband and fibre internet subscription may become obsolete.

Advanced technologies can only find applications adapted to local needs in countries with a strong innovation ecosystem and culture. Ecosystems of start-up incubators and accelerators and innovation labs to support new ideas across various life cycle stages of development are essential preconditions in this regard. More attention to the start-up ecosystem has been given in South Korea in recent years with the Creative Economy Strategy, but could still be further improved according to Lim (2017). This would include more support to start-ups and SMEs, preventing perpetual dependency on financial support and leaving venture capital to the private sector.

Cultural factors play an important role in innovation processes. The process from idea generation to the commercialisation of products is for instance determined by cultural attitudes towards entrepreneurial risk. Asian countries tend to score less well on this aspect than other countries. This is also true for South Korea, which ranks a mediocre 77/140 on this component of the WEF's Competitiveness Index.

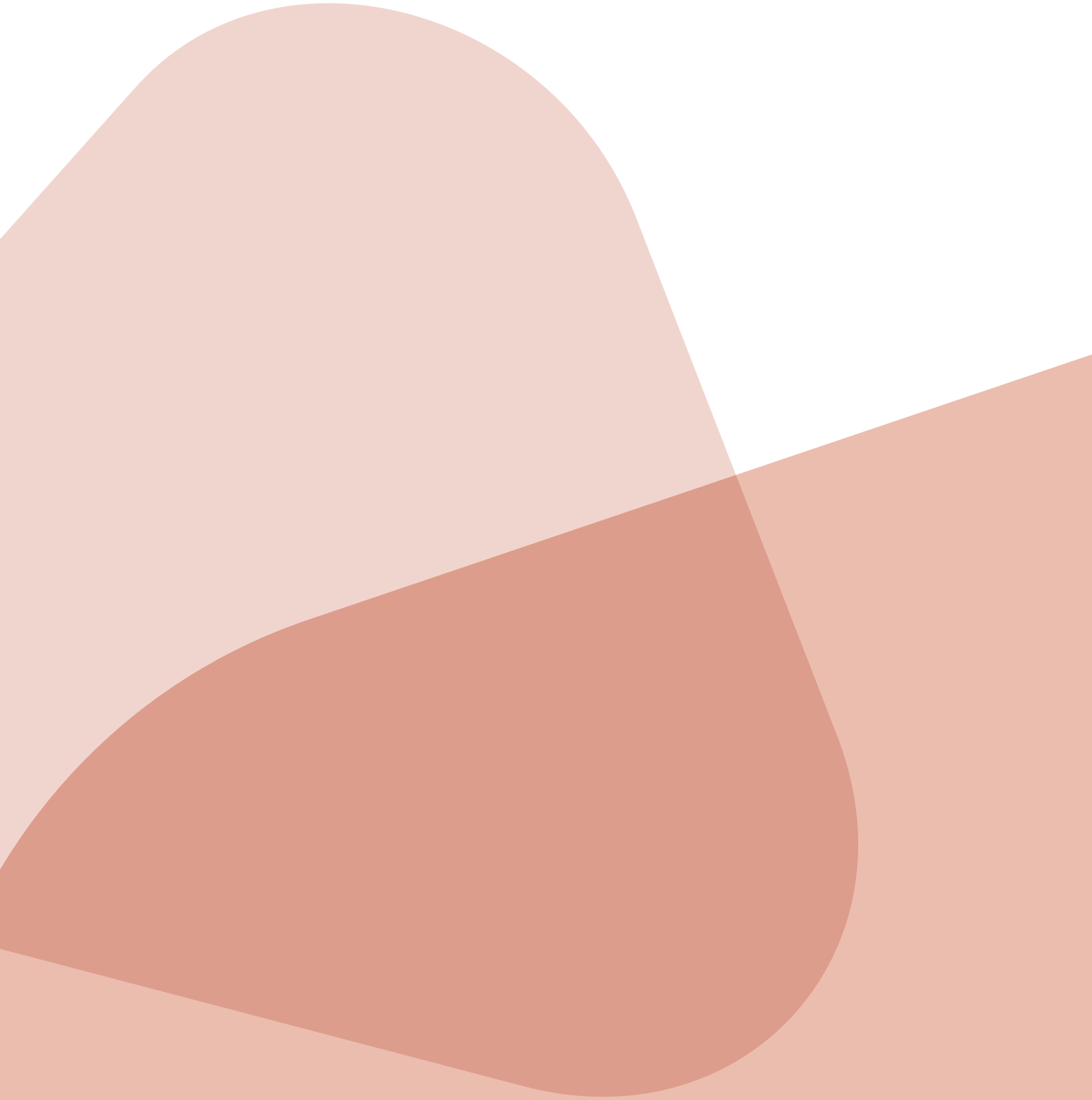
Innovation is also dependent on both the state and private sector investing substantially into research and development (R&D). R&D expenditure as a share of GDP amounted to 4.2% in South Korea in 2018, ranking the country 2/140 countries worldwide according to the World Economic Forum. It is expected that public investments in R&D will further increase in the coming years and it seems likely that the industry will at least maintain current investments to stay ahead of global competition.

As regards human capital and skills development, South Korea ranks 27 out of 140 in terms of digital skills among the population. However, the ageing population in South Korea means there is a strong urgent need to promote adult learning. A growing share of adults will need reskilling at all ages to cope with longer working lives. In fact, 43% of the workers in South Korea face a significant risk of automation. The country has a large difference in basic skills proficiency between 16-24 year olds and 55-65 year olds (largest in the OECD area) with less than 10% of the adults having digital problem-solving skills needed for today's labour market.

Nevertheless, South Korea is a strong performer in the area of flexible learning provision and guidance and financing constraints do not weigh heavily on the provision of training by firms or participation of adults. The Korean government has already put in place several policy initiatives to ensure that adults have (equal) access to high-quality training: The HRD Ability Magnified Programme (CHAMP) facilitates collaboration between SMEs and large companies in providing training and the HRD-Net website provides information on training programmes. Furthermore, loans are available for unemployed and non-regular workers that attend vocational training and for employers purchasing

training equipment or establishing training facilities. The Korean government also embedded provisions in legislation ensuring that adult learning programmes do not overlap and are complementary.[43]

For years, the South Korean government has orchestrated the development of industry and technology to become a strong economic power in a few generations. Now, South Korea is making a transition towards a more flexible, creative and entrepreneurial economy to strengthen its knowledge economy.



