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A Study on the Competitiveness for the Diffusion of Smart Technology of Construction Industry in the Era of 4th Industrial Revolution

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Abstract: The fourth industrial revolution (4IR) is bringing about enormous changes in various aspects of the construction industry. This influence is emerging as a smart technology and is regarded as a productivity innovation in the construction industry. In addition, several countries are attempting policies to diffuse technological innovation into various industries, such as those related to legal systems, investments, and additional markets. These policies commonly have the intention to encourage various industrial factors that are related to smart-construction competitiveness. Therefore, this study analyzed the competitiveness from an industrial perspective to revitalize smart technologies in the construction industry. For this purpose, the acceptance of innovation within the Korean construction industry (KCI) was reviewed through diffusion-innovation theory, and then competitiveness factors were driven by the literature, based on Porter's diamond model. Factors are measured by the contractors who utilize smart technologies, analyzing the competitiveness priority and differences between them. The main finding is that the "Demand Condition" is the most important industrial competitiveness for embedding smart technology in the early stage of construction industry. Moreover, to reduce the risks related to developing technologies, it suggested that distinct policies are required in accordance with the contractors. These findings are going to be helpful for policy makers as references for developing policies to embed smart technology in the construction industry.

Keywords: smart technology; industrial competitiveness; diffusion of innovation; contract type



Citation: Lee, B.; Park, S.-K. A Study on the Competitiveness for the Diffusion of Smart Technology of Construction Industry in the Era of 4th Industrial Revolution. *Sustainability* **2022**, *14*, 8348. <https://doi.org/10.3390/su14148348>

Academic Editor: Antonio Caggiano

Received: 26 May 2022

Accepted: 6 July 2022

Published: 7 July 2022

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1. Introduction

1.1. Fourth Industrial Revolution and Construction Industry

The fourth industrial revolution (4IR) emerged as a major issue at the 2016 World Economic Forum in Davos. Countries are trying to implementing various policies from a preemptive point of view to respond to the fourth industrial revolution. In the UK, the "Construction 2025" strategy aims to reduce construction period by 50% through research and development in digital design, cutting-edge materials, and innovation in new technologies, reducing carbon emissions by 50% and reducing overall cost and life-cycle costs by 33% [1]. The German government announced its "Industry 4.0" strategy and selected nine key technologies, such as big data, self-aware robots, and simulations, as future drivers for its manufacturing industry and is pushing ahead with its evolutionary strategy [2]. The Japanese government is pushing for "I-Construction" to cope with the productivity degradation caused by the expected manpower shortage of the construction industry in the future. This is a policy that utilizes new technologies such as ICT throughout the production process and aims to improve the productivity of the construction industry by 2025 [3]. The Chinese government has announced its "China Manufacturing 2025" strategy, which focuses on 10 key areas such as IT technology, digital control, and robots

through innovation, quality, and green development [4]. These policy trends are considered as a center of the key strategy for national industry development in the future.

The construction industry is also going through huge technological innovations, affected by 4IR. The construction industry generally has been considered as stuck with labor-centered construction, low-tech images, low productivity, and poor quality [5–9]. In addition, this industry tends to adapt slowly to new technologies and has conditions where it is difficult for innovation to take place [10,11]. This is a unique characteristic of the construction industry, and the challenge of innovation is applying the technology used in other industries to the construction industry [12,13]. Meanwhile, 4IR is able to create an opportunity for the construction industry to bring a much higher efficiency than ever before in terms of productivity, the business model, and the value chain. This opportunity is possible, via a convergence between existing technologies and emerging technologies from 4IR, and this change is called Construction 4.0 [13–15]. In the 4IR trend, Construction 4.0 represents a change in the construction industry, ranging from automated construction in the construction phase to high-level digitization by connecting virtual space and real construction projects [14,15]. The innovative technologies arising from the transition to Construction 4.0 are also called smart technologies [12,16], which improve the productivity, safety, and quality of the construction project [11,17–20]. Therefore, technological innovation leads to improvements in various project outcomes and is a key factor that greatly affects the development of the construction industry [21,22].

1.2. Necessity of Industry Competitiveness

Smart technology located in the center of technological innovation can change the paradigm of productivity in the construction industry, so construction firms are trying to utilize smart technology. In order to expand smart technology into the construction industry as a whole, the various factors of the industry must be corresponding with the acceptance condition of technology. The construction industry as public contracting work is more sensitive to government policy than other industries. The economic stimulation policies based on the construction industry have led to an increase in the volume and budget of construction projects, which affects the economic stimulus in the construction market and the impact of related industries. In addition, there are various stakeholders that comprise the construction industry. In particular, smart technology has unique characteristics in which the source technology of various industries is applied to construction technology in the project phases [15,23]. Source technologies such as sensors, drones, IoTs, and robots are developed in the electronics, telecommunications, and machinery industries, but these technologies are used in various ways in the construction industry for aircraft surveys, as safety sensors, and in robotics construction. Moreover, since the performance of the project is affected by various structured aspects such as systems, contracts, regulations, etc., institutional perspectives should also be considered for technical innovation in the construction industry [24–27]. As set out in the above, an industrial approach needs to consider a wide range of aspects, from the introduction of smart technology by companies to government policies. Therefore, this paper aims to study the industrial competitiveness of the expansion of smart technology in the construction industry.

As a specific research method, firstly, the review of the smart-technology status in the Korean construction industry (KCI) was conducted from the perspective of the recipient based on the theory of innovation diffusion. Secondly, Porter's diamond model was adopted as a framework to study industrial competitiveness, and an importance–performance analysis (IPA) matrix was used to analyze competitiveness priorities. In particular, the analytic hierarchy process (AHP) was also conducted to calculate competitiveness weights in order to considering the national trait. Finally, *t*-test analysis was conducted to derive differences in competitiveness and perception of smart technologies by the contractors.

2. Research Background

2.1. The Diffusion of Innovation

In order to consider the industrial competitiveness, the current status of a country regarding the acceptance of innovation needs to be understood. This is because industrial competitiveness changes dynamically due to the country's efforts for improving competitive [28]. In this regard, the national background for technology innovation needs to be understood about the innovation diffusion of users in the construction industry as well as the country's policy activities. In other words, experts dealing with technology have to be considered as innovation adopters and national policies relating to smart technology have to be reviewed in detail.

The diffusion of innovation theory (DIT) describes the process of accepting and adopting innovation, regarding the innovation of novelty felt by the acceptor, and has been studied in a wide variety of fields [29–33]. Rogers first proposed the theory of diffusion of innovation in 1962, which has evolved into a five-step study of the property of innovation and an acceptor perspective on innovation [34]. In particular, the innovation-acceptance curve is able to classify innovation adopters and indicates the size of a group varies depending on the period since innovation was introduced. It is significant in that it has shifted primarily from a conceptual study of the property and diffusion process of innovation to an acceptor perspective that accepts innovation over time [34]. The innovation-acceptance curve is described in five stages over time from the perspective of the acceptor who accepts the innovation (Figure 1). First, innovators are aggressive in innovation, adventurous, and willing to actively embrace uncertainty. Second, early adopters form a decisive cluster of large groups as innovations spread, which has a significant impact on innovation as groups discuss prior to adoption. Third, the early majority refers to layers in which innovations are accepted and adopted before they spread and reach their average values. Fourth, the majority is cautious and passive, showing a tendency to adopt innovation after it reaches an average point. Fifth, non-innovators are very unlikely to adopt innovation because they are negative about it and tend to choose to be very secure. From the perspective of accepting innovation, the innovation-acceptance curve shows that sales of innovative products are distributed with a bell-shaped curve when an innovation is released to the market. This curve separates the process of settling in the market from the time when an innovative technology appears in the market, which makes it easy to understand the current state of the industry where innovative technology is being introduced. Therefore, this paper studies the current status of the introduction of smart technology in the KCI through the innovation-acceptance curve.

