
NORTH KOREA'S ADVANCED TECHNOLOGIES

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Abstract

The Democratic People's Republic of Korea (hereinafter DPRK or North Korea) has been pursuing technological development in a very different way from the standard path of global technology growth due to its unique historical background and other factors and sought to develop its own science and technology to establish a complete socialist nation in line with its self-reliance (*juche*) philosophy. Its isolation was intensified by the international sanctions imposed as a consequence of its weapons-of-mass-destruction development programs since 2006. Throughout its existence, it has been leading the life of a reclusive nation with a closed economy, resulting in a low level of technology compared to that of advanced economies. In the meantime, its political structure bestows absolute power that allows the supreme leader to allocate resources in whichever sector he wants. Major industries, such as power, mining, metal, machinery, and coal, are being developed. The DPRK is also attempting to transition to a digital economy. Evidence suggests for example, that the DPRK is raising human capital in software, which appears to have brought positive outcomes in artificial intelligence.

1. Introduction

The world is witnessing drastic technological progress. It has already entered the 4th Industrialization as a result of new technologies in a variety of socio-economic fields. The United Nations selected 11 frontier technologies which would turn the world's future around, including artificial intelligence, the internet of things (iot), big data, blockchain, 5G, and 3D printing.¹ Enterprises which secured those technologies one step ahead of the rest are showing a huge increase in their productivity, and this gap will continue to grow. Enterprises are tussling over the proprietorship of technologies.

In contrast to much of the world, the DPRK has developed technologies on its own and its methods differ from the usual path of technological growth. It stresses economic growth led by its own unique technologies. Kim Jong-un further emphasized self-developed science and technology to counter the country's international isolation. In other words, the DPRK is clinging to technological development to overcome economic stagnation. So far, the DPRK does not have access to cutting-edge technologies, which are needed for economic development. Since new technologies would not only affect the economy but also the society as a whole, it is crucial to closely examine changes in the science and technology sector and not just political affairs.

The public knows little about North Korea's technology, and even that is sometimes misunderstood due to lack of information from North Korea's closed society. Public awareness of North Korea's technology relies mostly on media accounts, which mainly report that North Korea's technology poses a threat to world peace, as it is used for extortion of digital currency, hacking, nuclear weapons, and missiles. We, however, believe that the media shows only a small part of North Korea's technology, as it is prevented from seeing the whole picture of North Korea's technology.

North Korea is showing great interest in developing advanced technologies, which seems to be largely due to two objectives: the security of its regime and economic development. North Korea believes that the development of advanced weapons protects it from external threats, and believes that advanced technologies will lead to improved productivity and resource conservation, which will result in economic growth. As far as advanced weapons are concerned, North Korea is developing inter-continental ballistic missiles (ICBMs), submarine launched ballistic missiles, Iskandar missiles, and hypersonic

missiles. For economic growth, North Korea is researching mainly energy resource-substituting and energy-saving technologies. IT technology, such as network security and hacking technology, is being developed as well.

The problem is that North Korea's inappropriate use of advanced technology threatens international security, and now the public is alarmed about North Korea's advanced technology. More specifically, the public's concern centers on North Korea's advanced military technology because they have repeatedly conducted nuclear and ICBM tests, ignoring the norms of the international community. North Korea also attempted to illegally obtain foreign currency by hacking digital currency trading systems, which undermines the credibility and stability of its economic activities. Under these circumstances, the public can easily come to believe that North Korea has a high level of advanced technology. To what extent has North Korea's advanced technology actually been developed?

The overall level of advanced technology in North Korea lags far behind. Most of all, there is no social infrastructure to develop and use advanced technology. In 2019, only one in four people had electricity access, and even that is often fewer than 12 hours per day². To develop advanced technologies that improve the productivity of the whole society, the DPRK must have a higher income level than at present, and exchange ideas and cooperate with foreign scholars.

Of course, North Korea's advanced technology in some areas has reached a surprisingly high level considering its poor economic situation. When it comes to nuclear weapons, ICBMs and digital hacking, North Korea possesses top-notch skills but there is a different story in the agricultural sector as it still relies heavily upon oxen to plow a field. As mentioned above, we recognize North Korea's advanced technology as highly advanced because it threatens global security. North Korea could fire missiles to threaten the mainland of the United States and steal money by hacking digital currencies on block chain technology that is thought to be safe, but its leader cannot travel directly from North Korea to Singapore to hold a summit with the United States. North Korea lacks the technology to make airplanes and cannot purchase airplanes due to sanctions. In addition, their military technology is neither sustainable nor stable. It is misleading to conclude that North Korea's technology has advanced to a significantly high level just because a limited number of fields have been developed.

In this context, this study examines frontier technologies of North Korea as well as specific targets, policies, outcomes, challenges, and prospects to provide a broad picture of what North Korea aims to achieve, focusing mainly on economic and industrial-related technologies, rather than military technologies.

2. To what extent have advanced technologies of North Korea been developed?

1) *Economic Structure of North Korea*³

Before we delve into recent policies related to developing technologies, examining the economic structure of North Korea is necessary as it is highly correlated to the level of current technology and its policies. Considering such a closed society like North Korea, it is plausible to believe that the development of advanced technologies will remain on its current path unless there is a fundamental change in economic structure. Therefore, it is worthwhile to take a close look at a highly unique economic structure which takes two pronged approaches—one is the socialist economy, and the other is self-reliant national economy.

One striking observation is that the development and application of new technologies in North Korea hinge upon the policies designed by its government. Unlike most of the advanced economies wherein technologies are driven by fierce competition in the private sector, North Korea's technological development is directed by the country's leader, Kim Jong-un, under the country's socialist economic system. The motto of the socialist economic system is to never let ownership of the means of production fall into the hands of the private sector, represented by *donju* (North Korea's emerging capitalist class). The state allocates limited resources on the basis of detailed plans in all areas of the economy and thus the technology development.⁴ It seems that most technology development in DPRK is made according to the government, which can invest large-scale resources and allocate scientific and technological labour.

Some ask what role the private sector plays in the development of advanced technology in North Korea. In the past, the *donju* were a representative symbol of introducing a market economy into North Korea while accumulating private wealth within the framework of socialism. Since the companies run by the *donju* played an important role in many economic sectors, it seemed likely that the *donju* could play an important role in technology development. Thus, some could argue that technological improvement is made in the private sector. For example, the

private sector may be able to import and use products with new technologies faster than the public sector. However, this does not mean that the private sector is developing the advanced technology. Science and technology development is possible only when large-scale investments, skilled researchers, and social infrastructure are established. In particular, the development of technology to replace and save energy that North Korea pursues is even more so. What the private sector can do in North Korea is to import, use, and distribute products that contain energy-saving technologies that have already been developed abroad.

Recently, the *donju* are playing an auxiliary role in science and technology development. The influence of the *donju* in the economy has diminished since the advent of Kim Jong-un. Twenty years have passed since the appearance of the *donju*, which seems to introduce a market economy to North Korea, but they have failed to transform North Korea into a market economy. Since 2018, the North Korean government has adopted “uniform guidance and strategic management of the overall economy of the country” as its main policy and has been expanding its control over society as a whole. The government's social control is being strengthened due to recent sanctions against North Korea and the COVID-19 outbreak. Now the North Korean authorities have been using the *donju* to maintain the socialist system and the stability of the system. For example, on the front page of the North Korean *Rodong Shimbun* on June 10, 2020, an article was published thanking 18 workers who provided basic construction materials for the construction of Samjiyon City. These 18 people are very likely *donju*, as none of them were soldiers, party officials, or high-ranking officials. Now, in North Korea, the *donju*'s influence is limited to a role that helps stabilize the regime under the management of the authorities. The *donju* are failing to bring about changes in the North Korean economy, and thus in the technology development. Now, most things are controlled by the authorities, and the private sector cannot autonomously decide and operate it.