3
agriculture

3.1 KEY TECHNOLOGIES IN THE DOMAIN AND MARKET POSITION

Natural resources for agriculture in South Korea are not abundant and because two thirds of the country are mountains and hills, South Korean farmers need to be very productive. While in 1963 the majority of the South Koreans were farmers, by now the number of agricultural workers is less than 5 percent. The rapid urbanisation has led to a stark decrease of available farmland. Because South Korea is an import country with a large population, production does not meet demand and pushes up the market price, providing less incentive for Korean farmers to be innovative. The growth of the agriculture sector output has therefore also lagged behind that of the manufacturing sector.

In the 1980s, the country experienced an agricultural crisis as young people left rural areas for urban jobs and farm work was mainly done by old men and women (in 2018, still 50% of the population of farm households is over 60 years old, and over 40% is over 65). The gap between incomes of people in urban and rural areas widened considerably and farm families accumulated debts. Subsequently, the South Korean government initiated various programmes to improve rural conditions and prohibited unrestricted beef and rice imports and limited many other agricultural imports.46 In the 1990s, the government opened the agricultural market again and started investing in enhancing agricultural competitiveness and improving living conditions in rural and fishing villages. Despite large investments in the agricultural sector, its competitiveness did not increase substantially.

Currently, South Korea looks to other highly productive agricultural countries like the Netherlands for inspiration on how to increase farming productivity. Recently, the South Korean government is investing strongly in smart farming: intelligent systems that use data (including big data) to help simplify processes. The combination of AI and Big Data will allow for precision agriculture, such as yield monitoring, diagnosing insect pests, measuring soil moisture, diagnosing harvest time and monitoring crop health status. Internet of things will measure the temperature, humidity and amount of sunlight in production farms, making it possible for remote control via mobile devices. It will not only boost the production of the farms but also add to their value.47 Korean experts foresee that smart farming has a lot of potential in Africa, where water management in particular is of high importance.

Prior to 2017, the country upgraded facilities to allow farmers to check the growth status of agriculture via mobile devices. By 2020, productivity should be improved through the use of precise control and optimal prescription of agriculture. After 2020, all facility conditions should be automated according to the growth conditions of the crop. The Korea Rural Development Administration also tries to help farmers with this transition by providing a platform for testing various sensors and technologies in smart farms.[47]

3.2 POLICY STRATEGIES, OBJECTIVES, GOVERNANCE, IMPLEMENTATION

The business plan for the Ministry of Agriculture, Food and Rural Affairs (MAGRA) was in 2017: promotion of cutting-edge agriculture by generating state-of-the-art agricultural equipment for the 4IR.

During the period 2004-2009 the South Korean government invested in R&D on the deployment of smart IT in agriculture. These projects were installed after the rise of global competition in agriculture due to the Korea-US Free Trade Agreement (FTA) that opened up the oversea market for agriculture with the US. These technologies were intended to modernise and improve the efficiency of agriculture in Korea. Many projects were funded, leading to several models for the efficient and smart use of ICT in agriculture. Examples are automatic feeding, smart farm management systems and automation of labour-intensive work in agriculture. Since 2013, this has led to further policy actions to promote smart farming and further adoption of these technologies in the South Korean agricultural sector.

The South Korean Smart Farm policy has multiple goals. The first goal is to promote further adoption of smart farming and to improve the productivity of smart farmers. The government has defined specific targets for realising over thousand smart farms (using sensors/actuators, ICT and AI) in horticulture, arable farming (crops) and pastoral

farming (animals) by 2017. The second goal is to develop an ecosystem in which related industries collaboratively develop and expand smart farming through government investments. The government wants to expand the Korean position in the smart farming market and enhance export.[52]

The Department of Agricultural Resource Economics of the Kangwon National University suggested in 2017 that educational programs are needed to further enhance the uptake of smart fourth industrial revolution technologies in Korean agriculture.52 They suggested that training farms are needed and that further smartening of the agricultural supply chain (distribution, processing) is needed as well. So far, they state that farmers leading in smart farming have achieved a visibly improved business performance after the introduction of smart ICT solutions.

Currently, the South Korean Ministry of Agriculture, Food and Rural Affairs (MAFRA) is running an Agricultural Science policy called the Smart Farm Dispersion Method. This policy builds on the smart farming policy and is targeted at innovative farming through the adoption of smart 4IR technologies in greenhouses and sheds. With these technologies, farmers can control and manage their facilities for crops and livestock remotely and automatically through their smartphone, tablet or computer. The concrete goals of the policy are to create smart farms throughout the country (7,000 ha smart farms, 5,750 sheds by 2022) and to set up an innovation system for smart farming through four Smart Farm Innovation Valleys by 2022. The ecosystem will be targeted at starting-up smart agricultural business by young Koreans and building up an industrial infrastructure for smart farming. This should contribute to new products and new markets for South Korea.

So far, smart farms have led in South Korea to increased agricultural production and better productivity compared to traditional farms. The employment and labour costs of smart farms and the incidence of disease and pest are lower in smart farms as well.[53]

In several policies for agricultural R&D funding is made available for 4IR technologies. The Korean policy for Field-oriented R&D reinforcement promotes "R&D for agricultural goods to resolve agricultural management agendas and difficulties on site and to develop innovative technology for smart farming". The 2018 investment are, amongst others, directed at R&D strategies to bring together several key 4IR technologies such as smart farms, intelligent farming machines, AI and farming robots. Specifically, for these investments in digital 4IR technologies $8 billion is available.54 The policy for Fostering Farming Equipment Industry intends to "Mechanise upland field crops and introduce modern farming machines in major producing districts". South Korea intends to lead the 4IR in agriculture as a means to secure the country's food production in response to its decreasing farming population and ageing society. This includes the development of autonomous (unmanned) agricultural vehicles, such as tractors, drones for farming and farm robots to substitute the labour of farmers.[55]

3.3 PRECONDITIONS FOR ADOPTION OF 4IR TECHNOLOGIES IN AGRICULTURE

The Korean government supports the use of technology for agriculture to increasing farming productivity and the quality of products. As South Korea has a small agricultural sector in comparison with the national demand for agricultural products, the government has focused on innovation and technology in the sector.