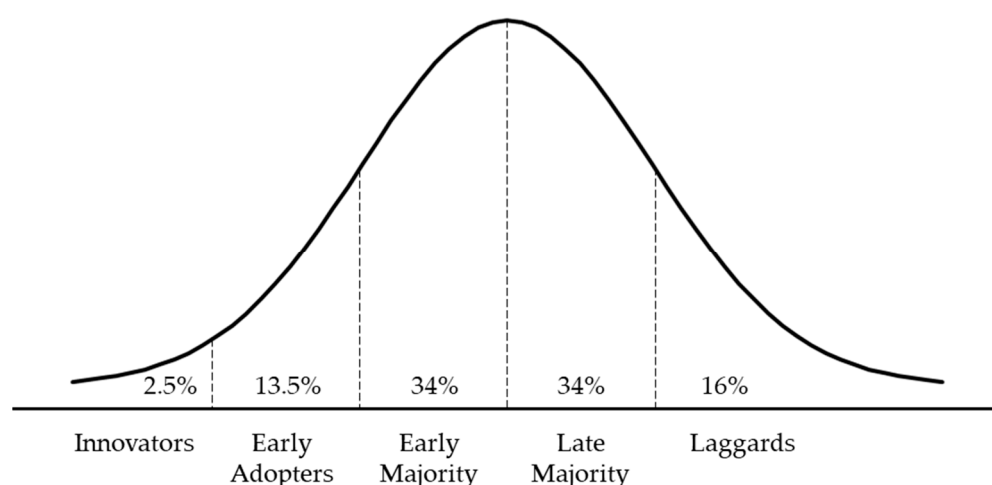


Figure 1. Adopter categorization on the basis of innovativeness.

2.2. Policy in Korean Construction Industry

The Korean government announced the “4th Industrial Revolution Response Strategy” in 2017 to respond to 4IR. Korea’s Ministry of Land, Infrastructure and Transport announced the “6th Construction Technology Promotion Framework Plan” at the end of 2017 to reflect the fourth industrial revolution and respond to government policy directions. Since then, with the announcement of the “Smart Construction Technology Roadmap” as a detailed action plan, for the basic plan, the KCI has begun to move toward smart technology in earnest (Table 1). This roadmap is in the early stages of introducing technologies that develop other technologies, and has been conducting pilot tests from 2020 while establishing short-term goals to establish a foundation for using smart technologies by 2025. It also aims to complete automation of the construction industry by 2030 from a long-term perspective.

Table 1. Smart technology policy in KCI.

| Smart Technology Policies | Governments | Date | Policy Goals |
|---|----------------|----------------|---|
| 4th Industrial Revolution Response Strategy [35] | A ¹ | April 2017 | Four goals are presented, such as smart land, transportation service industry innovation, public infrastructure safety efficiency improvement, and innovation foundation. |
| 4th Industrial Revolution Response Plan I-KOREA [36] | B ² | November 2017 | Challenges are promoted by securing technology for growth engines, creating industrial infrastructure/ecosystems, and responding to changes in future society. |
| 6th Construction Technology Promotion Framework Plan [37] | A | December 2017 | It will present “Smart Construction 2025”, which is applied by BIM and AI as its vision by 2025. |
| Construction Industry Innovation Plan [38] | A | June 2018 | Presentation of innovation measures on four themes, such as technology, production structure, market order, and jobs. |
| Smart Construction Technology Roadmap [39] | A | October 2018 | A roadmap is presented to specify the tasks implemented in the “6th Construction Technology Promotion Framework Plan”. |
| Construction Engineering Development Plan [40] | C ³ | September 2020 | Proposal of paradigm shift and smart-construction engineering promotion and development centered on high value-added construction engineering. |

¹ A = the Ministry of Land, Infrastructure and Transport, ² B = the 4th Industrial Revolution Committee,

³ C = joint government departments.

In order to understand the current status of smart technology spreading in the KCI, an interview with an expert was conducted on policies and the status of government policies. According to the interview, a few major firms were using smart technologies, but construction firms outside the top five in revenue were only aware of smart technologies. A common situation in the small number of major firms utilizing technology is that they are building independent teams to have smart-technology expertise, because they have expectations for business performance despite uncertainties related to the verification of smart technology. It started as a separate task-force team and operated within the firm as a project-support team. A common opinion of most construction firms is that they do not utilize smart technology, as they were collecting technical information by surveying the market situation from a risk-avoidance perspective, along with having doubts about the utility of smart technology. Although there is no separate smart-technology team, the management-support team has been collecting information or visiting sites utilizing technology.

Despite the government’s activation policy, the status of the KCI is one of restrictively using smart technology. A few major firms were organizing their own teams to spread technical information to project departments and to provide guidance on technology utilization, and they were exploring construction sites for finding smart-technology needs. However, most construction firms have observed, rather than actively accepted, smart technology and have avoided the potential risks of unfamiliar technology. Firms utilizing smart technologies were less than 1% of the whole number of construction firms, ones that could handle the potential risks, had formed a special organization within the firm, and had tried to use technologies on their construction sites. Thus, considering the circumstances of the policies and firms, KCI was considered as having a few innovators that led to smart-

technology application in the early stages of technology introduction, which implies that it is important to be expanding smart technology to the construction industry as a whole.

2.3. Industry Competitiveness

The theory of industrial competitiveness was largely classified as a theory of national competitiveness, and various theories have emerged over time. In the 1930s, American economists developed the structural–conduct–performance (SCP) model to understand the causal relationship between the environment, behavior, and performance of a company, in an attempt to eliminate factors that hinder competition in the industry. Starting with this, research on competitiveness from an industry perspective has continued to develop [41]. Based on the SCP model, the most influential model presented as an analysis of the corporate perspective is the five-forces framework, developed by Michael Porter [42]. However, the model is limited in that it does not describe specific competitive strategies between companies, because it describes the industrial structure as a static analytic component of changes in industrial trends. Therefore, the proposed model to overcome these limitations is the diamond model [43].