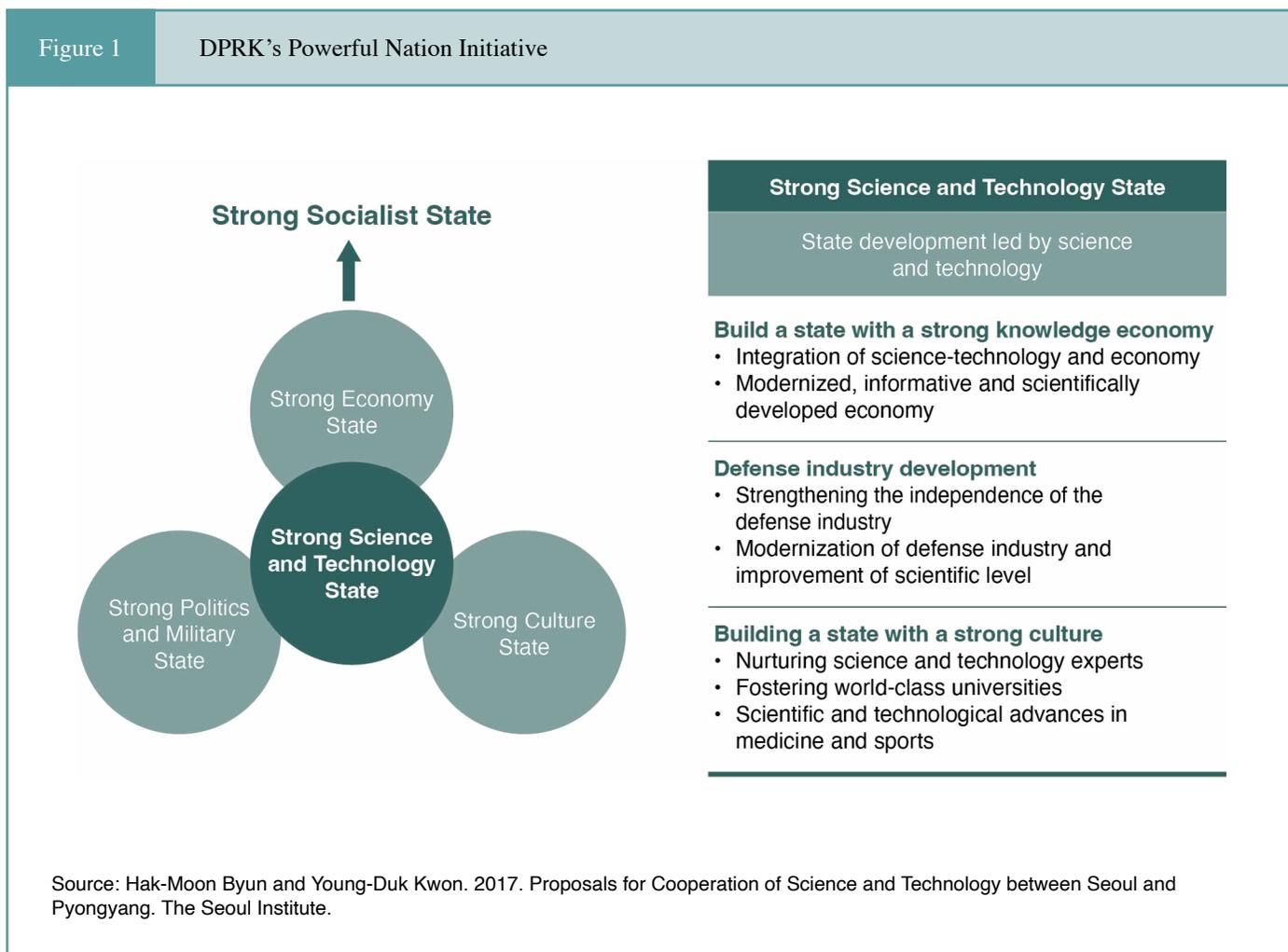
The other noticeable difference is that North Korea has pursued its own unique economic growth path—a self-reliant economy with traits focusing on the identity of its nation. Self-reliance means that it aims to produce every single good within the country with the least help possible from outside. According to the North Korean government, there are three conditions to be met to realize this economy; i) produce all of the necessary heavy, light and agricultural goods domestically; ii) attain independence in every technology to manufacture goods; and iii) secure raw materials within its territory.

Despite North Korea’s goal to build and sustain a self-reliant nationalist economy, it prioritized the expansion of heavy industries. The logic behind it is that heavy industries need to be developed in advance to manufacture the means of production, such as machinery. Light and agricultural industries have been less developed as a result. Moreover, North Korea’s obsession with strengthening its military power further emphasized the growth of heavy industries. Technology development in the DPRK, therefore, has been shaped in line with its political doctrine. However, the technology of the heavy and light industries and agriculture have not developed in a balanced way. The imbalanced strategy has reduced the DPRK’s ability to achieve its goal of self-reliance. Moreover, despite the importance attached to technology for heavy industries, its level of technology remains low by international standards. The DPRK has not achieved what it initially intended, and its weaknesses are most likely to remain the same in the future.

2) Science and Technology Policies in Kim Jong-un era

Figure 1 describes Kim Jung-un’s goals to make the best use of technology to develop North Korea into a strong socialist nation. At its 7th Party Congress in 2016, North Korea presented its blueprint to build a culturally, economically, and politically powerful nation, by making science and technology the driving force of national development.

The idea that science and technology determine the strength of the nation emerged in the late 1990s during the Kim Jong-il era and continued under Kim Jong-un,⁵ who introduced the “Instant Catch-Up Doctrine” (“단번도약론”).⁶ Kim Jong-un proposed technological development as a major state objective to ensure that the DPRK is fully equipped with an economic system that is in tune with the new industrial revolution announced in his speech in 2012. In 2018, he proposed a catchphrase “Let’s



leap through science and secure the future through education” (“과학으로 비약하고 교육으로 미래를 담보하자”) to ensure that science leads the nation and education secures the nation’s future. In the following year, he proposed to take the bull by the horns (정면돌파전) by promoting science and technology to weather the international sanctions.

The emphasis on developing science and technology that was initiated during the Kim Jong-il era changed over time. Since 1998, the DPRK has announced four consecutive Five-Year-Plans of National Science and Technology Development projects (Table 1). The last plan, which was established a

year after the inauguration of Kim Jong-un, placed a special emphasis on improving living standards along with overcoming energy shortages and sharpening technologies for a knowledge economy. He emphasized resolving the shortage of energy by producing more energy and adopting energy conservation. The North enacted a “Renewable Energy Law” which stipulates measures to use and manage renewable energy to generate electricity.⁷ There is not much known about the Five-Year-Plan after 2018 but the Five-Year-Plans of National Economic Development for 2016-20 and 2021-25 do highlight the importance of technological development in major industries.

