Science and Technology Trends
Blockchain Industries, Regulations and Policy

An Analysis and Diagnosis of the Korean Blockchain Ecosystem

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1. Introduction

The core values of the 4th Industrial Revolution lie in hyper-connectivity and superintelligence. Today, Blockchain is being highlighted as the core foundational technology that is expected to take a leading role in the 4th Industrial Revolution, as it not only is a core technology of hyper-connectivity, but also strengthens superintelligence. In 2016, more than half of the global experts and business executives who participated in the World Economic Forum predicted that blockchain-based platforms will account for about 10% of global GDP by 2025. Also in the same year, global experts at the World Knowledge Forum forecasted that blockchain, when commercialized, will not only result in a reduction of financial transaction costs, but also play an irreplaceable role in platforms of various sectors. In light of this, blockchain-related institutions are currently seeking to develop platforms using various means, such as establishing partnerships with fintech and IT enterprises, or through investments. Significantly, the institutions are currently undergoing service development and demonstration projects in various fields of industry through convergence with ICT. Governments and central agencies of key countries are establishing policies at the national level and announcing studies to invigorate blockchain technology. Since 2018, the Korean government has expanded its investment into blockchain R&D by allocating new funds, and is conducting a thorough review on the legislation and regulations that may be hindering the invigoration of blockchain.

Blockchain is a distributed ledger technology through which all participants in the network can verify, record and store transaction information. In other words, all records and management authorities are recorded and managed through a P2P network in blocks[1], without having to go through trusted agent institutions. Blocks with new transaction information are inter-connected every 10 minutes, and information in the blockchain is practically impossible to forge or falsify, as the blocks are validated every time they are newly connected.

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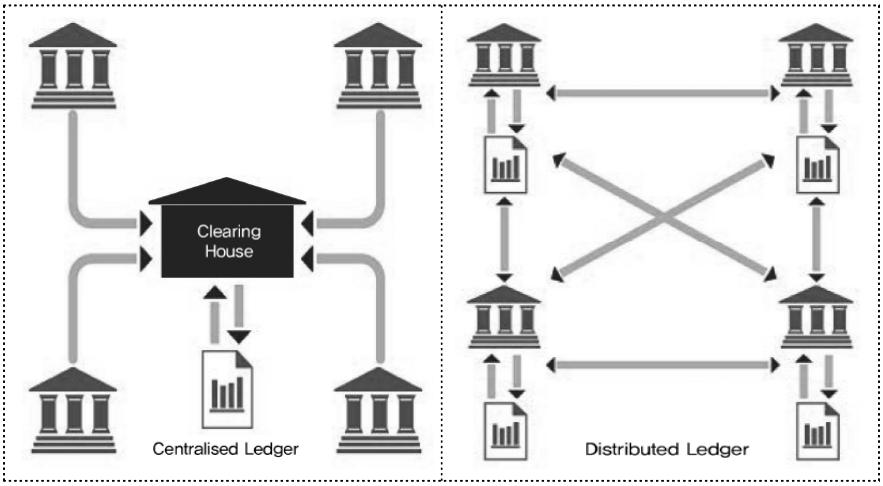
1) Block: A sequentially interconnected packet of data which stores content such as transaction records, or content encrypted in forms of letters or digits



* Source: Application of Blockchain in Financial Industry and Policy Tasks (Suh et al, 2017)

Thanks to these attributes, blockchain is rapidly spreading into not only the financial but also other sectors, promoting the actualization of the 4th Industrial Revolution.

Benefits of the adoption of blockchain include reduced transaction cost, safe and convenient utilization of data, and autonomous cooperation between IoT devices. First, blockchain allows agents of the economy such as the individual or the corporation to engage in transactions without having to rely on trusted third-party agents such as the government or public administrations. Also, the blockchain enables data to be stored safely thanks to the difficulty in forgery or falsification, and to be shared conveniently through access configuration. Based on smart contracts, another technology that is becoming popular in Korea, blockchain supports real-time autonomous cooperation among IoT devices without human intervention. Blockchain will bring changes to the overall industrial ecosystem, and is expected to create immense economic ripple effects and new industrial innovations in terms of productivity enhancement, competitiveness and effectiveness.