The diamond model explains that a country's competitiveness is due to environmental conditions, including the characteristics of the industry. These environmental conditions have Factor Condition, Demand Condition, Firm Strategy, Structure and Rivalry, and Related and Supporting Industry as endogenous variables, and Governance and Chance as exogenous variables [28]. For each factor, the endogenous and exogenous variables are divided as follows. Factor Condition represents everything in the human, technological, resource, and supply chain that is fundamental to production. It is divided into basic elements such as natural resources, workers, and advanced elements such as technology. Demand Condition refers to the presence of local and important consumers under market conditions that facilitate the continuous research on and development of products and businesses. In general, market size and demand can be viewed as related factors. Firm Strategy, Structure, and Rivalry derive the overall structure and strategy in which an enterprise is created, organized, and operated in a country, indicating the extent to which it can continue to gain a competitive advantage. Related and Supporting Industry indicates the presence of internationally competing related industries or support industries. These industries support target industries or competitiveness and make production activities work well. Government affects national competitiveness externally through the role of regulations on trade, industrial competition, etc., and Chance can be an unexpected opportunity for related industries through events such as war, climate change, and social events. Porter suggested that the diamond model consists of these endogenous and exogenous variables, which affect each other, and endogenous elements are influenced by exogenous variables.

The diamond model can effectively analyze the competitiveness of industries [44], and a lot of research applying this model has been conducted in various industries, including the construction industry [45–51]. As such, the model provides a good framework for analyzing the concept of competitiveness at the national level and provides directions for presenting elements that diagnose the competitiveness of the industry [47]. Therefore, this study intends to derive and analyze the industrial competitiveness of smart technology in the construction industry by utilizing the diamond model.

2.4. Construction-Contract Type

The construction project has a sequential production system from planning to maintenance, and it is implemented by contractual relationships between firms. As such, the contract serves to bind some stakeholders into a community for pursuing success of the project, so the starting point of the project begins with a contract. In particular, contracts have a significant impact on the performance of the construction project, and numerous studies have been undertaken regarding contracts from the past to the present [27,52–56]. Smart technology, which is in the spotlight for technological innovation, is also usually being used in construction projects via this contractual relationship. It is common for

contractors to improve their technical capabilities through in-house or outsourced management strategies, especially for construction firms that carry out projects by utilizing resources such as equipment, manpower, and building technology [57–62]. These strategies are traditional methods to ameliorate the organizational and technological capabilities of an enterprise [62–64]. In the initial introduction phase of smart technologies, construction firms tend to decide management strategies that apply smart technologies developed in accordance with their projects through contractual relationships, rather than developing their own technologies. This contractual relationship generates a difference between the supplier and the user in terms of the business view [65,66]. Therefore, it might be possible to divide such relationships into suppliers and users in terms of using smart technology in construction projects, resulting in differences in perception. According to the interview with the expert, a general contractor is normally focused on facilitating project management by utilizing technology as a consumer of smart technology. Contrastively, subcontractors tend to focus on business profits from contracts and operations to supply technology to other various businesses rather than project performance. Therefore, the following hypothesis was established in view of the difference in competitiveness and recognition required to activate smart technologies from the perspective of these contractual relationships.

Hypothesis a1: *The priority competitiveness and perception of smart technology in the construction industry do not differ depending on the contractual relationship of companies.*

Hypothesis a2: *The priority competitiveness and perception of smart technology in the construction industry do differ depending on the contractual relationship of companies.*

Hypothesis b1: *The advanced competitiveness and perception of smart technology in the construction industry do not differ depending on the contractual relationship of companies.*

Hypothesis b2: *The advanced competitiveness and perception of smart technology in the construction industry do differ depending on the contractual relationship of companies.*

3. Methodology

3.1. Smart Technology Competitiveness Derivation

Based on Porter's diamond model, classification was conducted according to the characteristics of smart technology in the construction industry, and the 25 measurement factors about competitiveness of smart technology were derived based on this. The factors were considered by reviewing the role of the 4IR in the construction industry and in research papers related to smart technology or industrial competitiveness. In order to derive these factors, the first discussion proceeded with general contractors utilizing smart technology and with development firms. As a result, the main feedback is that the candidate factors are not able to cover the whole industrial perspective. Thus, 15 industrial statistics were added to supplement the measurement factor as a competitive edge from an industrial perspective, and these factors matched the competitiveness of the diamond model. In order to examine whether the final, derived 40 factors are suitable as a competitive concept, a secondary consultation proceeded with experts in the industry and academia. This consultation was focused mainly on suitability, identification of factor levels, the ambiguous definition, and representation of the industrial competitiveness of smart technology. After revising the factors, a total of 40 smart technology competitive factors have been identified (Table 2).

Table 2. Competitiveness elements of smart construction industry.

| Competitiveness | Category | Num | Measurement Factors | Reference | Type |
|---------------------------------------|------------------------------|-----|--|---------------------|----------------|
| Factor Condition | Value of labor | 1 | Appropriateness of compensation for manpower using smart technology | [8,48,62,67] | A ¹ |
| | | 2 | Labor market | [44,64] | B ² |
| | Technical Professionals | 3 | Current status of manpower for developing source technology related to smart construction | [21,62] | A |
| | | 4 | Current status of experts who are available to use smart technology in the construction site | [8,47,48,62,68] | A |
| | | 5 | Employment-inducement coefficient in the construction industry | [69] | B |
| | Production Inducement | 6 | Wage-worker-inducement coefficient in the construction industry | [69] | B |
| | | 7 | Forward-linkage effect in the construction industry | [48,70] | B |
| | | 8 | Backward-linkage effect in the construction industry | [48,70] | B |
| | | 9 | Value added inducement coefficients in the construction industry | [71] | B |
| Firm Strategy, Structure, and Rivalry | Level of Technical Education | 10 | Ability to utilize smart technology for working-level staff of general contractors and subcontractors | [8,15,72] | A |
| | | 11 | Active competition for smart-technology development among companies | [72] | A |
| | | 12 | Level of technology compared to overseas smart technology | [47,48,67] | A |
| | Smart-Technology Culture | 13 | Maturity of communication using smart technology in the construction site | [8,15] | A |
| | | 14 | Establishment of management strategy for smart technology | [47,73] | A |
| | | 15 | Enabling in-house or outsourced management to enhance technical capability | [15,73] | A |
| | | 16 | Price competitiveness of smart technology | [47,72] | A |
| | | 17 | Uncertainty avoidance | [63,74] | B |
| Related and Supporting Industry | Vertical Industry | 18 | Growth potential of the safety and service industry | [11,67] | A |
| | | 19 | Technological level of the smart-technology-related industry | [47,48,67] | A |
| | | 20 | ICT adoption | [75] | B |
| | | 21 | Forward-linkage effect of the computer, electronic, and optical industries | [47,48,70] | B |
| | | 22 | Forward-linkage effect of the electrical industry | [47,48,70] | B |
| | | 23 | Forward-linkage effect of the machine industry | [47,48,70] | B |
| | Horizontal Industry | 24 | Forward-linkage effect of the transportation industry | [47,70] | B |
| | | 25 | Investment by financial institutions for smart technology | [76] | A |
| Demand Condition | Market Demand | 26 | Demand level of smart industry such as smart city, modular housing, etc. | [47,48] | A |
| | | 27 | Public corporations' and government's demand for smart technology | [8,48] | A |
| | Market Sizes | 28 | Size of the ordering market applying for smart technology | [47,48,68] | A |
| | | 29 | Size of domestic smart-technology market compared with the global market | [77,78] | B |
| | | 30 | Construction-business survey index | [79] | B |
| Government | Institution | 31 | Level of institutional support related to smart technology | [11,63,80] | A |
| | | 32 | Institutional barriers to related industries' entry into the construction industry | [48,67] | A |
| | | 33 | R&D investment for smart technology | [47,48,62,63,73,76] | A |
| | | 34 | Government's financial support related to smart technology such as incentive, pilot cost | [67,70,80] | A |
| | | 35 | Government's education-support level related to smart technology | [73,80] | A |
| | | 36 | Transparency of government-policy decisions | [48,62,67,68,75] | B |
| Chance | External Factors | 37 | Activation of the interchange of smart technology among companies | [47,62] | A |
| | | 38 | Status of entry overseas projects applying smart technology | [68] | A |
| | | 39 | Expansion of the size of the smart-construction market overseas | [47,68,81] | A |
| | | 40 | Needs for applying smart technology for overcoming crises such as decline in population and productivity | [3,11] | A |

¹ A means the survey data, ² B means the statistical data.