Table 1 DPRK’s Five-Year Plan for Science and Technology Development				
The 1st Plan (1998-2002)		The 2nd Plan (2003-2007)	The 3rd Plan (2008-2012)	The 4th Plan (2013-2017)
People’s Economy Technology reform	Overcoming shortages of energy	Technological improvement of the people’s economy	The four leading sectors of the people’s economy (electric power, coal, metal, and rail transport)	Overcoming shortages of energy (electricity production and saving)
	Normalization of key industries		Reconstruction and modernization of the people’s economy (resource extraction, machinery, chemistry, construction materials, and land environment)	Jucheization and modernization of industry (metals, chemicals, coal, machinery, electronics, construction materials, light industry, land environment, and city management)
People’s life improvement		People’s life improvement	Overcoming food shortages (agriculture, fisheries, light industry, and health)	Overcoming food shortages (agriculture, livestock, fruit trees, and fisheries)
Basic and advanced technology improvement		Advanced technology improvement	Advanced science and technology (IT, NT, BT, energy, space, ocean, and laser/plasma)	Increasing the proportion of advanced technologies (IT, BT, NT, new materials, new energy, and space)
		Basic technology improvement	Basic technology (mathematics, physics, chemistry, biology, and geography)	Basic technology (mathematics, physics, chemistry, biology, and geography)
<p>Note: There might be a 5th Five-year Plan for Science and Technology Development. However, the specific details have not yet been revealed to the outside, so it has not been included in the table.</p> <p>Source: Choon-geun Lee and Jong-seon Kim. 2015. Changes and Implications of Science and Technology Policy in North Korea’s Kim Jong-un Era. STEPI Insight No.173</p>				

Figure 2

Science and Technology Center



Source: North Korea media

Figure 3

Pyongyang Scientist Street



Source: North Korea media

Science and technology as the key of DPRK's doctrine was realized with concrete measures. The government attempted to raise management efficiency by establishing integrated manufacturing systems under the spirit of "modernization and digitization of the economy" and by introducing new technologies whose intellectual property rights are conferred to state-owned enterprises. It is also introducing a new educational scheme to educate all the individuals with the college-level science knowledge ("전민 과학기술 인재화"), even though nearly three-quarters of North Korean youth do not go to college. In this context, the duration of compulsory education was extended to 12 years, and the proportion of math and science increased. In addition, the opportunity for education has been offered to manual workers, farmers and office workers as a remote education system is swiftly equipped.

Large-scale research facilities have been established in Kim-il Sung University, Kim Chaek University of Technology, and Institute of Natural Science so that products made with frontier technologies can be developed and mass-produced.⁸ This is an exemplary case of integrating scientific education and research and manufacturing. The digitization of the agricultural, medical, and physical training sectors is in progress, although the level of technology is low compared to advanced countries. To motivate scientists for research, the government is also offering incentives, such as building an apartment complex, a department store, and resorts intended for scientists only, and it has been rewarding the best scientist/technician since 2016. Figures 2 and 3 represent propaganda buildings to show the nation that it is giving special treatments to scientists and cherishes science and technology.

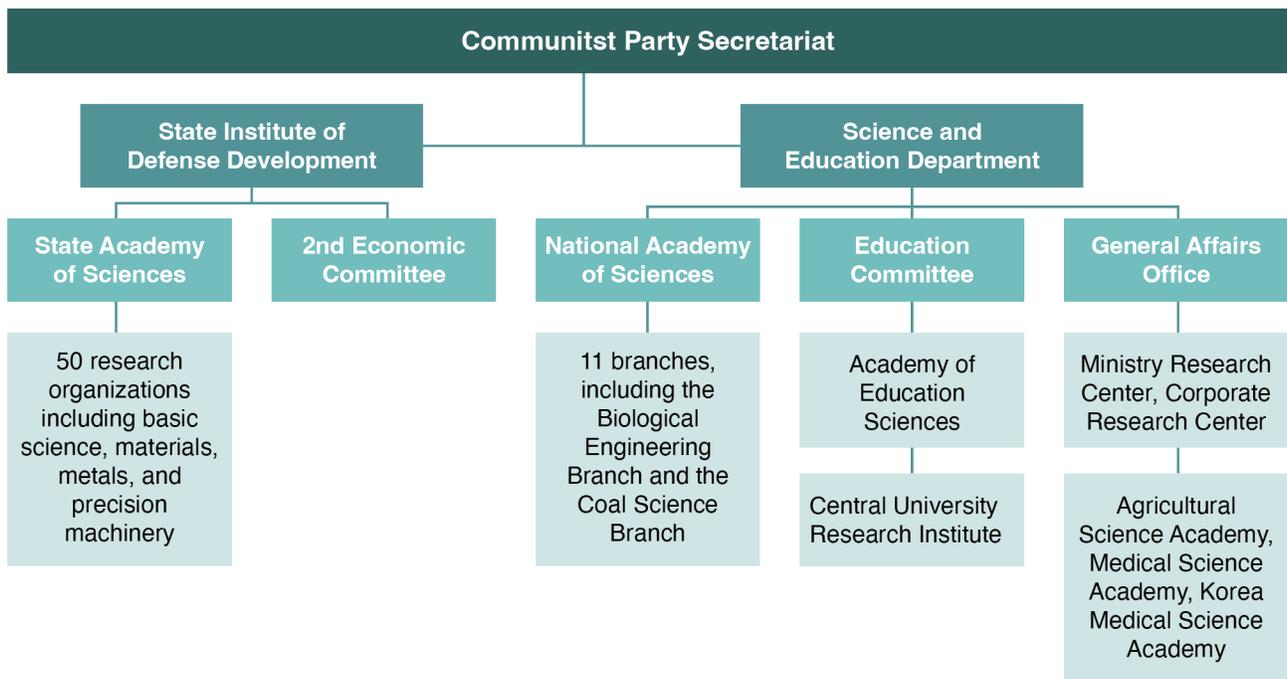
3) Management System of Science and Technology

The Science and Education Department is the leading institution which manages scientific research within the DPRK. It introduces new science and technology policies and education programs and operates them, as well as building science projects, developing a science and technology index, securing budgets, and managing research outcomes and personnel. It conveys orders through the State Academy of Sciences, State Science and Technology Commission, Education Commission, and other party organisations and oversees the overall process of finding research topics and implementing projects.

It is common for socialist countries to have a grandiose structure of scientific research and development. In North Korea, this structure incorporates the State Academy of Sciences, State Institute of Defense Development, research institutes within state-owned enterprises, state-owned research institutes and institutes attached to universities. The State Academy of Sciences, which conducts scientific research, and the State Institute of Defense Development, which fosters defense industries, play a pivotal role in state research institutions in North Korea. Other important research centers include the State Institute of Agricultural Science, State Institute of Medical Science and State Institute of East Asian Medical Science.

Figure 4

DPRK's scientific research organization



Source: n.a. (2016) Seung-hyuk Na. 2016. A study on the analysis of level of North Korea's Science & Technology and the derivation of its strategic utilization. Korea Institute of S&T Evaluation and Planning. Research Report 2016-007

The majority of state research projects are led by the State Academy of Sciences.⁹ This is because unlike other socialist economies, the research institutes of the Cabinet and those within the universities and enterprises lack capacity to conduct their own research. The State Academy of Sciences was the birthplace of numerous technologies until the 1980s, according to state economic development plans, but when industrial activities went dormant after the severe economic downturn in the 1990s (the Arduous March) it started to handpick the subject of research by looking into the world trend, and build its own science technology development project.