The OECD suggests that investments in agricultural innovation is important for Korea and acknowledges the country's many investments in public agricultural R&D – as is clear from their ambitious smart farming policy and other investments in agricultural 4IR. Knowledge is mentioned as an important aspect to adopt these innovations by the market – this includes knowledge to understand the technology and how to use it. Focus should be on skills. In that respect digital skills become more important as well – as agriculture will be associated with more use of data and ICT. The OECD also suggests that it is important that also private parties are involved in agricultural R&D, including investors and suppliers.

A precondition for the uptake of agricultural 4IR in South Korea also seems programmes to invest in the further use and uptake of these 4IR technologies by farmers. Several programmes are directed at this diffusion of the technologies. There is a top-down technology push from the government towards the sector, as the country struggles with decreasing productivity due to a decreasing farming population.

4
energy

4.1 KEY TECHNOLOGIES IN THE DOMAIN AND MARKET POSITION

Historically, South Korea has not had much of an energy base of its own. Natural resources were mostly found in North Korea and during the Japanese colonial period (1910-1945) South Korea served as the centre for rice production. The mineral production in South Korea is not enough to supply its manufacturing output and energy needs are therefore met by importing resources like oil and liquefied natural gas. The domestic energy producers are mostly government enterprises. The electricity produced in South Korea is mainly generated from thermal (60%) and nuclear power. In 2017, the South Korean president vowed to move away from nuclear energy and to end Korea's reliance on coal. In South Korea 100% of the population has access to electricity and the demand for energy is growing.

South Korea suffers from high levels of air pollution, including fine dust particles. More than 50% of the population is exposed to dangerous levels of fine dust. The country ranks 173 out of 180 on the environmental performance index when it comes to air quality. This results in a greater demand from consumers for energy sources that do not pollute the environment and public health. Consequently, the South Korean government decided to launch an "era of safe and clean energy" where the focus of energy policy has shifted to more renewable energy and liquid natural gas (LNG). For this, the government aims to use core technologies of the fourth industrial revolution such as AI, IoT and big data.

Apart from the South Korean government, the Korea Electric Power Corporation (Kepco), the country's state-run utilities provider, is investing heavily in new energy technology. It has stated that it will invest 764 billion won (around $674 million) through 2020 in nine areas. The investments include developing new ways to monitor energy consumption, sharing big data on electricity use and finding new business models. The company said it would use artificial intelligence to help monitor conditions at its energy facilities 24 hours a day and predict their lifespan to cut operation costs. Next to this, the company tries to improve its safety standards through drones and thermal imaging cameras. It has developed a diagnostic system that can detect failure in equipment by analysing the thermal images and images taken by drones. The South Korean government invests in fuel cell, solar, wind energy and electric vehicles.

4.2 POLICY STRATEGIES, OBJECTIVES, GOVERNANCE, IMPLEMENTATION

The South Korean government is planning to increase its public R&D investment in clean energy to $980 million in 2021 and has set up a new fund for new electricity industries. Furthermore, the government in 2017 has put in place the Renewable Energy 2030 Plan, aiming to increase the share of renewable energy from the current 7% to 20% of total energy production by 2030 (experts estimate that the country will not reach these targets but will get to a 17% share instead). Part of this plan is the use of technologies such as AI, Internet of Things and Big Data to deliver smart energy systems. Examples of initiatives that are part of the plan are:

- integrated control systems should precisely forecast the amount of power that will be generated from renewables and should address the intermittency of renewable energy.;
- supervisory control and data acquisition systems (SCADA) and distributed automation systems (DAS) should enhance energy efficiency in power transmission, transformation and distribution;
- a nationwide smart distributed generation system should be deployed that combines renewable energy with an energy storage system (ESS) and energy management system (EMS);
- by 2020, every household in South Korea should have an advanced metering infrastructure (AMI) to efficiently adjust power consumption and, through this, also organise power trading and related services markets such as small-scale DER (distributed energy sources) trading;
- a platform to enable the use of big data in the power sector is under development. The platform should allow consumer to monitor their power use and electricity bills, encouraging electricity savings. If the platform is successful, it will also be applied to the gas and heat energy sector;

- investments in technologies to double the energy density of batteries for electric vehicles (EV) and improve EV infrastructure by 2020, including the establishment of home-charging infrastructure in 4,000 apartment complexes nationwide, the instalment of EV chargers in 240 centre areas (e.g. big markets and shopping malls) and in all expressway rest areas;
- finally, the government will allocate $6.4 billion towards replacing environmental facilities to minimize the impact of environmental pollution from coal-fired power generation, for example through dust collectors and desulfurisation systems. This should reduce the production of fine dust particles during power generation from 34,000 tons in 2017 to 13,000 tons in 2030.

The government also invests in the electrification of transport, including cars. In 2030 all buses and trucks should have zero emission – either by driving electric or on hydrogen. The government plans to install fast-charging stations for electric cars throughout the country to foster the use of electric vehicles. Also, the mail delivery will be electrified. Furthermore, the Korean government is investing in autonomous vehicles. In 2018 an unpopulated city for autonomous vehicle testing (based on 5G mobile networks) was completed and a consultation committee with a total of 188 companies for the development of autonomous vehicles was set up. The government has also announced that it is creating a roadmap that proactively deals with regulations towards self-driving cars.

The South Korean government is also ahead of others when it comes to smart city solutions. The government has invested heavily in smart grids that use advanced information technology to efficiently deliver electricity and maximize power by analysing its distribution. Example projects are the carbon-free making of the island Gapa in Jeju by offsetting carbon emissions with renewable energy and developing a high-capacity storage system that stores power captured from renewable sources like a battery. Combining smart grids with artificial intelligence solutions is also expected to help distributors forecast unpredictable demand for power and help people prepare for abnormally hot or cold weather and with reducing the possibility of blackouts.

Other examples of solutions are maximized efficiency of energy management for industries and housing through smart home systems and bringing together both public- and private-sector urban data and intelligent IT to establish a smart city platform capable of optimizing the management of urban resources, such as roads, water and energy (by 2020)[75].

4.3 PRECONDITIONS FOR ADOPTION OF 4IR TECHNOLOGIES IN ENERGY

The South Korean government recognises that cooperation between countries is crucial for the convergence and distribution of Fourth Industrial Revolution technologies. Therefore, it is undertaking 14 jointly funded projects by Memoranda of Understanding on cooperation in energy technology development with eight countries (US, Canada, UK, Germany, Mexico, Indonesia and France) and an additional 117 projects with a total of 27 countries are underway.