3.2. Data Collection

In order to approach for industrial competitiveness point of view, it is necessary to extensively consider stakeholders relating to smart-technology industries, as well as construction companies applying smart technologies in construction projects. Therefore, survey candidates were selected such as general contractors who currently use smart technology in construction sites, subcontractors who are developing and delivering smart technologies, owners who order construction projects including smart technologies, and researchers who study smart technologies. The measurement method of competitiveness was applied to the Likert five-point scale, and the measurement criteria were set as level and importance, to analyze the difference in the competitiveness. In order to increase the response rate and conduct an appropriate measurement through a clear understanding, the intention, purpose, and competitiveness factors of this research were sufficiently explained to 282 survey candidates over the phone. The distribution and collection of questionnaires (Appendix A) were conducted through email. The collected data basically reflect the Korean construction industry in 2020, in terms of smart-technology-introduction stage, and the survey period is from August to October 2020. The questionnaires were distributed to 193 out of 282 people who were contacted for understanding the research purposes. The candidate's contacts were tried three times because of the low response rate. As a result, a total of 131 questionnaires were collected, and the response rate was 67%.

Statistical indicators factors were converted respectively into a Likert five-point scale in consideration of the characteristics of statistical data. For example, in the case of "Forward Linkage effect in construction industry", an industrial statistical indicator released annually by the Bank of Korea, the index score is announced by classifying dozens of Korean industries. To convert this, it was ranked in descending order for each industry and calculated using linear interpolation based on five points. The other factors were converted in the same way to measure the level of competitiveness. Measurement of the importance of industrial statistical indicators was conducted simultaneously during the expert survey. Likewise, linear interpolation was used to convert the average value for measuring the importance of competitiveness into a Likert five-point scale. Hence, the level of competitiveness and importance of smart technology competitiveness factors was measured by examining data from expert surveys and industrial statistical indicators.

3.3. Analysis

In this study, a top-down approach was taken for systematic analysis from the industrial competitiveness of smart technology to the corresponding detailed factors. Thus, a gap analysis of industrial competitiveness was conducted, and priority and advantage factors were selected for each factor through IPA-matrix analysis.

The diamond model for competitiveness analysis has strengths in analyzing national and industrial perspectives, but it has limitations, in that it is difficult to explain differences of competitiveness, and there is no comparative criterion. Therefore, the AHP was applied to compensate for these limitations and to reflect different weights among competitiveness in accordance with national characteristics. The AHP is a decision-making technique used to systematically set and evaluate criteria when decision-making goals and criteria are diverse or complex [82]. Therefore, the AHP was applied for each of the six competitiveness of the diamond model to reflect the characteristics of the Korean construction industry as a weight. Measurements of weights for the AHP analysis were included in the survey, excluding 39 questionnaires with a consistency index of more than 10% calculated through pairwise cross-matrix calculations. In order to calculate the comprehensive weights for the 92 multiple cases to be analyzed, the weights were derived by calculating the eigenvector for each competitiveness and applying the geometrical average. The calculated weights were added to the level of competitiveness and importance, and the competitiveness and importance of smart technology were derived. For the convenience of comparative analysis

for each calculated value, the values of the final calculated measurement factors were standardized based on 100 scores.

In addition, IPA-matrix analysis was conducted to identify the priority factors for revitalizing smart technology in the construction industry from the perspective of detailed factors. It is possible to consider improving competitiveness from an efficient perspective by deriving the priority competitiveness required in the introduction stage of smart technology in the construction industry. The x-axis constituting the IPA matrix is the level of competitiveness of factors, the y-axis is the importance of factors, and the reference axis for constructing the quadrant is calculated as the geometrical mean value of each axis. The IPA matrix configured in this way can identify the priorities of competitiveness factors in each quadrant characteristic and can present strategical options for improving competitiveness in consideration of short- and long-term perspectives [83]. On the premise of the initial introduction stage of smart technology in the construction industry, in order to activate smart technologies used by only a few innovators, 2nd quadrant is classified as priority competitiveness that should be considered first, and 1st quadrant is selected as advanced competitiveness. In addition, statistical analysis was applied to priorities and advantage factors to verify the hypothesis established. Based on the contract type, a *t*-test was conducted on Priority and Advanced factors, and some factors were identified with statistically significant differences in competitiveness and importance.

4. Results

4.1. Factor Performances

Based on the diamond model applied the AHP, the competitiveness and importance of smart technology in the construction industry were analyzed as follows. As a result of the AHP, “Demand Condition” and “Government” were analyzed as the highest for the eigenvector values, while “Chance” was analyzed as the lowest value. In terms of competitiveness, “Related and Supporting Industry” and “Factor Condition” were analyzed to be the highest, while “Chance” was analyzed to be the lowest. In terms of importance, “Demand Condition” and “Government” were analyzed to be the highest, while “Chance” was analyzed to be the lowest. As a result of gap analysis for each factor, “Demand Condition” and “Government” were the lowest competitive factors compared to importance, and “Related and Supporting Industry” was the least different (Table 3).

Table 3. Smart-technology competitiveness in KCI.

| Industrial Competitiveness | Weight | Competency | Importance | Gap |
|---------------------------------------|--------|------------|------------|-------|
| Factor Condition | 15% | 46.97 | 87.11 | 40.14 |
| Firm Strategy, Structure, and Rivalry | 13% | 38.51 | 80.54 | 42.03 |
| Demand Condition | 27% | 45.55 | 99.70 | 54.15 |
| Related and Supporting Industry | 10% | 49.12 | 77.24 | 28.11 |
| Government | 22% | 38.39 | 92.29 | 53.90 |
| Chance | 9% | 37.86 | 70.83 | 32.96 |