4) Capacity for developing science and technology in the DPRK

An examination of external and internal conditions is required to make an assessment of a nation's level of science and technology. Internal conditions—human capital and other resources—come first. However, international comparisons are difficult as the DPRK does not disclose any budget specifics in absolute terms, which are essential to compute ratio of expenditures on research and development to GDP. The only figure that can be obtained is the growth rate of expenditures on science and technology, which is slightly higher than that of total state expenditure. This indicates that the proportion of expenditures for science and technology in state expenditure is growing.

Table 2	Growth rate of total expenditure of DPRK's national budget and expenditure (plan) in science and technology sector											
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Total	8.3	8.9	10.1	5.9	6.5	5.5	5.6	5.4	5.1	5.3	6.0	1.1
Science Technology	8.5	10.1	10.9	6.7	3.6	5.0	5.2	8.5	7.3	8.7	9.5	1.6

Source: Kim (2020) Suk-jin Kim. 2020. Achievements, Limits, and Prospects of North Korea's Science and Technology Policy. KDI Review of North Korean Economy. 2020. 3, Rodong Shinmun

In case of human capital, the overall level of education in the DPRK is higher than other developing nations. This is because the DPRK introduced compulsory education earlier, which is demonstrated by the fact that over 90 percent of the population has at least a secondary level of education. Moreover, the percentage of students admitted to colleges is higher than in other developing nations.

Table 3	Comparison of education levels between North and South Korea and other developing select countries in Asia								
		South Korea	China	Vietnam	Cambodia	Laos	Myanmar	Bangladesh	North Korea
Gross enrollment ratio (%)	Secondary	99.7	95.0	-	-	67.9	64.1	67.3	92.9
	Tertiary	93.8	51.0	28.3	13.1	15.7	16.0	17.6	28.2
Expected years of schooling		16.5	13.8	12.7	11.7	11.2	10.0	11.4	12.0

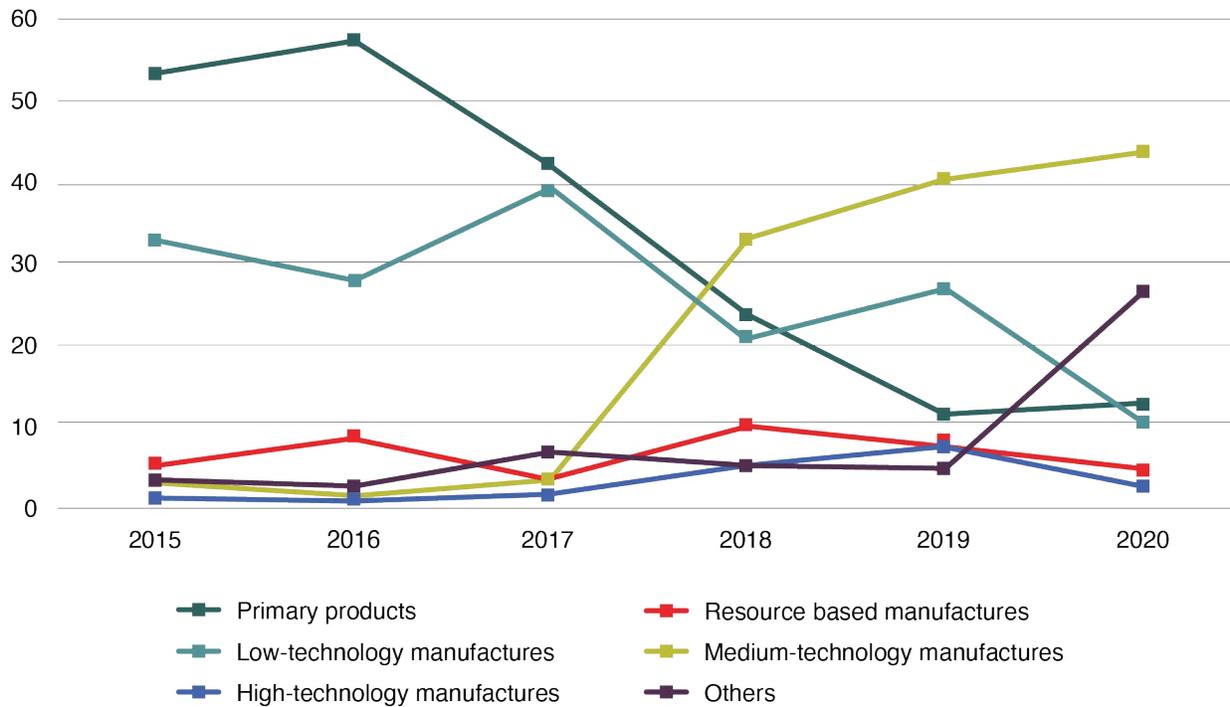
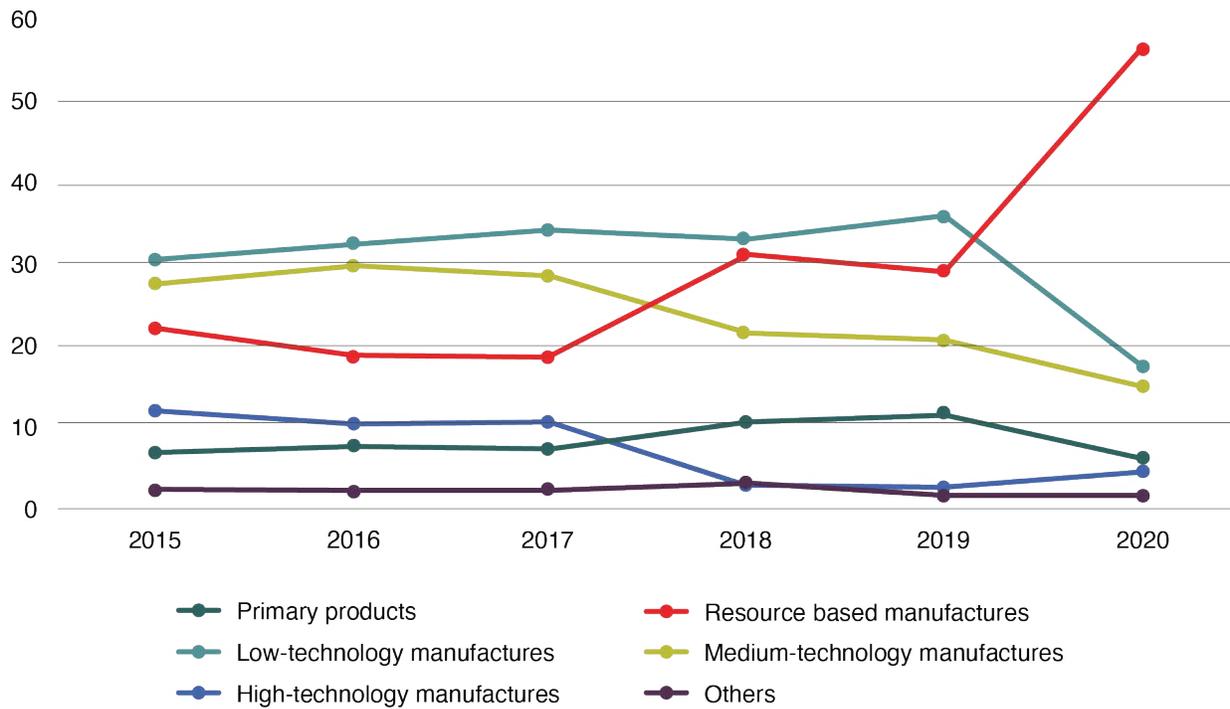
Source: Suk-jin Kim. 2020. Achievements, Limits, and Prospects of North Korea's Science and Technology Policy. KDI Review of North Korean Economy. 2020. 3

There are around 350 universities in the DPRK with 300,000 students.¹⁰ In contrast, there were approximately 340 universities and 2.6 million students in South Korea in 2020. Therefore, the DPRK has fewer students per university than the South does.¹¹ The DPRK is moving towards reinforcing education in engineering schools, which seems to be part of an agenda to automate economic activities. A computer science college was founded in 1999 within Kim Il-sung University, and information technology and machinery and technology colleges within Kim Chaek University of Technology. Kim Il-sung University admits 300 students every year and the total number of students amounts to around 1,500. Kim Chaek University of Technology has around 1,000. The number of students appears inadequate to promote the digitalization of the North Korean economy.