In South Korea one of the triggers of the use of 4IR technologies in energy are environmental challenges, which are similar to those in Africa. Technologies, such as AI, are used to monitor and reduce energy consumption and pollution. Preconditions were already well-established power grids, with all households connected. Many of the 4IR technologies are applied to this infrastructure. For autonomous and electric vehicles, this infrastructure is important for charging. A major precondition before 4IR technologies took off in the energy sector in South Korea is thus an established energy infrastructure.

According to a Korean expert, lack of incumbents and loose regulations provides Africa with a favourable market for experimenting with energy blockchain technologies. However, an institutional basis for market players to easily develop technologies and access and use data will need to be developed in Africa.

4
industrialisation

South Korea is known for the fast growth of its industrial sector. The country has benefited from strong domestic encouragement and foreign aid to introduce new technologies and facilities at a rapid pace, resulting in a quick urbanisation and industrialisation of the country. Major sectors are steel production, electronics, shipbuilding, automobiles and automotive parts, construction, chemicals, textiles and footwear and armaments[78].

5.1 KEY TECHNOLOGIES IN THE DOMAIN AND MARKET POSITION

South Korea is known for the fast growth of its industrial sector. The country has benefited from strong domestic encouragement and foreign aid to introduce new technologies and facilities at a rapid pace, resulting in a quick urbanisation and industrialisation of the country. Major sectors are steel production, electronics, shipbuilding, automobiles and automotive parts, construction, chemicals, textiles and footwear and armaments.

The electronics sector, in particular Samsung, is vital to the global electronics supply chain. South Korea produces 17 percent of global semiconductors, 40 percent of LCD displays and 64 percent of mobile chips. The government-funded Electronic Technology Research Institute (ETRI) has also been an important enabler of South Korea's leading role in industrial and consumer electronics. It has a strong position in the commercialisation of IP and other tech-transfer from the Institute, earning $154 million in royalties and filing nearly 1,700 patents over 2011-2016. Aspects of technologies such as 4G LTE (the current fast mobile internet technology), memory chips, digital technologies for high-resolution broadcasting and large screen tv's have been worked on and patented by ETRI. Currently, the institute is investing in AI to catch up with tech firms in the US.[73]

Furthermore, South Korea is a leading manufacturing economy. On the global manufacturing competitiveness index, the country scores an index score of 77 out of 100. Notable is the fact that the country has the highest robot density in the manufacturing industry. It has held this position since 2010 and eight times exceeds the global average. The high growth rate of robots is the result of continued installations of a high volume of robots, especially in the electronics industry and the automotive industry. The largest South Korean company using industrial robotics is Hyundai Heavy Industries, which uses robots to build ships for commercial and military purposes. Last year, the company made its robotics division a standalone business unit, where it also builds robots for other purposes like surgery.

Lowered language barriers, thanks to machine translation, maximized efficiency of office space and energy management and reduced cost of security, increased efficiency in maintaining and operating agricultural and mining equipment and more effective control of ground transportation routes. Expanded lifespan and reduced equipment failures in six major industries (electronics, automobiles, petrochemicals, machinery, steel and shipbuilding) thanks to increases in operational efficiency and preventive maintenance, growth of new robotics and manufacturing market, increase productivity and reduced accident rates through the application of robotics.

5.3 POLICY STRATEGIES, OBJECTIVES, GOVERNANCE, IMPLEMENTATION

Korea is one of the few countries in the world that has managed to radically transform its economy in a lead industrial power in 30 years' time. This implies that there are lessons to learn from Korea's policy regarding industrialisation for developing and emerging economies. Korea has had a deliberate national development strategy with sequences of and complementary policy interventions that fostered industrialisation in heavy and chemical industries. Key policy tools have been the five-year development plans that set clear targets, identified lines of actions and assigned resources to achieve these. When objectives were achieved, targets were gradually upgraded, and coherent actions were taken.

The current multi-annual plan by the South Korean government, contains a pillar on the development of smart factories: factories using a combination of information and communication technology and manufacturing, often using technologies like AI, robotics and IoT.

In 2014, the previous government already introduced the "Manufacturing Industry Innovation 3.0" as part of its Creative Economy Initiative with a focus on the smart factory, using automatization, data exchange and enhanced manufacturing technologies. The Smart Factory Standard Research Council was formed and the previous government implemented a strategic plan to bring 20,000 smart factories to the country by 2020, later increased with another 10,000 by 2025. The ShinSung E&G factory,

located on the edge of Seoul, is one of the first government-recognised smart factories. Other companies like Samsung and LG are however also experimenting with intelligent smart factory technologies and smart factory platforms to optimize their production processes.

Furthermore, in 2016 the Korean government announced the Joint Robot Industry Development Initiative, with the goal to grow the robot industry as one of the new export industries of Korea. The initiative was supported by an investment of $450 million over a five-year period and promotion of 80 public projects within the top 4 promising industries (rehabilitation use, unmanned transport, social works and security) by the year 2020. The government also tries to grow the demand for advanced manufacturing robots by providing and expanding smartphone factories and by creating public demand for service robots.

A Korean expert states that the trend of smart factories might result in the reshoring of manufacturing to developed countries, hampering economic growth in this sector in Africa. On the other hand, the application of 4IR technologies might help Africa with leapfrogging traditional industrialisation and might raise African manufacturing productivity.

5.3 PRECONDITIONS FOR ADOPTION OF 4IR TECHNOLOGIES IN INDUSTRIALISATION

Despite Korea's successes, the manufacturing industry in South Korea has lately lost some of its competitive edge. Advances in information technology, nanomaterials and sensors lower the costs of leading-edge manufacturing processes and improve performance. Companies are under a lot of pressure to improve their productivity and better respond to the needs and expectations of customers. South Korea's manufacturing sector is also highly vulnerable to the competition it faces from China.

According to Hyosung Noh, member of the presidential committee for the 4IR, few Korean companies are currently positioned on key technologies such as artificial intelligence and the Internet of Things. The country lacks experts on the subject, and it is estimated that South Korea is 2-3 years behind in the development of AI compared to the United States. The Korean Research Institute of Education and Vocational Training estimates that there are 28,000 software specialists short of industry demand by 2020.