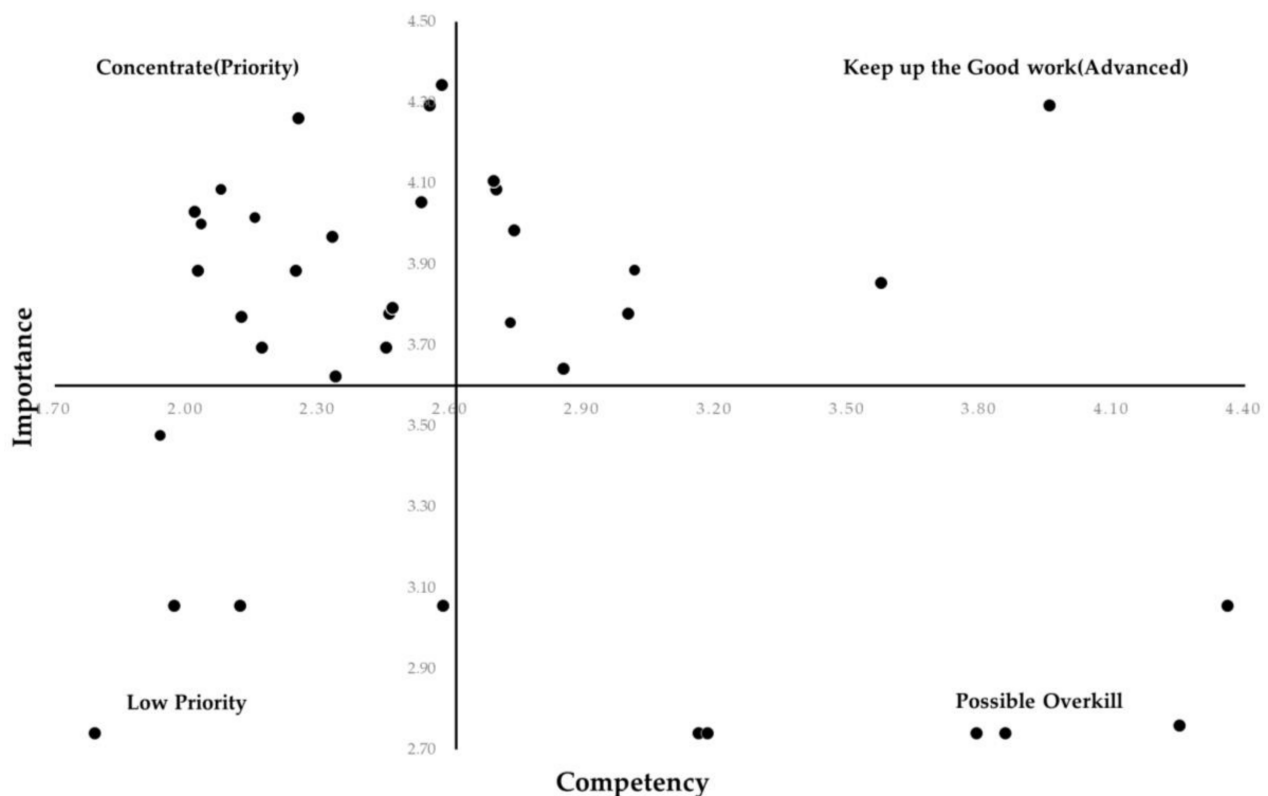
As a result of the IPA matrix, the whole average values of competency and importance were 2.61 and 3.60, respectively, and factors belonging to the second quadrant were classified into a total of 17 factors. In terms of competitiveness, all items were included, and the most included competitiveness was for “Firm Strategy, Structure and Rivalry”.

In terms of the second quadrant (Table 4 and Figure 2), the average values of competency and importance were analyzed as 2.28 and 3.95, and the gap was analyzed as 1.67. The top three factors with the biggest gap are, in order, “Application of compliance for management smart technology”, “The level of internal support relaxation to smart technology”, and “Industrial barriers to restructuring”.

Table 4. Smart technology competitiveness factors in Korean construction industry (2nd quadrant).

| Competitiveness | Factors | C ¹ | I ² | G ³ | R ⁴ |
|---------------------------------------|---|----------------|----------------|----------------|----------------|
| Factor Condition | Current status of experts who are available to use smart technology in the construction site | 2.53 | 4.05 | 1.52 | 13 |
| | Appropriateness of compensation for manpower using smart technology | 2.02 | 4.03 | 2.02 | 1 |
| | Ability to utilize smart technology for working-level staff of general contractors and subcontractors | 2.02 | 3.88 | 1.86 | 5 |
| Firm Strategy, Structure, and Rivalry | Maturity of communication using smart technology in the construction site | 2.15 | 4.02 | 1.86 | 6 |
| | Establishment of management strategy for the smart technology | 2.46 | 3.78 | 1.32 | 15 |
| | Enabling in-house or outsourced management to enhance technical capability | 2.47 | 3.79 | 1.33 | 14 |
| | Price competitiveness of smart technology | 2.33 | 3.97 | 1.64 | 10 |
| | Public corporations' and government's demand for smart technology | 2.58 | 4.34 | 1.77 | 7 |
| Demand Condition | Size of the ordering market applying smart technology | 2.03 | 4.00 | 1.97 | 4 |
| | Size of domestic smart-technology market compared with the global market | 2.55 | 4.29 | 1.74 | 8 |
| Related and Supporting Industry | Investment by financial institutions for smart technology | 2.17 | 3.69 | 1.53 | 12 |
| | The level of institutional support related to smart technology | 2.25 | 4.26 | 2.01 | 2 |
| Government | Institutional barriers to related industries' entry into the construction industry | 2.08 | 4.08 | 2.01 | 3 |
| | Government's financial support related to smart technology such as incentive and pilot cost | 2.25 | 3.88 | 1.64 | 11 |
| | Government's education support level related to smart technology | 2.12 | 3.77 | 1.65 | 9 |
| Chance | Activating interchange of smart technology among companies | 2.34 | 3.62 | 1.29 | 16 |
| | Expand the size of the smart construction market overseas | 2.45 | 3.69 | 1.24 | 17 |

¹ C = Competency; ² I = Importance; ³ G = Gap; ⁴ R = Rank.

**Figure 2.** Smart-technology-competitiveness classification in Korean construction industry.

The factors belonging to the first quadrant were classified as a total of 9 factors, and all competitiveness was included. In terms of the first quadrant (Table 5 and Figure 2), the average values of competency and importance were analyzed as 3.03 and 3.93, and the gap was analyzed as 0.90. The top three factors of the biggest gap, in order, are “R&D investment for smart technology”, “demand level of smart industry such as smart city, modular housing, etc.”, and “current status of manpower for developing source technology related to smart construction”.

Table 5. Smart technology competitiveness factors in Korea's construction industry (1st quadrant).

| Competitiveness | Factors | C ¹ | I ² | G ³ | R ⁴ |
|--------------------------------------|--|----------------|----------------|----------------|----------------|
| Factor Condition | Current status of manpower for developing source technology related to smart construction | 2.74 | 3.98 | 1.24 | 3 |
| Firm Strategy, Structure and Rivalry | Active competition for smart technology development among companies | 2.73 | 3.76 | 1.02 | 4 |
| | The level of technology compared to overseas smart technology | 3.00 | 3.78 | 0.78 | 7 |
| Demand Condition | Demand level of smart industry such as smart city, modular housing, etc. | 2.70 | 4.09 | 1.39 | 2 |
| | Construction business survey index | 3.96 | 4.29 | 0.34 | 8 |
| Related and Supporting Industry | Growth potential of the safety and service industry | 3.02 | 3.89 | 0.87 | 5 |
| | The technological level of the smart-technology-related industry | 3.57 | 3.85 | 0.28 | 9 |
| Government | R&D investment for smart technology | 2.69 | 4.11 | 1.41 | 1 |
| Chance | Needs for applying smart technology for overcoming crises such as decline in population and productivity | 2.85 | 3.64 | 0.79 | 6 |

¹ C = Competency; ² I = Importance; ³ G = Gap; ⁴ R = Rank.