What can be done to improve the level of technology in the DPRK? As in any other least-developed countries, the DPRK needs to be able to introduce advanced technologies from abroad. An import-export analysis of the DPRK shows that it has been importing manufactured goods which contain a medium- and high-level of technologies. However, due to the impact of major import sanctions imposed at the end of 2017, the quantity of imports of those goods has decreased significantly. The DPRK thus finds itself extremely limited in acquiring new technologies from abroad. Exports from the DPRK show a completely different pattern as it exports goods that incorporate little technologies. The comparative advantage of DPRK thus lies in products with a low level of technologies. The relative increase in medium-technology products is attributable to a large decline in exports of low-tech products. North Korea lost opportunities to export minerals due to sanctions.

Figure 5

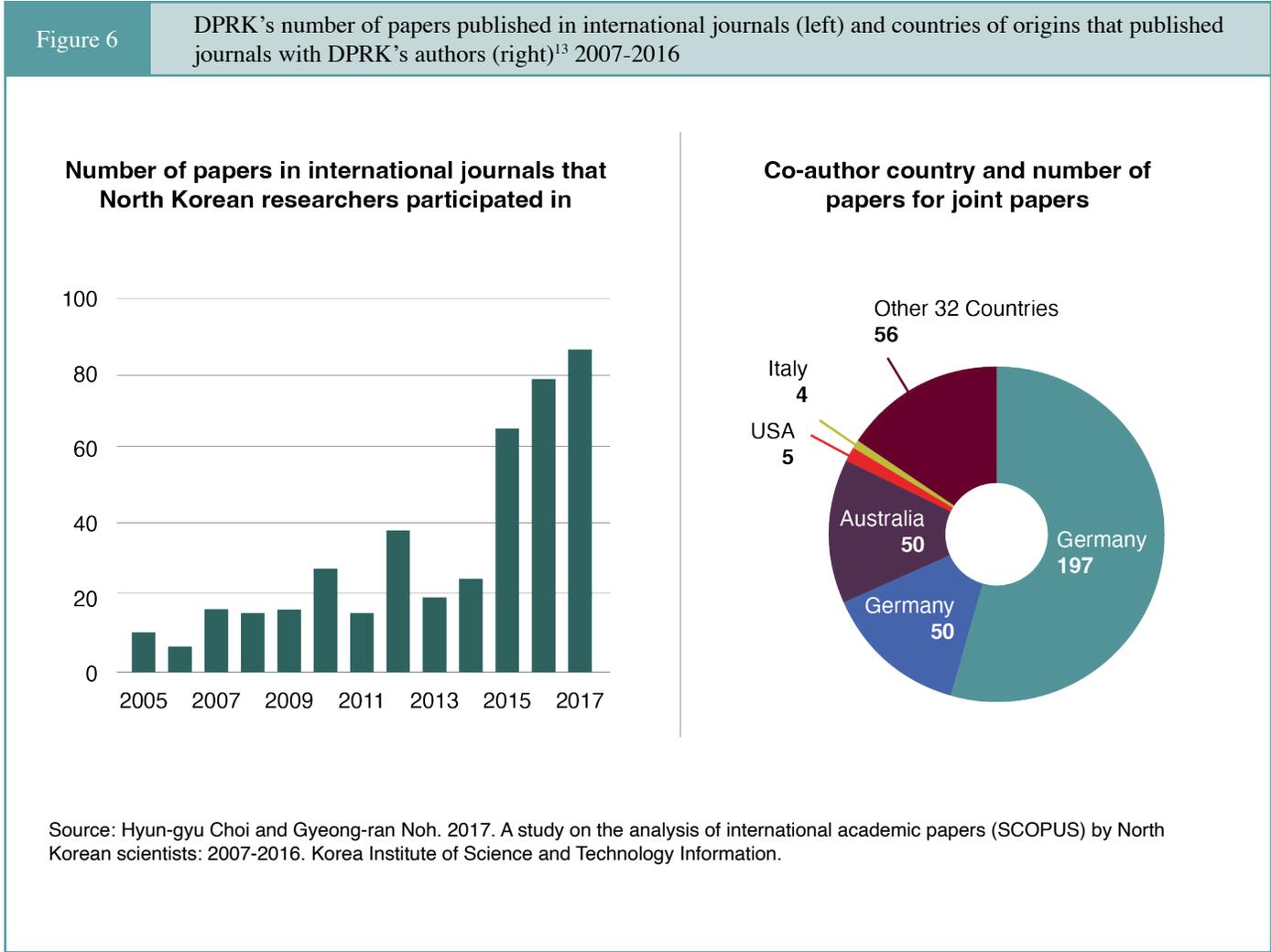
Share of DPRK's imports (up) and exports (down) by technology level



Source: Jangho Choi and Yoojeong Choi. 2021. Evaluation of DPRK-China trade in 2020: Focusing on the effect of COVID-19 on North Korean economy. KIEP World Economy Today.

In recent years, the number of articles submitted to international journals in science and technology has been increasing.¹² The Scopus Database run by Elsevier shows that there have been 549 papers submitted by the DPRK's scientists between 2007 and 2016, with the number growing at an average growth rate of 15 percent. The growth trend is much steeper after 2012 when Kim

Jong-un assumed his father's post. The most submitted field is engineering, followed by physics, mathematics, and chemistry. Those fields have been actively studied since Kim Jong-un came to power. The DPRK has been engaged with Chinese and German scholars throughout the experimentation and research based upon the outcomes registered at SCOPUS.



3. Where do advanced technologies of DPRK stand and what are the outcomes of research and development in these areas?

The DPRK is putting significant effort into the development of cutting-edge technologies in six key industries that address urgent needs, namely electricity, coal, metals, chemicals, machinery, and mining. In terms of increasing self-reliance, these areas do produce raw materials, intermediate goods, and machinery, and as such bear huge importance. The gravity of the situation surrounding the DPRK in terms of sanctions is making it difficult to import raw materials, fuel, and other intermediate goods and as a consequence those industries are becoming more crucial than ever. An exploration of targets in terms of technologies related to those industries would shed a light upon what their long-term goal would be.¹⁴

1) Power Industry

Given critical shortages of electricity, the DPRK is developing technologies to maximize the efficiency of generating power.¹⁵ In other words, the technologies would minimize the energy consumed to maximize the electricity generated by it. It is also seeking variations in energy sources. Examples of technological development are coal gasification, fuel-efficient generation technologies, and renewable energies. More specifically the DPRK is pursuing ignition technologies that use little or no oil, thereby saving significant amounts of fuel. The ignition technologies are used to boil water to operate power plants. The technology is being developed as a way to save significant amounts of petroleum used for ignition. So far, the technology to use hardly any petroleum is already introduced and it is expected to develop ignition technology without any petroleum at all.