Furthermore, Donghun Oh, the director of one of the first smart factories in South Korea, believes the Korean industry is three to five-years behind in the deployment of smart factories compared to Europe. Reason for this is the fact that few Korean companies offer process optimisation technologies and import of these technologies is expensive. The government therefore encourages the current smart factories to create their own solutions. While large companies like Samsung and LG have the means to access optimization technologies of other companies like General Electric and Siemens, Korean SMEs struggle. As SMEs represent about 70% of the Korean jobs, action to overcome this barrier is needed.[84]

6
wellbeing

6.1 KEY TECHNOLOGIES IN THE DOMAIN AND MARKET POSITION

This section looks at examples of the use of technologies in three areas affecting well-being: education, healthcare and (smart) cities.

As regards education, South Korea has historically prioritised first literacy and later excellence in training and research, accompanying the growing demand for skilled labour by the domestic industry. Currently, the South Korean government feels that the facilitation of self-directed learning will enable teachers to focus more on personal development and creativity-enhancing education and reduce the demand for and financial burden of private education. Creativity is seen as very important to improve the technical and innovative capacity of South Korea. To that end, the government feels that education should be redesigned to foster creativity and the technological capacity of citizens. It aims to increase the two to three dozen skilled specialists in Korea that each year receive their doctorates in Artificial Intelligence, among others through software- and convergence-based learning.86 In 2015, Korea is overall ranked 31st among 139 countries on the Global Creativity Index, but is ranked 1st on the aspect of Technology . The South Korean government wants to:

- increase software and STEAM (convergence-oriented education on science, technology, engineering, arts and mathematics) education for elementary and middle school students to enhance their computational thinking and problem-solving capabilities;
- support the autonomous capability development of students by reforming class styles, curricula and degree requirements;
- establish new college entrance and screening procedures that induce effective educational reforms and support the establishment and practical application of innovative education policies.

Healthcare is expected to benefit greatly from fourth industrial revolution technologies in terms of new revenue generated and costs saved. Intelligent solutions will enhance the precision of medical diagnostics and treatments and contribute to decreasing the cost and improving the quality and accessibility of healthcare services. Expected benefits of the technology are optimised efficiency of investment in and operation of hospital facilities and equipment, maximised efficacy of clinical trials and reinforced accuracy and safety of surgical processes through the use of intelligent robotics. Outside the hospital, daily exercise and health-monitoring programmes should improve health together with real-time monitoring and responses to air and water pollution, reducing the prevalence of diseases and resulting in lower mortality rates. The country's Master Plan for an Intelligent Information Society states that intelligent IT is expected to increase the health span of citizens.[86]

Advanced language recognition and machine translation technologies will enhance the accessibility and convenience of services available inside and outside Korea, lowering language and cultural barriers.[21]

South Korea is considered to be an example for other countries worldwide when it comes to Smart Cities, as the country has invested largely in this field and is ahead of many others when it comes to the number of smart city projects that are underway. For the past ten years, the South Korean government has been investing in the Ubiquitous City project (U-City) with involvement of the MOLIT and MSIP ministries. The project focused on the building infrastructure in new cities, for example the management of water, gas and energy, transportation and building structures. More recently, the focus of the government has shifted to urban regeneration and the budget of the U-City project has been greatly reduced.

As mentioned in the chapter on energy, the concept of Smart City fits with South Korea's energy ambitions and its push for green technologies and lower carbon emissions. The country has been at the forefront of developing smart grid systems to reduce CO2 levels and already in 2008 launched a Smart Grid national project to implement smart grids across the country.

Local authorities in South Korea have also started to implement their own smart city projects across the country.

Leading projects are the development of New Songdo, Saemangeum and Sejong City. A cluster of developments has also been ongoing in the area of Seoul.

A Korean expert also expects synergies between Africa's rapid urbanisation and the development of smart cities in Korea and elsewhere. The availability of undeveloped land provides Africa with the potential to develop pilot smart cities.

6.2 POLICY STRATEGIES, OBJECTIVES, GOVERNANCE, IMPLEMENTATION

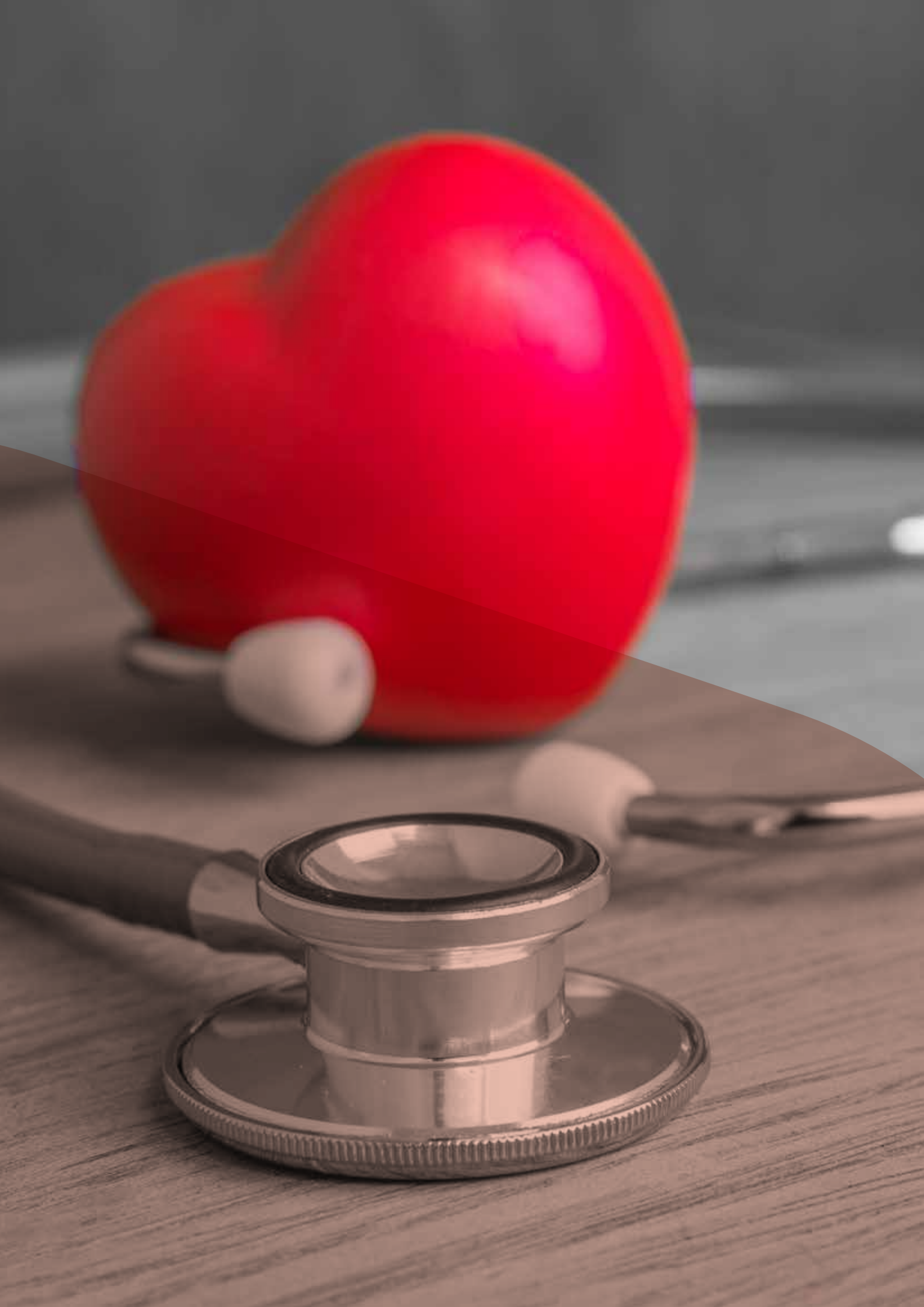
The Korean Master Plan for Intelligent Information Society expects the application of intelligent solutions to increase wellbeing by reducing car accidents, improving air quality, reduced traffic congestion, reduced housework and improved public health.89 Examples of smart city solutions that will be used for this are the automation of patrolling, surveillance and other dangerous tasks and the improvement of crime-forecasting models using Big Data. Real-time updates on traffic information and the intelligent control of traffic flows will also help minimize traffic congestion and car accidents.[21]