The factors belonging to the third quadrant were classified into a total of 8 factors, and the rest of the competitiveness were included except for “Firm Strategy, Structure, and Rivalry” and “Demand Condition”. As for the detailed factors, “Related and Supporting Industry” was most often included as four factors. In terms of the third quadrant (Table 6 and Figure 2), the average of competency and importance were analyzed as 1.96 and 3.08, and the gap was analyzed as 1.12. The top three factors of the biggest gap were analyzed, in order, as “Forward linkage effect in the construction industry”, “Status of entry overseas projects applied smart technology”, and “Transparency of government policy design”.

Table 6. Smart technology-competitiveness factors in Korean construction industry (3rd quadrant).

| Competitiveness | Factors | C ¹ | I ² | G ³ | R ⁴ |
|---------------------------------|---|----------------|----------------|----------------|----------------|
| Factor Condition | Forward-linkage effect in the construction industry | 0.61 | 2.74 | 2.13 | 1 |
| | Value added inducement coefficients in the construction industry | 1.79 | 2.74 | 0.95 | 5 |
| Related and Supporting Industry | Forward-linkage effect of the computer, electronic and optical industries | 2.12 | 3.06 | 0.94 | 6 |
| | Forward-linkage effect of the electrical industry | 1.97 | 3.06 | 1.09 | 4 |
| | Forward linkage effect of the machine industry | 2.52 | 3.06 | 0.54 | 7 |
| | Forward-linkage effect of the transportation industry | 2.58 | 3.06 | 0.48 | 8 |
| Government Chance | Transparency of government-policy decision | 2.15 | 3.42 | 1.27 | 3 |
| | Status of entry overseas projects applying smart technology | 1.94 | 3.48 | 1.54 | 2 |

¹ C = Competency; ² I = Importance; ³ G = Gap; ⁴ R = Rank.

A total of six competitive factors in the fourth quadrant included “Factor Condition”, “Firm Strategy, Structure and Rivalry”, and “Related and Supporting Industry”. As for the detailed factors, “Factor Condition” was most often included as four factors. In terms of the fourth quadrant (Table 7 and Figure 2), the average of competency and importance were analyzed as 1.96 and 3.08, and the gap was analyzed as 1.12. The top three detailed factors showing the largest gap were analyzed, in order, as “Uncertified avoidance”, “ICT adaptation”, and “Labor market”.

Table 7. Smart technology competitiveness factors in Korean construction industry (4th quadrant).

| Competitiveness | Factors | C ¹ | I ² | G ³ | R ⁴ |
|---------------------------------------|---|----------------|----------------|----------------|----------------|
| Factor Condition | Labor market | 3.86 | 2.74 | 1.11 | 3 |
| | Employment-inducement coefficient in the construction industry | 3.79 | 2.74 | 1.05 | 4 |
| | Wage-worker-inducement coefficient in the construction industry | 3.16 | 2.74 | 0.42 | 6 |
| | Backward-linkage effect in construction industry | 3.18 | 2.74 | 0.44 | 5 |
| Firm Strategy, Structure, and Rivalry | Uncertainty avoidance | 4.36 | 3.06 | 1.30 | 1 |
| Related and Supporting Industry | ICT adoption | 3.77 | 2.80 | 0.97 | 2 |

¹ C = Competency; ² I = Importance; ³ G = Gap; ⁴ R = Rank.

4.2. Different Performances by Contracts

In terms of the second quadrant, the results of *t*-test analysis on competency and importance based on the contract type are as follows (Table 8). In the case of competency,

there was no significant difference overall. The only factor that showed statistical significance was analyzed as “Investment by financial instruments for smart technology”. In the case of importance, six factors were analyzed as statistically significant factors such as “Current status of experts who are available to use smart technology in the construction site”, “Enabling in-house or outsourced management to enhance technical capability”, “Investment by financial institutions for smart technology”, “Level of institutional support related to smart technology”, “Government’s financial support related to smart technology such as incentive and pilot cost”, and “Activating interchange of smart technology among companies”.

Table 8. Difference of priority competitiveness between general contractors and subcontractors.

| Factors | Competency | | Importance | |
|---|------------|----------|------------|-----------|
| | Mean | t-Value | Mean | t-Value |
| Current status of experts who are available to use smart technology in the construction site | 2.53 | 0.025 | 4.05 | 1.700 * |
| Appropriateness of compensation for manpower using smart technology | 2.02 | 0.211 | 4.03 | −0.748 |
| Ability to utilize smart technology for working-level staff of general contractors and subcontractors | 2.02 | −0.716 | 3.88 | 1.449 |
| Maturity of communication using smart technology in the construction site | 2.15 | −1.648 | 4.02 | 0.483 |
| Establishment of management strategy for smart technology | 2.46 | 0.291 | 3.78 | 0.454 |
| Enabling in-house or outsourcing to enhance technical capability | 2.47 | 0.801 | 3.79 | 2.288 *** |
| Price competitiveness of smart technology | 2.33 | 0.235 | 3.97 | −0.813 |
| Public corporations’ and government’s demand for smart technology | 2.58 | −0.792 | 4.34 | 1.281 |
| Demand level of smart industry such as smart city, modular housing, etc. | 2.03 | 0.247 | 4.00 | 1.228 |
| Size of domestic smart-technology market compared with the global market | 2.55 | − | 4.29 | − |
| Investment by financial institutions for smart technology | 2.17 | −2.293 * | 3.69 | 1.842 * |
| Level of institutional support related to smart technology | 2.25 | 0.568 | 4.26 | 2.155 ** |
| Institutional barriers to related industries’ entry into the construction industry | 2.08 | −0.354 | 4.08 | 1.854 |
| Government’s financial support related to smart technology such as incentive and pilot cost | 2.25 | −1.350 | 3.88 | 1.928 * |
| Government’s education-support level related to smart technology | 2.12 | 0.344 | 3.77 | 0.942 |
| Activation of the interchange of smart technology among companies | 2.34 | 0.779 | 3.62 | 2.548 ** |
| Expansion of the size of the smart-construction market overseas | 2.45 | −1.508 | 3.69 | 0.494 |

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

In terms of the first quadrant, the t -test analysis results of competency and importance based on the contract type are as follows (Table 9). In the case of competency, four factors showed statistical significance, and these factors were “Level of technology shared to overseas smart technology”, “Growth potential of the safety and service industry”, “R&D investment for smart technology” and “Applied technology”. In the case of importance, two factors, which are relatively less than competency, showed statistical significance. Factors that showed statistical differences were analyzed as “Growth potential of the safety and service industry” and “R&D investment for smart technology”.