Table 1. Examples of Future Blockchain-based Services

Type	Examples	Description
Reduced Transaction Cost	Blockchain-based Logistics Service	All documents regarding containers such as logistics contracts or shipping are shared using blockchain technology to reduce management costs
Utilization of Data	Blockchain-based Genome Data Distribution	Safe sharing of sensitive genome data with research institutions using blockchain
Autonomous Cooperation Among IoT Devices	P2P Electricity Trading among neighbors	Real-time matching and automatic electricity trade between prosumers and consumers through blockchain based electricity trading platform

*Source: Blockchain Technology Development Strategy (Ministry of Science and ICT, 2018)

Table 2. Characteristics and Applications of the Blockchain by Generation

Type	[Introductory Stage] 1st Generation (2009~2014)	[Proliferation Stage] 2nd Generation (2015~Now)	[Maturing Stage] 3rd Generation (Future)
Main Characteristics	Virtual Currency Assets Transaction	Smart Contract (Automatization of Business) Decentralized Application	Expandability Interoperability Among Blockchains Supporting IoT
Representative Cases	Bitcoin	Ethereum Hyperledger	Various platforms being developed

*Source: Blockchain Technology Development Strategy (Ministry of Science and ICT, 2018)

2. Current Status of Blockchain Technology Development and Application in Korea

2.1. Blockchain Paradigm

While in its early stages of development blockchain technology was used as a means of payment, it is now expected to become recognized as a foundational technology leading the innovation of industry and society by overcoming technological limitations and being applied in various transactions and contracts.

Blockchain technology's development and application can be broadly broken down into three stages, each with their own technological characteristics.

The 1st generation (2009-2014) refers to the period when over 1,600 types of virtual currencies using blockchain entered the market, shortly after the emergence of Bitcoin in 2009 based on the sharing of a distributed ledger. The main attributes of the 2nd generation blockchain (2015~now) are the emergence of smart contracts which allow automatic fulfillment of contracts based on predetermined conditions, and private blockchain which can be used by enterprises in certain tasks. And so the application of the technology is spreading in various fields, such as sharing of electronic documents and e-commerce. But for blockchain technology to enter other industries, the issue of expandability and interoperability should be dealt with. With the advent of the "3rd generation blockchain" the government is actively engaging in the proliferation of blockchain technology by supporting the development of core technologies and actualization of the platform and announcing plans to establish a performance assessment system, to assist Korean enterprises in developing competitive blockchain platforms. Through these supportive measures being pursued by the government, blockchain technology is expected to overcome the existing centralized structure and be applied in various fields which require trust, including public services, contracts and verification (Ministry of Science and ICT, 2018).

2.2 Fields and Cases of Application of Blockchain Technology

Blockchain technology is currently being used on transactions and payments, contracts, information recording, and platforms. In the field of transactions and payments, the technology is being used in e-commerce, overseas remittance, deferred payment and microfinance, thanks to the advantages it offers in terms of cost reduction and higher transaction effectiveness by enabling transactions without the need to go through agents or trusted organizations. In the field of contracts, it is also being used in content copyright usage-related contracts and transaction protection services, allowing transaction

assurance and conclusion of a contract at the same time by inputting a program into transaction data. For information recording, blockchain is being used in public services, medical information management, supply chain management and copyright protection services thanks to the stronger information security and reliability the technology enables. Finally, in terms of platforms, the technology is being used for data protection security and sharing through linkage with IoT platforms. In Korea, blockchain technology is actively used in transactions and payments, information recording, and platforms.

2.2.1 Transaction and Payment

As blockchain transactions take place without having to go through agents or trusted institutions, transaction cost is reduced and efficiency is enhanced, which has led to its active adoption in transaction and payment industries. In particular, cases of investment in the technology and alliance with fin-tech startups are rapidly increasing, with major banks at the center. For example, KB Kookmin Bank established a non-face-to-face identification storage system (2016.4), while KB Kookmin Card adopted a convenient personal authentication system using blockchain technology, becoming the first Korean financial company to adopt the technology (2016.8). Shinhan Bank initiated a cooperative project with 'Streami,' a foreign exchange remittance service developer (2016.7), and launched 'Shinhan Gold Assurance Service'in August 2016, issuing proof of purchase and warranty when gold transactions were made based on blockchain technology. NH Nonghyup Bank mounted a FIDO (Fast Identity Online) based biometric verification solution which can replace the existing public certificate system on its financial platform (2016.8), and in October of the same year, the bank widened its application to on-line services by combining blockchain technology with original fingerprint certification to enhance protection. In June 2015, KEB Hana Bank collaborated with fintech enterprises including Sentbe through the bank's fintech startup incubation center '1Q Lab' to establish a blockchain-based overseas remittance service, and conducted a project on domestic deferred payment and authentication, for which technological verification was completed (2016.11). Woori Bank cooperated with US remittance company 'MoneyGram' to launch a service in February 2017 that allows 24H overseas remittance to more than 200 countries around the world. The Industrial Bank of Korea commenced the development of a blockchain-based financial service in March 2016 by working in cooperation with 'Korbit,' a fintech company, and concluded an MOU on mutual cooperation four months later with 'BitPesa,' a Kenyan Bitcoin-related startup which provides a Bitcoin transfer service between Europe and Africa. In September 2016, Korea Exchange cooperated with 'Blocko,' a blockchain-specialist company, to develop 'KSM (KRX Startup Market) System' for over-the-counter trading, and joined 'Hyperledger,' a global cooperative organization focused on the development of blockchain technology on April 2017 (Min, 2018).