The Presidential Committee on the Fourth Industrial Revolution has a special smart-city subcommittee that supports the government in their aim to continue to create leading smart cities. These smart cities will use fourth industrial revolution technologies to make the lives of citizens safer and more convenient. One of the components of the new cities will be a real-time health monitoring system, so that citizens are able to get customized health management.

6.3 PRECONDITIONS FOR ADOPTION OF 4IR TECHNOLOGIES IN WELLBEING

For South Korea to realise the ambitions mentioned above, and generating impact on wellbeing, might not be that easy. Bringing about a cultural change in the field of education and entrepreneurships might require more effort than developing a new technology. The use of 4IR technologies for better healthcare will require health care professionals to change their way of working and trust technologies to diagnose a patient or make decisions on what treatment a patient should get.

Finally, while South Korea has been at the forefront with smart city developments, the development of these cities in a way that provides sufficient added value for citizens has been a learning process for the country. The city of Songdo has, for example, been accused of being too anonymous, expensive and overly planned, resulting in a lack of interest by citizens to actually live in the city, which made the city not attracting enough for economic activity. The country continues to learn from its activities in this field and shares lessons with others by, for example, organising events like the International Conference on Smart Cities and Smart Cities Innovation Summit Asia.



7
overall conclusions and lessons learned for Africa

South Korea has transformed in a few generations from a weak economy to a highly advanced and competitive economy. Technology plays an important role in the Korean economy. The country has made great strides towards 4IR adoption in multiple sectors, most notably in the high-tech industry South Korea has many multinationals – often family owned – that are important players in, for instance, the semiconductor industry with applications such as mobile phones and tv's. The country has the highest density of robots worldwide with 631 robots per 10,000 human workers.

In South Korea, across multiple sectors and in national policies, most attention is given to the adoption of the Internet of Things and to Artificial Intelligence. Together they form the basis of all smart initiatives in the country: smart farms, smart factories, smart grids, smart cities etc. Drones are less mentioned as applied 4IR technology but play a role in agriculture and energy. Blockchain and additive manufacturing have far less attention in the sectors explored in this country case study.

The Korean example shows that a country can successfully develop a globally competitive manufacturing sector even without a sizeable home market by focusing on high-tech products, then on exports. The country is particularly strong in the development and export of hardware, but mostly imports software products. Many development economists doubt that this export-oriented model for economic development can be replicated in Africa, especially in the context of the 4IR, which may lead to more decentralised and local production and reduces the importance of the relative cost of labour in different markets. Small markets also have one disadvantage compared to the likes of the US or China when it comes to the use of AI for revolutionising industries, which is the lack of a large data basis, with data being the most important resource in the context of 4IR. This could mean that smart specialisation in niche sectors becomes more important than ever – as South Korea has done with focusing on the electronics sector in industry.

The differences between South Korea and Africa are quite significant. South Korea has a strong economy with a well-developed and technologically advanced industry, among which several multinationals. The country has a knowledge economy, with a good innovation infrastructure, and is not dependent on low-cost labour. The government is well-organised and plans several years ahead accompanied by a fairly large expenditure on R&D. Technology is seen as beneficial for the wide society and several societal issues. Also, the demographics are largely different, with a higher life expectancy and ageing, stagnating population in Korea. The lessons that can be learned from the Korean situation can therefore not be transferred one-to-one to Africa. In the rest of this chapter we have tried to identify and formulate lessons that can be valuable or adapted and transferred to the African context. However, we also note that some opportunities of 4IR to Korea could be a threat to Africa: think of the competition with low-cost labour.

7.1 DRIVERS OF 4IR ADOPTION

One of the enablers for 4IR application in South Korea is its strong economy and economic structure. South Korea has a knowledge economy and hosts several multinationals in electronics, of which many are still family owned. These large family owned businesses have a strong position in the Korean economy and are thus important for policymakers. The focus on 4IR is partly due to this dependency on some very large technical companies that have the capacity to invest heavily in R&D.

The country spends a lot on R&D and has good manufacturing infrastructure. Many people are able to deal with modern digital technology in daily life and in their work environment. The ICT and electricity infrastructure are of good quality – with all people connected to the grid and the Internet – and many people are educated in technology and engineering. This provides a good basis for implementing 4IR technologies throughout the country.