Table 9. Difference of advanced competitiveness between general and sub-contractors.

| Factors | Competency | | Importance | |
|--|------------|------------|------------|----------|
| | Mean | t-Value | Mean | t-Value |
| Current status of manpower for developing source technology related to smart construction | 2.74 | −1.202 | 3.98 | −0.962 |
| Active competition for smart technology development among companies | 2.73 | −0.337 | 3.76 | 0.546 |
| Level of technology compared to overseas smart technology | 3.00 | −2.103 ** | 3.78 | 1.295 |
| Demand level of smart industry such as smart city, modular housing, etc. | 2.70 | −1.486 | 4.09 | 1.299 |
| Construction-business survey index | 3.96 | − | 4.29 | − |
| Growth potential of the safety and service industry | 3.02 | 1.891 * | 3.89 | −1.799 * |
| Technological level of the smart-technology-related industry | 3.57 | 0.983 | 3.85 | 1.214 |
| R&D investment for smart technology | 2.69 | −2.684 *** | 4.11 | 1.797 * |
| Needs for applying smart technology for overcoming crises such as decline in population and productivity | 2.85 | −1.691 * | 3.64 | −0.693 |

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

5. Discussion

5.1. Smart Technology Competitiveness in Industry Point of View

“Government” is an exogenous variable of the competitiveness model, and Porter (1990) argues that endogenous variables are more important than exogenous variables which cannot be controlled by companies. However, “Government” was analyzed to high importance, interestingly, and the reason is as follows. According to the policies investigated in this study, the role of the government is largely classified into the following areas. First, guidelines are presented for supporting various projects through smart-technology activation plans. These plans suggest future directions of industrial development with keywords such as technology development, creating the industrial environment, industrial response, and job creation, and there are specific plans related to this. Second, it proposes plans to support the matters that are systematically regulated for smart-technology activation. Therefore, the role of the government can promote the technological translation and development by relaxing institutional barriers and promoting entrepreneurship or by suggesting policies to encourage collaboration and start-ups between domestic and foreign companies [28,84]. In particular, “Government” competitiveness plays a role in positively affecting “Demand Condition”. The government’s policies, such as linking the project sites for R&D and pilot tests and the increasing amount of ordering, which is based on smart technology, are meeting the needs of smart-technology developers. These policies have led to rapid technological development by actively inducing technological innovation that applies new technological trends to existing technologies [76,84,85]. Therefore, “Government” as industrial competitiveness for smart technology can be considered as a key competitive aspect that plays a role in promoting vertical integration of smart-technology-related industries in the construction industry through institutional improvement.

In terms of the second quadrant, “Appropriateness of compensation for manpower using smart technology” has the largest gap among factors in “Factor Condition”. The compensation is able to motivate technical professionals [86], and this has the possibility to expand to the professionals’ competitiveness. Thus, it is implied that the competitiveness of professionals is the essential factor for activating smart technologies in the construction industry. “The level of institutional support related to smart technology” and “Institutional barriers to related industries’ entry into the construction industry” are factors related to the regulations of “Government”. The project performances were closely connected to the institution, which is able to affect various stakeholders who are considering to be involved in the construction projects [27]. However, in order to improve the legal systems, it is necessary to continuously identify regulations and verify the ripple effect on allied industries. Therefore, it is not easy to revise the system for technology diffusion in a short period, and it needs preemptive steps for responding to regulations with a long-term perception. “Expand the size of the smart construction market overseas” and “Activating interchange of smart technology among companies” are the factors of “Chance”, and the importance is lower than internal factors. These factors are belonging to the second quadrant, which means that global market and technology are as important competitiveness factors as ever. “Establishment of management strategy for the smart technology” means that construction firms need to take management innovation for using the smart technologies. Although most construction firms recognize the importance of smart construction for their project performances, they tend to avoid using smart technologies due to a large burden on technological risks. According to innovation theory, this tendency appears to most adopters, excluding minor innovators who stay within budget with proven technologies to avoid risks.

In terms of the first quadrant, “R&D investment for smart technology” is a factor of the largest gap. “Demand level of smart industry such as smart city, modular housing, etc.” is classified not only as “Demand Condition” but also as related to the government’s role in accordance with construction-industry features. This shows that the policy on 4IR for the advancement of the national industry is leading to the development of smart technologies in the construction industry. “Current status of manpower for developing source technology

related to smart construction” means that smart technology has high performance volatility depending on the user’s capability. BIM, a representative innovative technology, also has a significant impact on business performance depending on the user’s ability [76,78–88]. Thus, since smart technology has not been standardized and popularized, it suggests that it is necessary to cultivate professionals who can use smart technologies skillfully. “The level of technology compared to overseas smart technology” and “The technological level of the smart-technology-related industry” are the lower gap factors. This means that the construction industry’s smart technology is in its early stages, but the source technology industries such as IT, telecommunications, and electronics are very advanced. Therefore, it suggests that efforts to incorporate source technology into various construction projects are important for technological innovation in the construction industry. “Construction-business survey index” shows that the construction business is improving due to the government’s housing-supply policy. These policies will lead to the expansion of demand for various smart technologies according to supplying many construction sites and will have a positive effect on the spread of technologies. Therefore, it suggests that the role of the government, such as pilot projects and industrial environment creation, is important in the spread of smart technology.

5.2. Differences in Contract-Type Point of View

In terms of the second quadrant, there are importance differences of factors in accordance with contract type such as “Current status of experts who are available to use smart technology in the construction site”, “Investment by financial institutions for smart technology”, “Enabling in-house or outsourced management to enhance technical capability”, “Government’s financial support related to smart technology such as incentive and pilot cost”, and “Activating interchange of smart technology among companies”. In the case of general contractors, the purpose of technical application is to create project performance, and in particular, major firms are fully aware of the effectiveness of smart technology in the construction project. Therefore, as innovators for smart technologies, they are already attempting to accumulate related data by applying smart technologies to various construction sites and developing specialized smart technologies. Therefore, it is judged that technical ideas specialized for major businesses and support policies for pilot tests will be important for general contractors. The competency difference is only one, “Investment by financial institutions for smart technology”, which implies that subcontractors have more risk for investment in developing technologies than general contractors. Subcontractors usually have limited finances and business models, so the burden of technology-investment failure is higher than general contractors. Therefore, it suggests that institutional financial support is needed in consideration of these characteristics of SMEs.

In terms of the first quadrant, there are statistical differences factors such as “Level of technology compared to overseas smart technology”, “Growth potential of the safety and service industry”, “R&D investment for smart technology”, and “Needs for applying smart technology for overcoming crises such as decline in population and productivity”. The government’s R&D support has recently been implemented, but it is not sufficient for subcontractors. Support projects generally benefit only a small number of selected firms. Therefore, in order to spread smart technologies in the early stages, it is judged that a policy has to consider this aspect. Specific factors belonging to “Chance” also were analyzed as statistical differences, which seem to be due to different business models. General contractors usually are project managers classified as front industries, so service supply for customers is the top priority, and subcontractors usually are constructor units classified as rear industries, who react sensitively to technology-market demand. Therefore, it is judged that these differences in business models represent differences in competitiveness depending on the type of contract.

Comparing the analysis results, there are many differences in the importance of the second quadrant and in the competency of the first quadrant, depending on the contract. The large difference of importance means that the perception of smart-technology compet-

itiveness varies, and the large difference of competency means that the realistic level of capability for smart technology varies. In the construction industry, innovation should focus on understanding the value of innovation by various stakeholders [84]. Therefore, this implies that it is necessary to approach distinguished plans to enhance smart-technology competitiveness by classifying stakeholders.