The DPRK supplies power to areas where there is scarce supply of it by generating hydroelectric power on a tiny scale, which is intended to provide power to neighboring farmhouses and households.

Kim Jong-un has shown great interest in generating electricity through renewable sources such as sunlight, wind power, and biomass. There has been moderate success in harnessing solar energy as a source of energy, with multiple solar panels (imported from China) observed on the outside of buildings or on rooftops.

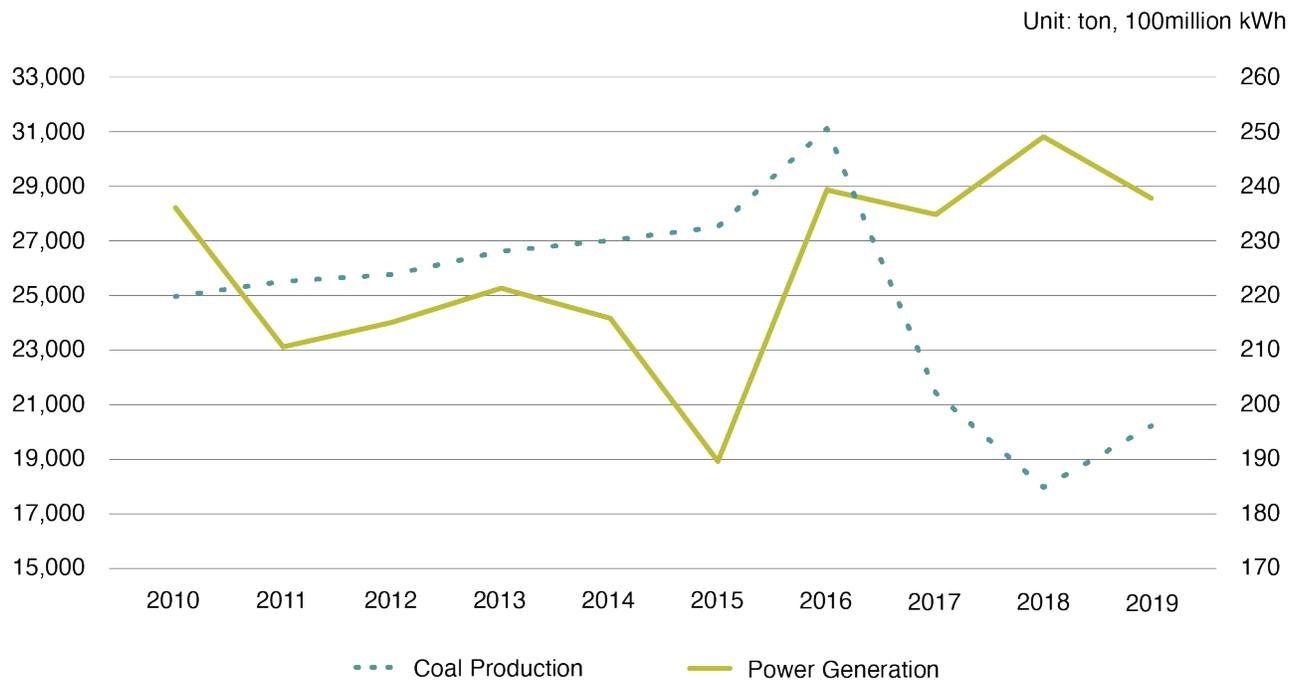
2) Coal and Mining industries

Coal is covered separately from mining industries due to the pivotal role it plays in the DPRK's economy. Coal is used as a fuel for thermoelectric power plants and steel manufacturing. However, due to recent sanctions imposed, it is extremely difficult to import intermediate goods as well as other components and machinery, which forces the DPRK further in its reliance on domestic coal. Two of the challenges that the DPRK faces in coal industries are to develop drills and to construct new briquette plants. The Ministry of Coal Industry has its own research institution which developed a so-called "enormous drill" which can raise the advance rate by 130 percent. A new automated Sinuiju plant is reportedly built and producing such drills.

There is no statistical indicator that shows a direct result of technology development in coal production and power industries, unfortunately, and the best available indicator is the estimated output. Figure 7 indicates that power generation in 2019 exceeded that in 2011. It appears that the renovation and modernization of thermoelectric power plants have led to the increasing amount of electricity, as was publicly announced in the Rodong Sinmun. Of course, it is difficult to conclude that this figure directly means a causal relationship between technology and production. It is also demonstrated by the increase in coal production until 2016. However, it fell sharply starting in 2017 when it was hit by international sanctions.

Figure 7

Estimated DPRK power generation and coal production



Source: DPRK statistics portal. n.d. Statistics Korea. Accessed May 15, 2021. <http://kostat.go.kr/portal/eng/index.action>.

3) Metal Industries

Metal is one of the key industries in the DPRK. It is given additional weight along with electricity, coal, and railways. Metal industries comprise one of four sectors that should take priority over other sectors to normalize the DPRK's economy. It is no exaggeration to say that the DPRK regards metal industries as crucial for its economy.

During the DPRK's Arduous March in the 1990s, metal industries were on the wane and efforts to resuscitate them failed to increase their capacity. This was complemented by the import of required elements but now that is impossible due to sanctions. However, it shifted its reliance from imported goods to domestic production of raw materials, components, and machineries based upon their steel supply chains.

The DPRK is committed to producing "Juche steel," which is steel produced within the DPRK using raw materials and technologies from the North. There are two methodologies to produce steel; one is Samhwa iron production and the second is smelting reduction production.¹⁶ Neither methodology uses coke, but the DPRK is paying more attention to smelting reduction, which is much simpler and consumes less energy

than the former.¹⁷ The smelting reduction method uses oxygen heat furnaces and floating preheating oxygen heat furnaces. The former is already being used in some mills in the North and the latter is still being developed. Once it is completed, it will lift productivity significantly by reducing raw materials and fuel.

4) Chemical Industries

Chemical industries play the role of a go-between in each industry. Like metal industries, these declined during the 1990s and the DPRK tried to revive them with huge investment, but other than a few areas such as fertilizers, it had not succeeded. A distinct character of chemical industries in the DPRK is that their major fuel is anthracite, not petroleum. There is no oil supply within DPRK, so it has developed its own way to operate chemical industries with its ample anthracite, including the production of composite materials and the development of technologies to liquefy coal.

The biggest chemical project the DPRK is pursuing is the "Carbon Hana (One) Chemical Industry." It was identified at the 7th Party Congress in 2016 as a priority project. The "Carbon Hana Chemical Industry" uses a process in which one single carbon

(C) is used as the base to create organic compounds that possess more than two Cs, such as methanol, ethylene, and propylene. It can go one step further and generate complex compounds such as synthetic oil, resins and rubber.¹⁸ If this project is successfully spread throughout the country, coal can replace crude oil, which would be highly beneficial for the DPRK.

5) Machine Industries

Machine industries within the DPRK have contributed to the construction of major plants and the modernization of infrastructure whose significance has been highlighted since 1953. As such, they have been one of the successful groups of industries among the heavy and chemical industries. One of the noteworthy technology developments is computerized numerical control machine tools, whose operations are controlled by computers, and their distribution. Machine tools that require high accuracy must be made with the CNC machine tools.¹⁹ Automation technology that is closely related to CNC machine tools is facilitating the automation of the industrial sector.

The development and distribution of CNC machine tools was first launched in Kim Jong-il's era and came to fruition in his son's time. Kim Jong-un stressed the modernization and automation of every manufacturing process realized by automatic control technology, a by-product of CNC machine tool, but little progress has been made.