Several national institutes play and have played an important role in the economic and technological development of South Korea. The country has a good innovation ecosystem with companies, government, institutes and universities collaborating on technological and economic development. Currently, the KISTEP institute is appointed by the Korean government to shape its fourth industrial revolution initiative. Investing in good

institutes on 4IR niches for the context of Africa could be a valuable approach for further adoption and benefit of 4IR technologies in Africa.

South Korea is well-organised and plans several years ahead in their national innovation/R&D policies. With 5-year plans the country gives direction to economic and technological development by setting clear targets and installing (high-level) committees – consisting of public and private figure heads – to lead strategic implementation. Technology is seen as a solution to economic and societal problems in the country, resulting in 4IR technology adoption in all sectors explored in this case study. South Korea already pays attention to 4IR, wants to lead in 4IR technologies and their applications in some sectors, and sees the importance for their (knowledge/manufacturing) economy and society at large. Implementation is organised through top-down technology push combined with large investments in R&D, technology diffusion programmes, start-up promotion and educational renewal and promotion.

These aspects provide good enablers for the application and further development of 4IR in several sectors of the Korean economy.

7.2 BARRIERS TO UPTAKE

South Korea faces several stumbling blocks to full adoption of 4IR as well. Most of these have the attention of the Korean government. The challenges are not completely preventing the adoption of 4IR solutions but are aspects that should be tackled to facilitate the uptake of 4IR and enhance the competitiveness of the country's economy.

A first stumbling block is the fact that Korea lacks global competitiveness in ICT services industries such as software publishing and professional IT services, where the country is behind other OECD countries. The fact that companies rely on the import of commercial software services weakens the country's international position. Furthermore, like many Asian countries, South Korea does not score very high on creativity. With 4IR this becomes much more relevant to develop/design new products and processes. South Korea is improving this in education, by providing more attention to personal development and creativity.

Next to this, for the 4IR it is very important that the workforce (including people working for government) is well educated and (sufficiently) technology minded. A barrier for Korea is the fact that Korean business leaders (especially those with a hardware manufacturing background) are insufficiently aware of the importance of software creation and process reengineering, resulting in a lack of R&D spent on software.

In agriculture, the adoption of smart farming is an issue due to the ageing farming communities. Young people have better digital skills and are more open to adopt new digital technologies than older people are. In policies that are directed at implementing 4IR technologies in the agricultural sector attention is given to fostering smart farming start-ups by young people.

The government is investing a lot in new technology/R&D but is more risk averse than private sector investors. The number of private sector investors are less available than in western countries. The same holds for Africa, where the availability of long-term budgets could pose an issue. The lack of private investors might also explain the reluctance to invest in start-ups (one of the routes for commercialisation of knowledge and innovation). In general, there is a lack of entrepreneurial spirit and a rigid/vertical regulatory system that could limit innovation in 4IR technologies and further uptake.

7.3 LESSONS LEARNT

Although South Korea is in many respects different from Africa, still some lessons can be learned. As South Korea is already industrialised, the 4IR is much easier to implement in industry. For Africa this may be different, although the technologies used in 4IR could be applied in several sectors.

Private sector development has been at the basis of the growth of the Korean economy in the last century. The country invested in (small) family owned business, leading to a well-developed industry and knowledge society. The focus is now on innovation through R&D investments. For Africa the biggest potential is probably not in innovating in 4IR but adapting and applying 4IR technologies in several sectors. The history of South Korea shows that it might be a good strategy to invest in small local companies intending

to use new 4IR technologies in their business. South Korea names such companies "hidden stars". They could set an example for further uptake of these technologies in the economy or sector – as South Korea is also promoting in, for instance, the agricultural sector. However, selecting the right candidate companies to invest in is not easy, because of the high degree of uncertainty in the business case of applying 4IR to create a new business. The adoption of 4IR technologies by existing companies might also require a new business model. Furthermore, it is important to develop both the supply and demand side for products to become successful – therefore, timing is critical.

The Korean government is investing in creating an environment where there is room to experiment with 4IR technologies. They do this by fostering a start-up ecosystem, which includes funding and venture capital to build new business around good business ideas. A start-up ecosystem tailored to 4IR may be a good way to start new business activities and to test their potential in Africa.

In South Korea several national institutes play an important role in the country's technological and economic development. African countries may benefit as well from (national) institutes focusing on 4IR niche technologies to adapt to and apply in the African context in several sectors or in relation to solutions for local challenges. When it comes to 4IR technologies, however, there have been few outputs of Korean national institutes. A good practice by the South Korean government to ensure the effectiveness of government interventions is the enforcement of (self-) assessments. The government requires key performance indicators (KPIs) to be carefully selected for each policy or programme beforehand and measurement of these KPIs to evaluate the result.

Another lesson is to follow a planning approach with clear – ambitious – targets and a strategic high-level committee of public and private figure heads supporting and giving direction to the implementation of 4IR technologies in several sectors. South Korea uses this approach in its five-year plans. The government shows clear leadership, focuses on regional development and local issues and is able to mobilise the private sector. It is important that decision makers are well educated, since a lack of understanding might lead to poor programmes that lack relevance and result in wasted investments. Africa might use such an approach with strategic investments potentially connected to societal issues, so that their wider benefits are recognised by society.

African countries can also learn from the Korean approach to focus on national niches first, before focusing on export. Korea is focusing on high-tech products in industry, developed first for the national market, and then for export. Similarly, in the agricultural sector smart farming machinery and technology is developed, produced and adopted to solve national issues, before thinking of exporting products – but keeping an eye out for such opportunities. In both cases a niche is chosen that fits the national needs and context, which may have potential for exporting to other countries later. Be aware that this does not always hold: sometimes it might be wise to import the best product globally available rather than trying to produce machines domestically, in order to keep up with international competitiveness.