The application of blockchain in fields other than the financial sector has also been increasing. First, Nowon-gu District Office developed a blockchain platform on which 'No-Won,' an exclusive virtual district currency, can be used, to enhance the usability and invigorate the usage of the currency. The currency is provided as compensation to individuals or organizations engaging in volunteer work, donations or recycling of resources. No-won can be used as fiat money in 122 affiliates (21 public affiliates and 101 private affiliates) through scanning a QR code with a mobile app or using a card, and also can be traded (or given as a gift) between users.

Next, the Korea Electric Power Corporation established its 'power trading platform' which

matches ideal prosumers and consumers in real-time to enable prosumers[2] to sell self-generated power to neighbors with high electricity demand, with the corporation serving as the middleman. The transaction is made using 'energy points,' which can be used to pay electricity bills, reimbursed for cash, or used at electric vehicle charging stations.

Kyobo Life Insurance Co. currently provides an automated actual medical expense reimbursement system which simplifies the insurance claiming process to minimize renunciations of insurance claims by policyholders. Through the system, the entire process from claiming to provision is recorded on the blockchain, and the policyholder reimbursement process is automatically carried out once the medical expenses are paid by the policyholders. That is, the claim is automatically submitted to the company when the policyholder notifies the hospital that he/she wishes to file an automatic claim, and selects medical records to send to the insurance company using a smartphone application. The pilot system was launched in December 2016 at three hospitals in the metropolitan area for certain policyholders of Kyobo Life Insurance, and will be expanded to medium and large hospitals around the country in the near future (Moon, 2018).

2.2.2 Information Recording

Blockchain technology is also used in various fields of information recording to enhance the effectiveness of information use, thanks to its stronger information security and reliability. Several countries are currently using blockchain technology in public service areas such as electronic citizenship issuance, real estate records, voting and public data records based on security and reliability. The technology is also used in the medical sector to collect medical data of patients, verify and share health records in real time, and improve the protection of medical data. Other blockchain technology applications include distributed database-based data sharing, copyright protection of artworks distributed on-line, and safe messenger services which use encrypted keys to deliver messages, audio and images.

Recently, KT developed a 'Blockchain-based Next-generation Electronic Document Management System'to meet domestic demand for an electronic document storage system (2017.11). 'KT Blockchain' can store any data of any enterprise regardless of its size or format, and is parallelized in real-time to allow high-speed encryption.

A significant change in the public administration services sector brought about by blockchain is the application of the technology to electronic voting. Several local administrations in Gyeonggi-do have sought to adopt a blockchain-based electronic voting system to increase referendum turnout and better reflect the opinions of the majority in policymaking. In February 2017, a blockchain-based electronic voting method was used in the public contest for helpful suggestions for the administration, in which residents from 815 communities participated (Jang, 2017). Also, Korea Securities Depository is currently developing a PoC[3] electronic voting system to assure stockholder convenience and prevent forgery and falsification of data during the drafting and registration of stockholder lists or the exercise of stockholder voting rights (Moon, 2018).

In the logistics sector, SK C&C developed a 'blockchain logistics service' for domestic and overseas shipping companies in May 2017. In contrast to the conventional method in which all logistics data are recorded and stored in central

2) Electricity Prosumer: Someone who produces electricity through solar generation panels installed on rooftops of houses or stores

3) PoC (Proof of Concept): A small project carried out to resolve technological uncertainties prior to adopting technologies which did not exist in the market before.

servers, the blockchain logistics service allows for shared data management by all parties concerned including shipowners, land carriers and consignors through the P2P network. Not only the locations of containers, but also management information such as temperature or humidity are automatically collected and shared to all parties concerned in real time, while blocking any possibility of intervention. The system helps maintain the content of the data and reduces the burden of having to verify and re-register the cargo when the means of shipping is changed from land to sea or vice versa, and therefore is expected to enhance the efficiency of logistics-related works, resulting in shorter time consumption and cost reduction (Kim, 2018).