6. Conclusions

Construction 4.0 is in the spotlight as a technological innovation that can solve the problem of low productivity in the construction industry. At the center of this innovation is smart technology, and many countries are trying to various efforts for developing and activating smart technology. Therefore, this study aims to examine industrial competitiveness for the revitalization of smart technology in the construction industry. Since industrial competitiveness varies depending on the structure and background of the industry, the level of smart technology in the Korean construction industry was studied based on the theory of innovation diffusion. Industrial competitiveness was derived through the literature, and the priorities of competitiveness were analyzed using quantitative methodology. The main results of this study are as follows.

The core competitiveness is “Demand Condition”, “Government” for revitalizing technology in the early stage of smart technologies, and “Government” as a factor to promote the entry of related industries and to stimulate the use of technologies for construction firms. This is because “Government” has a positive effect on the vertical integration of the front-back industry and market-demand expansion of the construction industry. Specifically, appropriate compensation for technical personnel and wide expansion of technology development R&D are prioritized. Since smart technology has differences in performance depending on the user’s proficiency, it is important to secure professionals who can be put into the right place and to compensate appropriately. In addition, a wide range of R&D investments are needed to reduce the risk of small companies developing smart technologies. Moreover, since smart technology competitiveness varies depending on contractual relationships, specific distinct policies were required for various stakeholders.

The contributions of this study are as follows. First, the smart technology of the construction industry was approached from the perspective of industrial competitiveness. Most studies have been concentrated on technology development, and studies on a competitiveness perspective have been very insufficient. Therefore, this study provides implications from a macro perspective for technological innovation in the construction industry. Second, the limitations of qualitative research were supplemented by combined quantitative methods. In general, industrial studies focus on qualitative research, but this study tries to combine quantitative methods. Therefore, it is possible to identify priorities for competitiveness and can be utilized as various strategies from a short- and long-term perspective. Third, it is able to be used as a reference for the development of policy from a national point of view. It was suggested as a competitiveness factor that is necessary for the construction industry in the early stages of smart technology. Therefore, these achievements can be a reference for policy development for countries in the early stages of technological innovation in the construction industry.

However, there are some limitations in this study. This study focused on the construction industry in Korea. Therefore, if the industrial environment of the target country is different, it is difficult to blindly trust the results of this study. Since Korea basically lacks natural resources, it has developed industrial competitiveness centering on competitiveness such as human resources to supplement them, and this background cannot be generalized. Therefore, it should be analyzed for countries with various characteristics through multi-case analysis. In addition, it is necessary to study the impact and direction of each industrial competitiveness. Each competitiveness is not formed independently but can be influenced by related competitiveness to enhance each other. Therefore, in the future, the limitations of static perspective should be supplemented through research on the influence between competitiveness.

Author Contributions: Conceptualization, B.L.; methodology, B.L.; formal analysis, B.L.; investigation, B.L. and S.-K.P.; writing—original draft preparation, B.L.; writing—review and editing, B.L.; supervision, B.L. and S.-K.P.; project administration, S.-K.P.; funding acquisition, S.-K.P. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by National R&D Project for Smart Construction Technology, grant number 21SMIP-A158708-02.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Not applicable.

Acknowledgments: This research was conducted with the support of the “National R&D Project for Smart Construction Technology (No.21SMIP-A158708-02)”, funded by the Korea Agency for Infrastructure Technology Advancement under the Ministry of Land, Infrastructure and Transport and managed by the Korea Expressway Corporation.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A. Questionnaire Examples for Evaluating Industrial Competitiveness

In this paper, we have built on the following questions for the collection of data. They were translated into English for presenting this paper. The evaluations were divided into two parts. The first part has the goal of evaluating the country’s characteristics. The second part has the goal of evaluating the industrial competitiveness factors.

Appendix A.1. Evaluation of Korean Construction Industry Characteristics

The table below is a two-way comparison table to consider the characteristics of the construction industry in Korea. Look at the competitive factors and check which side seems to be more important.

Table A1. The AHP evaluation of Korean construction industry characteristics.

| Number | Competitiveness | Strong Important | ←————→ | Weakly Important | Neutral | Weakly Important | ←————→ | Strong Important | Competitiveness |
|--------|-----------------|------------------|--------|------------------|---------|------------------|--------|------------------|-----------------|
| 1 | A ¹ | | | | | | | | B |
| 2 | A | | | | | | | | C |
| 3 | A | | | | | | | | D |
| 4 | A | | | | | | | | E |
| 5 | A | | | | | | | | F ⁶ |
| 6 | B ² | | | | | | | | C |
| 7 | B | | | | | | | | D |
| 8 | B | | | | | | | | E |
| 9 | B | | | | | | | | F |
| 10 | C ³ | | | | | | | | D |
| 11 | C | | | | | | | | E |
| 12 | C | | | | | | | | F |
| 13 | D ⁴ | | | | | | | | E |
| 14 | D | | | | | | | | F |
| 15 | E ⁵ | | | | | | | | F |

¹ A = Related and Supporting Industry; ² B = Demand Condition; ³ C = Government; ⁴ D = Factor Condition;

⁵ E = Firm Strategy, Structure, and Rivalry; ⁶ F = Chance.

Appendix A.2. The Evaluation of Industrial Competitiveness Factors

Below are the evaluation factors for smart technology in the construction industry. Each question was distributed by industrial competitiveness features and the measurement scale is 1–5. The evaluation was conducted twice in accordance with the competitiveness level and importance. In the competitiveness level, 1 means a poor level, and 5 means an excellent level. In the competitiveness importance, 1 means little (no) importance, and 5 means great importance.

Note: Evaluate each factor on a scale of 1 to 5. The criteria of evaluation should be based on personal experience and perceptions.

Factor Condition

- Appropriateness of compensation for manpower using smart technology
- Current status of manpower for developing source technology related to smart construction
- Current status of experts who are available to use smart technology in the construction site

Firm Strategy, Structure, and Rivalry

- Ability to utilize smart technology for working-level staff of general contractors and subcontractors
- Active competition for smart-technology development among companies
- Level of technology compared to overseas smart technology
- Maturity of communication using smart technology in the construction site
- Establishment of management strategy for smart technology
- Enabling in-house or outsourced management to enhance technical capability
- Price competitiveness of smart technology

Related and Supporting Industry

- Growth potential of the safety and service industry
- The technological level of the smart-technology-related industry
- Investment by financial institutions for smart technology
- Growth potential of the safety and service industry

Demand Condition

- Demand level of smart industry such as smart city, modular housing, etc.
- Public corporations' and government's demand for smart technology
- Size of the ordering market applying smart technology

Government

- Level of institutional support related to smart technology
- Institutional barriers to related industries' entry into the construction industry
- R&D investment for smart technology
- Government's financial support related to smart technology such as incentive, pilot cost
- Government's education-support level related to smart technology

Chance

- Activation of the interchange of smart technology among companies
- Status of entry overseas projects applying smart technology
- Expansion of the size of the smart-construction market overseas
- Needs for applying smart technology for overcoming crises such as decline in population and productivity

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