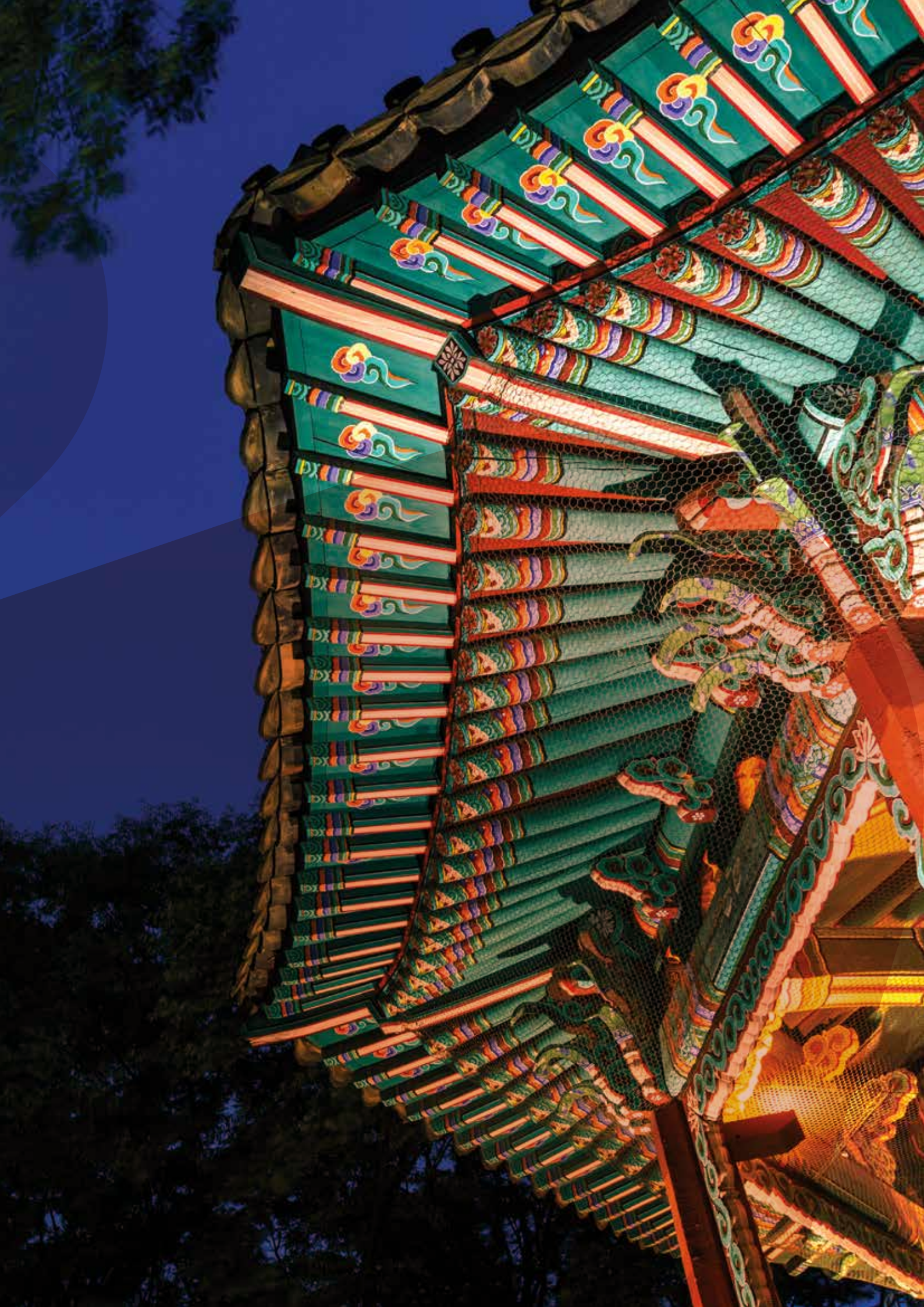
Although South Korea does not have many people employed in agriculture, they invest a lot in innovation in agriculture. In Africa the amount of people employed in this sector is much larger, so these investments and technologies could be interesting to some extent. Agriculture could be an interesting sector for Africa to invest for 4IR. However, one of the reasons for South Korea to invest in smart farming (IoT/AI) is the diminishing farming population: with smart farming the amount of labour and workers will be reduced. Production and productivity increase are also intended with smart farming – this may be a goal that South Korea shares with many African countries.

An important lesson for Africa from South Korea is also to not focus on competing on the international market with low-cost labour. New technologies can reduce the amount of labour needed to produce products and to improve productivity, lowering the factor of labour in the overall costs. This might be a threat to many African countries. Instead, it is therefore wise to focus on high-tech niche products for the African context that might open the door for foreign markets.

A precondition to 4IR application is a good internet connection, South Korea is one of the countries with the best ICT infrastructure and internet connectivity world-wide. For Africa it would be important to invest in a good digital infrastructure as well. As for the Internet, this does not have to be land lines, but does require a fast-mobile Internet connection (sufficient bandwidth and retention) to exploit 4IR – specifically IoT, AM, AI and blockchain. In that respect 5G may be of interest as well. 5G could be a prerequisite for further innovation in 4IR or adoption thereof in Africa. Some ideas for a roadmap to 5G in Africa have already been launched.

South Korea invests in building digital talents. Any country around the world that wants to profit from the 4IR will need to build its digital workforce, which presents an opportunity for Africa. Korea invests in the education of people to further innovate and to become more entrepreneurial and creative. With 4IR more low-cost labour is further automated and products become more customised, software and products as a service become more important. This requires more creative skills in the workforce – apart from a good general education. As production is expected to be more local with 4IR as well, entrepreneurial skills are important to reap the opportunities of 4IR. This could bring further growth to local economies. Adapting education and improving education-support programmes (training the trainers) to include more creative and entrepreneurial skills could be an important lesson from South Korea.

South Korea makes some links to societal challenges in their innovation investments for technologies, like those for the 4IR. Connecting the application of 4IR technologies to societal challenges could contribute to wider well-being than just in the economic sense. Especially in relation to healthcare some opportunities are seen in South Korea, which could also be opportunities in Africa. In more remote or rural regions, AI, big data and digital technologies in general may help in personalised health self-management for certain deceases, in improved farming etc. In the more urban regions, smart city technologies could contribute to improved public health and safety. Korea has mixed experiences with these smart cities, of which lessons can be transferred to countries in Africa.



Appendix A
List of interviewees

9 May 2019 Dr. Jong Sung Hwang, Research Fellow of the *NIA*
9 May 2019 Dr. June Sung Park, Chairman of the *Korea Software Technology Association*
16 May 2019 Dr. Kyoo Sung Noh, Chairman *Korea Productivity Center* (written answers)

EN
end notes

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