2.2.3 Platform

Blockchain technology is widely used through linkage with platforms of various sectors. Korea Electrical Safety Corporation developed a blockchain-based electrical fire ignition point analysis system which utilizes data acquired from the IoT platform to identify the source of fire in disputes among landlords, insurance companies and tenants (2017.11). Through the system, information on the occurrence of arcs, which are flames or sparks that occur on wiring due to electrical discharge, is generated by sensors installed on panel boards of each floor of the building and recorded on the blockchain every five minutes. Through the mechanism, objective evidence required to identify the cause of a fire is collected. The Korea Electrical Safety Corporation formed a consortium with other companies including SK Telecom to launch pilot projects in 10 locations including buildings, traditional markets, temples and cattle sheds, and is planning to expand the project all over the country.

The medical sector is currently developing a data management platform and app service through which personal medical information can be filed into digital documents and be recorded, saved and shared. Today, medical records of patients are handwritten or stored and managed by individual hospitals, and therefore are prone to tampering, and cause inconveniences and unnecessary medical expense. However, once the system is launched, a doctor can record medical information of patients, which will automatically be encrypted and saved on the blockchain platform, giving access and right to sell the record only to the patient through decryption keys. Also, a smartphone app will be launched to enable the patient to manage his/her medical information him/herself. In August 2018, MEDIBLOC published a teaser page on YakOlLim, a service which allows patients to own and manage prescription information, and is conducting beta test (Han, 2018).

In the energy sector, blockchain is used as a ledger which records the credit (virtual currency) provided as a compensation for energy conservation by collecting data on usage conditions such as temperature, humidity, illuminance and percentage of occupants, and on power consumption, to calculate the estimated conservation and actual conservation. This platform may also prove to be helpful in not only enhancing existing carbon mileage projects conducted by local administrations, but also carbon credit trading. The amount of energy conserved for a month or a year, and calculation of earnings is shared transparently and in real time on the platform, allowing the user to check his/her performance and give feedback accordingly. Currently, Australia is testing power trading using blockchain, and the U.K. and Germany are also providing a blockchain-based electricity and gas usage management system. The Korean government also announced plans to replace 5% of the maximum power consumption with negawatt by 2030. E-GenPartners, a Korean company, was selected as the developer for ‘blockchain-based energy service platform for small buildings’ as a part of the integrated convergent security product development project launched by

Korea Internet & Security Agency (KISA) (Woo, 2018). Once the development is completed, blockchain-based information trade will be enabled, allowing anyone to produce and sell energy.

3. Policy Trends and Limitations of the Blockchain in Korea

3.1. Policy Trends of Blockchain in Korea

Korean blockchain companies are still in the course of confirming the technological feasibility of their projects, and have not yet made their way into the market. This may seem reasonable, considering that the technology itself is still in its early stages of development, and that those currently in the race for platform development are restricted to developer groups such as the Ethereum foundation, specialized companies, and multinational corporations. But if Korean companies are to gain technological competence and dominate the global market, the government should be responsive and provide strategies for the formation of the blockchain ecosystem.

The Ministry of Science and ICT recently announced the 'Blockchain Technology Development Strategy' (2018.6) to establish early markets and support private-led growth of the technology by securing global competence, in order to facilitate the development of blockchain, the core technology of the 4th Industrial Revolution.

The strategy aims to promote the adoption of blockchain in public sector areas to bring efficiency to public services and attract private investment, through which the early blockchain market will be formed. To this end, beginning in 2019 the government will select up to two pilot projects with significant effects in terms of simplification of work process or cost reduction, and provide multiple-year funding to commercialize the services. Also, private-led nationwide projects to build public awareness of the utility of the blockchain technology will be initiated. The government aims to discover projects which can strengthen the blockchain utilization capacity of the private and public sector, draw out the demand for blockchains throughout the industry, and significantly reduce unnecessary social costs. Blockchain technology will be applied in 8 leading industries of innovation including intelligent hyperconnection, smart factories, smart farms, fintech, newly developed energy, smart cities, drones and futuristic vehicles, on a preferential basis, to kickstart private-led innovation.