Machine industries are playing a crucial role in switching every product to local sources, and in so doing, modernizing production equipment and facilities. This process of localization is critical during the times when there is no chance of importing machinery due to sanctions against DPRK.

6) Information Technology (IT)

The DPRK is far behind in terms of technology in the Information Technology (IT) sector, but it is trying to follow global standards at its own pace. The investment in IT industries began in the 1980s and IT industries were reinforced by policies starting from the 1990s.²⁰ The software protection law and software industries law were enacted in the 2000s and other related laws have been implemented as well. The DPRK developed its operating system and produced IT machineries using their own technologies.

The DPRK recently coined the term "Suja economy," which basically means "digital economy," and showed great interest in strategies to develop it and follow world trends in this sector. North Korea has decided to expand the number of university

students in cutting-edge science and technology, such as artificial intelligence, big data, and boundary science in order to encourage the development of advanced technologies.²¹ There is no concrete information on how many people are engaged in software industries but it is estimated that there are approximately 20,000 workers, of whom only 1,000 are believed to be skilled workers.²² The DPRK has been exhibiting its capability of developing software by beating other competitors at the World Computer Go Championships. Moreover, software that the DPRK developed such as character and facial recognition which harness AI technology are reported to be of a high quality.²³

However, in terms of the infrastructure that supports IT technology, it is estimated that the DPRK is far behind South Korean technology in its backbone network and mobile networks. The North established the "Pyongyang Optic Fiber Communications Cable Factory" in the early 1990s with the support of the United Nations Development Programme and began constructing an optical fiber cable network. The 2.5 Gbps optical fiber cable network was constructed to connect major cities within DPRK and is harnessed to access "Gwangmyeonmang," the intranet of the DPRK, and for mobile communication.

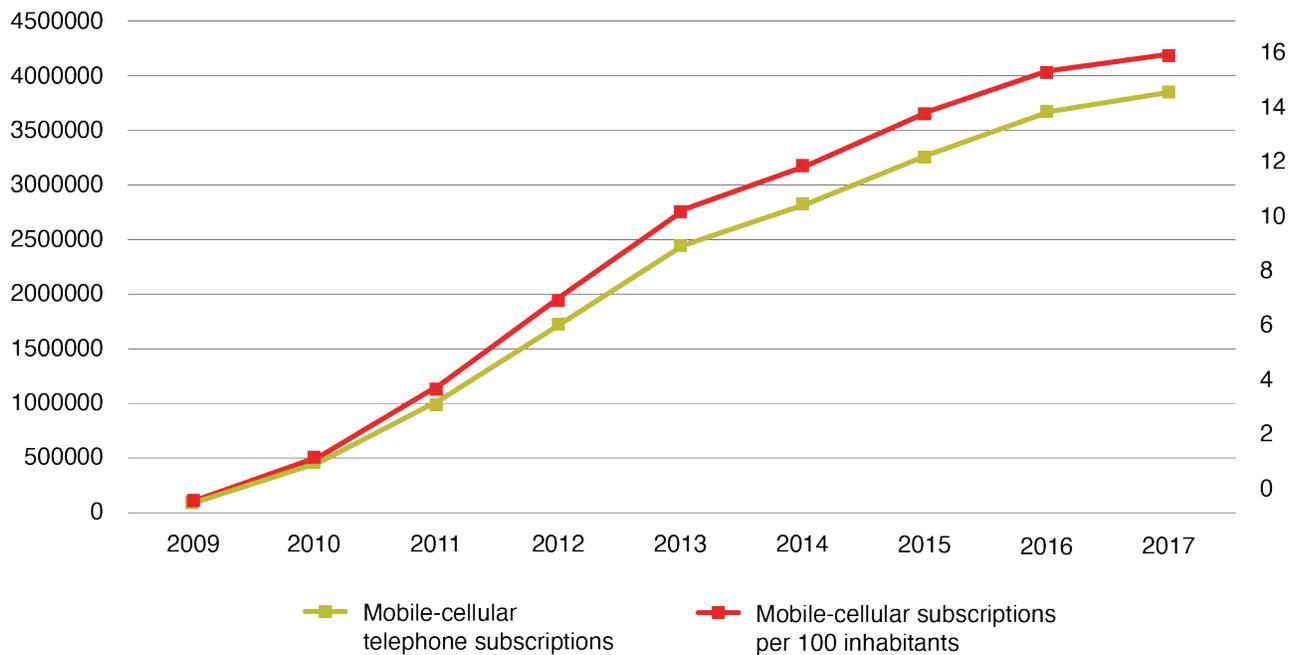
In the early 2000s, the DPRK introduced GSM technology which was widely used in Europe to provide 2G communication. Orascom, the Egyptian communication provider, introduced WCDMA, a 3G mobile communication network, in 2008. Fourteen cities, including Pyongyang, are evaluated as being able to maintain quality mobile communications to some extent. Mobile communication is possible in about 94 percent of North Korea's major residential areas.

The number of people with access to mobile phones has increased since 2009. By 2017, 3.8 million people in the DPRK (15 percent of the total population) were estimated to possess mobile phones.²⁴ It turns out 46 percent of a survey of defectors from the North identified themselves as owners of mobile phones while still in the North, and 21 percent of them had first-hand experience from borrowing one. Therefore, 67 percent of respondents had a chance to use mobile phones at least once.²⁵ Despite the small population owning a mobile phone, the survey of defectors thus suggests that a larger share of the population had some experience of using mobile phones.

The DPRK does not produce mobile phones but relies on original equipment manufacturing (OEM) using companies in China or purchasing components to assemble them within

Figure 8

Mobile-cellular subscriptions (2009-2017)



Source: ITU statistics Country ICT Data

the DPRK. The phones, however, use software based on an Android operating system used in North Korea. The DPRK does recognize trademarks and therefore their smart phones are branded as “Pyongyang,” “Arirang,” “Jindalae,” and “Blue Sky.”

Sales of smart phones are increasing, along with mobile service.²⁶ North Koreans access “Gwangmyeongmang” (the internal intranet) to trade commodities using applications such as “Manmoolsang,” “Okryu,” and “Shilly.” Such applications are believed to enable people to order delivery food, clothes, shoes, and other consumer products. “Woolim” is a mobile payment application that allows them to pay electronically. Even though the DPRK is well known for its reclusiveness, censorship, and security checks, there are signs of a digital economy at an early stage.

It is also known that the DPRK is expanding its remote education and medical treatment to address the issue of a specialized training workforce that is not only scarce, but also skewed toward certain regions. With remote education, a large number of students can be educated with a small number of educators, so the regionalization of educators is not a problem. The Supreme Peoples’ Assembly in April 2021 enacted a law regarding remote education so that field workers at plants, enterprises, and farms can gain access to college education online. Later, Kim Il-sung University and Kim Chaek University of Technology established new faculties that cover remote education, which is becoming firmly rooted starting from enterprises in Pyongyang. The remote medical system is also expanding, allowing doctors to make their diagnosis remotely based on images. There is a huge gap between Pyongyang and the other cities in the DPRK in terms of medical technology and services. The remote medical system allows doctors in Pyongyang and in rural areas to communicate with each other to diagnose patients if there is network available.

4. Conclusion: Prospect of Advanced Technologies of DPRK

There is clearly a limit to what the DPRK can do to overcome international isolation and to pursue a self-reliant development strategy based on frontier technologies. The ultimate reason for the slow technological development in North Korea lies in the historical path it has chosen. Aside from this, the obstacles to North Korea's technological development are summarized as follows. First, it is extremely difficult to import any of the components necessary to develop its technology due to international sanctions. The external situation has limited the DPRK's access to technological developments overseas and impeded its ability to acquire new technologies, particularly since the tightening of sanctions in 2016. Second, there is a lack of human capital engaged in science and technology. The DPRK is grooming its own scientists, but they are not even close to world-class level. Additionally, they lack diversity in terms of education as they heavily rely upon Russia and China. Third, they do not have sufficient infrastructure to develop new science and technology, nor do they have full access to the internet and information.

The key objective of technological development in North Korea is the survival of the nation. Kim Jong-un acknowledged in the 8th Party Congress that despite the termination of the Five-Year-Plan, little has been achieved in almost every sector. He indicated that North Korea is suffering from economic difficulties, and one of the reasons is that science and technology are not promoting economic development. With its self-criticism in mind, the leadership of the North proposed a new Five-Year-Plan which emphasized maintaining the current state of the economy, rather than on making it grow. It would transform its economic structure to significantly reduce dependency on natural resources and build a strategy to find alternatives to imports to muddle through sanctions.

However, the outlook for North Korea's technological development is not bright. There are certain constraints, as identified earlier, and there is little chance for them to improve the current situation. The DPRK has shown progress in a few areas, but as other countries are showing a remarkable progress, the technological gap continues to widen. Besides, as their success is limited to certain areas, not every sector has been developed equally, such as replacing oil with coal. The essential elements of a growth strategy, i.e., semiconductors and cutting-edge IT technologies, have not yet even been attempted by the DPRK. Given the current state of North Korea, it will remain isolated for the time being, with little hope of rapid economic development.

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¹ Technology and Innovation Report 2021, UNCTAD. Their market shares across the globe are estimated at \$350 billion in 2018 and are expected to grow to more than \$3.2 trillion in 2025.

² CIA World Factbook. Accessed February 6, 2021.

³ Refers to Sooho Lim. 2008. Coexistence of planned economies and markets. SERI

⁴ This pictures the prototype of the North Korean economy. Evidence is also observed that the autonomy of economic agents has significantly expanded due to North Korea's decentralization policy. However, when it comes to technological development, it is safe to assume that private sector's engagement with the program is highly limited, as mobilizing human capital and other materials is nearly impossible.

⁵ Hak-moon Byun. 2020. North Korea's head-on breakthrough and science and technology. KDI Review of North Korean Economy. 2020. 3

⁶ "While pursuing a socialist economic system in North Korea, fostering new advanced technologies and industrial development would surmount the current economic difficulties swiftly and with superior quality," 단번도약론 North Korean Knowledge Dictionary, Ministry of Unification. Accessed April 5, 2021. https://nkinfo.unikorea.go.kr/nkp/term/viewNkKnwldgDicary.do?pageIndex=1&dicaryId=64&menuId=NK_KNWLDG_DICARY.

⁷ Eunjin Park. 2017. North Korea's Science and Technology Policy and Progress by Major Industry. KDB North Korea Development 2017 Winter

⁸ Hak-moon Byun. 2020. North Korea's head-on breakthrough and science and technology. KDI Review of North Korean Economy. 2020. 3

⁹ It is estimated that approximately 30,000 researchers are affiliated with State Academy of Sciences, according to this research. Lee, Kim and Nam (2016). Choon-geun Lee, Jong-seon Kim and Dalri Nam 2016. Current Status of S&T Human Resources in North Korea and Future Cooperation. STEPI Research Report 2016-17

¹⁰ Choon-geun Lee, Jong-seon Kim and Dalri Nam 2016. Current Status of S&T Human Resources in North Korea and Future Cooperation. STEPI Research Report 2016-17

¹¹ It is natural for North Korea to have fewer average students per university as it does not believe in scale efficiency as in other socialist countries. Choon-geun Lee and Kye-soo Kim. 2001. The National R&D System S&T Human Resources Training System in North Korea. STEPI Research Report

¹² Hyun-gyu Choi and Gyeong-ran Noh. 2017. A study on the analysis of international academic papers (SCOPUS) by North Korean scientists: 2007-2016. Korea Institute of Science and Technology Information.

- ¹³ This is the ratio of countries of the first authors between 2007 and 2016 that include North Koreans as co-authors.
- ¹⁴ Note that the development of ICBM and SLBM, which North Korea uses for military security, is also an advanced technology, but little is known about its specific status. Therefore, this paper does not deal with technology development in the military field. In addition, digital currency such as bitcoin hacking technology is also an advanced technology that North Korea uses to acquire foreign currency. However, this paper does not describe North Korea's hacking techniques because little is known about this field either.
- ¹⁵ The Bank of Korea estimated that the amount of power that was generated in South Korea in 2019 was 563 billion kWh, whereas that of North Korea in the same year was 23.8 billion kWh which is 4.2 percent of that of South.
- ¹⁶ The DPRK developed "Samhwachul" technology and used it to manufacture steel out of anthracite instead of coke that is widely used elsewhere in furnaces for steel production since the 1970s. Coke is a vital component when manufacturing steel but as the DPRK possesses none in its land, it must rely on imports.
- ¹⁷ Soho Lim, Moonsoo YANG, and Jungkyun Rhee. 2017. An Analysis of Operation Mechanism of Foreign Exchange Acquisition Project in North Korea: Focuses the Mineral Sector (anthracite, iron ore). Korea Institute for International Economic Policy.
- ¹⁸ Kukki-heon, "A quick commentary on 'Carbon Hana Chemical Industry', the core of North Korea's self-reliance," Yonhap News, September 20, 2003, (<https://www.yna.co.kr/view/AKR20200902128400888>).
- ¹⁹ North Korean Science and Technology, "Start of North Korean CNC Technology," KISTEP Knowledge Base Service, https://www.k2base.re.kr/north/tech/pds12ANDpds13/view.do?recordCountPerPage=10&pageUnit=10&pageSize=10&pageIndex=5&nttId=5481&nttId2=71253&menuNo=&viewType=pds13&schScale=IN2_TITLE%2FCONTENT%2FFILE&searchCont.
- ²⁰ Korea Development Bank (2015). Korea Development Bank. 2015. Analysis of the technology level of the IT industry in North Korea and plans for inter-Korean cooperation.
- ²¹ Rodong Newspaper, "Digital economy with great development potential," October 2, 2019.
- ²² The labor force engaged in software development and education in DPRK. See: https://spri.kr/posts/view/22602?code=industry_trend.
- ²³ It is alleged that DPRK is clandestinely selling the facial recognition and fingerprint verification technologies abroad according to James Martin Center for Nonproliferation Studies. See: Sasha Ingber, "North Korea is Selling Facial Recognition Technology, Report Finds," NPR, May 16, 2018, <https://www.npr.org/sections/thetwo-way/2018/05/16/611729732/north-korea-is-selling-facial-recognition-technology-report-finds>.
- ²⁴ "North Korean mobile phones, the number of units supplied, and the number of users should be classified," VOA, January 28, 2019, <https://www.voakorea.com/korea/korea-politics/4761619>.
- ²⁵ "6 out of 10 North Korean defectors 'Use cell phones in North Korea'. Half of them owned the phones that they used," BBC, June 19, 2019, <https://www.bbc.com/korean/48687288>.
- ²⁶ KB Financial Group Research Center (2019). KB Financial Group Research Center. 2019. North Korean mobile payment application. ("북한의 모바일 결제어플: <울림 1.0>")