To gain technological competitiveness in the global market, the Korean government will assist domestic enterprises in self-developing competitive blockchain platforms by supporting the development of core technologies and the actualization of the platforms, and establish a performance assessment framework. Currently, Korea's blockchain development capacity is about 2.4 years behind the US. The government aims to reduce this gap and achieve 90% of the total output produced by the country with the most advanced technological capacities by providing a technological development roadmap and updating it every year. In detail, the government plans to adopt a competitive approach - that is, to have several companies compete in a project for two years, after which the final candidate for the project will be selected - in its support for the development of blockchain platforms in each sector, including finance, logistics and the medical industry. The government will also establish a 'blockchain technology support center' and provide a reliability assessment service and testbed to strengthen the competitiveness of private enterprises.

Table 2. Key Contents of Blockchain Reliability and Performance Assessment

Type	Main Contents
Verification of Elementary Technologies	○ Works to verify elementary technologies essential for the realization of blockchain - (Consensus Algorithm) Reviews malicious node tolerance and performance of consensus algorithms such as PoW or PoS - (Encryption Technology) Reviews conformance of encryption technology applied to blockchain * Applies latest encryption technologies including homomorphic encryption, multi-signature, secure multiparty computation and zero-knowledge protocol
Evaluation of Blockchain Platform	○ Conducts assessment on the reliability of blockchain platform to assure public administrations and private enterprises that it is safe to adopt and utilize the technology - Observes the relationship between the reliability attributes by selectively applying the attributes in regard to the type and domain of the blockchain platform * China conducted demonstrative evaluations on the reliability of blockchain, led by the China Academy of Information and Communications Technology (CAICT) (2017.6~2017.9)
Decentralized App Testing	○ Tests the reliability and quality of DApp and identifies risks of realization of Smart contracts that are applied in DApp * IBM announced that 94.6% of tested Ethereum-based smart contracts were found to be vulnerable (2018.2)

*Source: Blockchain Technology Development Strategy (Ministry of Science and ICT, 2018)

Standardization activities will also be reinforced to help Korea take the lead in the global blockchain market. The standardization of blockchain is still in its early stages, and is currently being led by ISO·ITU-T (Official Standardization) and W3C·IEEE (De Facto Standardization). Korea is also currently operating a specialized committee under the National Radio Research Agency and Korea ITU Committee to manage matters related to ISO·ITU-T, and is planning to upgrade its blockchain standardization roadmap and link it with the R&D roadmap to utilize the outcome as a long-term plan for achieving global leadership in the early stage of the industry's development. The government is also planning to expand support for expert actions regarding official standardization, de facto standardization and consortium standardization, and to promote national-level standardization to facilitate consultation among stakeholders and secure inter-compatibility in adopting blockchain in major sectors.

Finally, the government is planning to promote the development of a professional workforce, incubate specialized companies and make improvements to the legal framework to establish the basis for the invigoration of the industry. The government will begin by fostering a professional workforce of 10,000 to meet the demands of the industry, and expedite the establishment of the blockchain ecosystem by providing start-up assistance, increasing investment and making institutional reforms until 2022. Beginning next year, 1,000 blockchain professionals will be educated at a facility where details on blockchain technology and services are taught and discussions take place. As well, blockchain research centers will be established at universities and will receive KRW 800 million in funding every year for up to six years to foster master and doctoral level blockchain experts. Special lectures and curricula on blockchain

will be provided at KAIST and GIST, the two national institutes on science and technology, and on-line open access lectures will be provided for students and office workers who wish to learn about the technology. A cloud-based blockchain platform service (BaaS)[4] will be provided to foster specialized companies with competitiveness in the global market and to expand the number of blockchain companies from 30 to 100 by 2022. In the area of legal reforms, a 'Regulatory Reform Panel' will be launched to identify regulations and institutions that are hurdles to the development of blockchain technology and services and to make changes, and blockchain technology will be added to the list of technologies for which R&D expenses can be used as tax credits (Ministry of Science and ICT, 2018).

3.2. Limitations of Blockchain

As mentioned above, blockchain is a technology through which all participants connected through a network jointly verify, record and store transaction data. The application of the technology ensures integrity and reliability, as transaction records cannot be forged or falsified without having to go through official third parties such as Korea Financial Telecommunications & Clearings Institute or Korea Securities Depository. In particular, blockchains based on a distributed network infrastructure using security technologies such as hash, digital signature and encryption allow the actualization of various application services. As a result, services using blockchain technology are emerging not only in the financial sector but also in diverse other industries such as distribution, logistics and the medical industry. In particular, pilot services are beginning to emerge in real estate contracts, food distribution records, and import/export documents with the help of smart contracts.

However, the distributed ledger technology, one of the most distinct and strongest features of blockchain, may in fact serve as a problem. Since transaction records cannot be modified, those with access can freely observe the records at any time, resulting in unregulated transfers and financing which may potentially cause problems. Also, experts note that the technology may act as a burden to middleware, database, security, analysis and the financial sector, as transactions are continuously recorded onto the peer-to-peer (P2P) transaction agent platform. This means that for the blockchain technology to be applied in various fields and used in a stable manner, perfecting the technology is more crucial than making improvements on the administrative side, such as by enhancing the related legal framework.

In its prenatal stages, it is expected that the blockchain technology will require more time to be actualized as stable services in the industrial field. In fact, the first actual applications and pilot projects only took place 2-3 years ago. And due to the immaturity of the technology, various problems occur during its application. For instance, if a user uploads images as a part of a transaction record, data usage may rapidly increase and cause a network overload, and the costs required may also skyrocket as bigger data have to be copied to each node.

Another significant issue is the security; while data in blockchains are known to be practically impossible to forge or falsify as all information distributed throughout the P2P network is recorded and managed in units of Blocks without having to grant any middlemen the recording and storage authority. However, the emergence of supercomputers has overturned the existing information security system, as they were found to be able to break the distributed ledger algorithm. While it takes up to eight months for more than

4) BaaS (Blockchain as a Service): Service which provides a cloud-based distributed virtual network to test the blockchain service development environment

1,600 high performance computers connected in parallel to factorize a 129-digit number, experts argue that with a quantum computer it only takes a few hours, and thus blockchains can also be penetrated in a short amount of time. At a recent workshop, a professor at Chongqing University in China claimed that the destruction of the blockchain will pose a great threat to the security of all internet and applications based on hierarchical systems using public keys, and that new encryption systems using quantum computers should be adopted to ensure the security of the network space.

As blockchain is a core technology with great applicability in various sectors, there are also many tasks and issues to resolve. As suggested above, development should be focused on perfecting the technology, while at the same time administrative issues such as legislations should also be resolved in line with the speed of technological development. A good example would be the existing Korean laws and regulations on networks for commercial use; they were mainly established based on a centralized computer environment. As regulations such as the Electronic Financial Transaction Act or Regulations on the Supervision of Electronic Financial Transaction were devised based on a centralized computing environment, it is difficult to apply these regulations to the blockchain.

4. Conclusion

A swift response to the evolving paradigm and changing environment of blockchain is crucial for the stable invigoration and proliferation of blockchain technology. In this article, applications of the technology in sectors including transaction and payment, contracts, information recording and platforms were observed. In the early stages of blockchain, various service models for transaction and payment were developed, with the financial sector at the center. And as the technological development was invigorated and relevant policies were established in several countries, the technology found its way into industries other than the financial sector. In particular, technologies and service models required for the application of blockchain technology in the information recording sector such as electronic voting and logistics information management have been developed in earnest. Furthermore, platforms on which service models could be mounted were being developed, with several being in the pilot project stages.

However, domestic blockchain businesses still remained at the stages of confirmation and verification of technological potential, and were still far from actual market expansion. Recently, the Korean government announced strategies to establish the basis for the invigoration of the industry by securing technological competence through means such as forming early markets, supporting the self-development of blockchain platforms and establishing a performance evaluation system, and fostering professionals and specialized enterprises. The Korean government's initiative is expected to trigger efforts to strengthen the blockchain competency of the Korean market and narrow the gap with leading countries. However, to take a step further in order to hold technological dominance in the global market and prepare for preemptive responses, it is necessary to focus on current key issues such as data authentication process efficiency or stronger protection against quantum computing. Needs in the area of technological enhancement should be clearly defined, and a staged approach for problem-solving should take place. Active responses should be pursued by the Blockchain Technology Support Center, which was proposed by the government, informed by a swift understanding of the technological, administrative and legal issues of each applicable sector. Korean experts in the field predict that commercialization of the technology will take place in earnest beginning

in 2020, and for this reason the government should actively work to develop its response to the fast-changing global market.

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