Identification of Overall Innovation Behavior by Using a Decision Tree: The Case of a Korean Manufacturer

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Abstract: Based on the two recent consecutive Korean Innovation Surveys in 2014 and 2016, this research empirically identifies the influencing factors and overall behavior of innovation success and failure in the manufacturing industry by using decision-making tree analysis (DT). The influencing factors and behavior of a successful innovator are also investigated from the perspectives of financial contribution, innovation activity, and research and development (R&D) activity. By using DT, this study acquires comprehensive knowledge of the arguments on innovation factors and behaviors in different contexts over time while dealing with all the factors in a single statistical framework based on the Oslo manual. Results with around 80% predictive accuracy show that the role of R&D is crucial for innovation success. The larger the firm size and the older the firm, the higher the success achieved by the firm will be. Firms in a low-technology industry prefer other innovation activities rather than R&D. Concerning a successful innovator’s behavior, target market characteristics that drive a firm to seek market needs influence innovation behavior and the use of information for innovation. Firms prefer implementing low-cost R&D activities across sectors, but firms in low-technology sectors prefer non-R&D activities. Regional characteristics of well-established business environments help firms to focus on R&D activities and reduce costly non-R&D activities. Most firms having R&D institutes focus on conducting in-house R&D using their own information. Cooperative R&D is conducted for closing capability gaps, but absorptive capacity is required to complement cooperative R&D. These empirical findings reaffirm the arguments on innovation behavior and arrange them in the overall perspective; they also provide managerial and political implications. Establishing and strengthening private or public R&D support programs to increase the capability of both in-house and cooperative R&D through funding as well as leveling up the information environment on technology and the market is crucial to the national innovation system.

Keywords: innovation success and failure; innovation factors and behavior; financial contribution; innovation activity; R&D activity; manufacturing industry; decision-making tree analysis

1. Introduction

Given the fiercely competitive business environment in the globalized economy that has evolved over the years, innovation success plays a crucial role in promoting sustainable growth at the firm, industry, and national levels [1–7]. Therefore, numerous academic researchers, managers, and policymakers have conducted frequent examinations on the structure of successful innovation in terms of its inherent factors and behaviors in various aspects of political, strategical, or managerial landscapes [8–14].
The famous Scientific Activity Prediction from Patterns with Heuristic Origins (SAPPHO) project conducted by the Science Policy Research Unit (SPRU) was deliberately designed in the 1970s to test generalizations of innovation based on a comparative analysis of paired successful and unsuccessful innovations on the first large-scale national level [15–17]. Since then, innovation studies have mainly focused on factors influencing the success and failure of innovations and their behavior as well as successful innovative firms. Additionally, the focus of these studies has gradually shifted to specific subjects to acquire knowledge of the in-depth mechanism of innovation behavior, thereby leading to a close investigation of the overall structure [18–25].

Despite these efforts that have evolved over the past decades, there is a lack of understanding of the precise prescription of innovation [18,19]. Previous studies have pointed out the following three underlying reasons. First, the intrinsic complex context of innovation makes it difficult to contribute toward a comprehensive and precise prescription of successful innovation [20,21]. Additionally, several variables and behaviors related to innovation have been identified in various empirical studies. These variables have sometimes led to a conflicting conclusion or have failed to exert a significant impact on innovation. Second, the aforementioned gap can be attributed to the difficulty faced by empirical studies in maintaining consistency in measuring innovation based on the existing definition of innovation and by various proxy measures with differing perspectives [22,23]. Third, changes in the business environment and different contexts of innovations over time may have also contributed to the gap [24–26].

The aforementioned shortcomings emerge from different contexts of empirical studies and their proxy measures, which have been changed over time. Additionally, the reason studies were conducted on specific subjects can be attributed to innovation data and statistical methodologies. Innovation data have been measured together by various types of ratio, interval, ordinal, and nominal variables. These characteristics of innovation data in terms of type and scale have restricted methodological application. Innovation data are usually measured on a nominal scale (categorical variable). Additionally, they are frequently measured on a binomial scale, such as innovation success and failure, regardless of whether R&D is performed and whether innovation activities are conducted. These kinds of whether or not problems make it difficult to apply advanced statistical methodology. This problem, involving different types of variables, requires well-structured analytical models, which can ensure comprehensive results in a single statistical significance framework. Since previous research results cannot be put in a single frame while retaining the same statistical significance, comprehensive research based on a single frame would be necessary.

The development of data mining methodologies has recently increased the application of these methodologies to studies on innovation [27,28]. Decision-making tree analysis (DT) is one of the predictive modeling techniques commonly employed in the data mining domain. DT produces a robust model that predicts the value of a dependent or target variable from various independent or input variables. Additionally, the DT algorithm provides an accurate prediction model and visualization. It also deals with both numerical and categorical variables. In addition, DT performs very well with large datasets and produces easily comprehensible and interpretable results [28]. In this respect, the application of DT to innovation studies can be considered suitable in terms of the freedom of using various proxy measures together, which are mostly measured categorical variables with numerical variables. Additionally, DT reduces the burden of developing structured analytical scenarios required when employing statistical methodologies due to constraints involving innovation data characteristics. In these regards, DT can present a comprehensive knowledge of factors influencing innovations and their behaviors in an interpretable format through a single and statistically significant predictive framework treating different types of variables together, regardless of them being categorical or numerical variables.

The methodological advancements in the field of data mining and the increased feasibility of using large-scale innovation data have increased the possibility of facilitating a comprehensive understanding of factors influencing innovation and behavior. Given the improved innovation study environment
in terms of data and methodology, this study aims to acquire knowledge of sustainable innovation behavior based on evidence from the Korean manufacturing industry. Considering these aspects, this study investigates factors influencing the success and failure of innovation and behavior as well as successful innovative firms from a longitudinal perspective, by using the DT analysis model based on the Korean Innovation Survey (KIS) data on 8075 manufacturing firms for the past two consecutive surveys (in 2014 and 2016).

Accordingly, the first objective of this study is to examine the sustainable behavior for the success and failure of innovation by capturing changes from a longitudinal view in accordance with the guidance from the Oslo Manual, which maintains international principles for measuring innovation. The second objective of this study is to investigate the sustainable behavior of successful innovative manufacturers from the perspectives of innovation activities and contribution. With these research objectives in mind, this study intends to contribute toward mitigating the shortcomings of comprehensive knowledge by treating all the factors, which are used in KIS based on the Oslo Manual, in an analytical and predictive DT model through a single statistical significance framework. As an empirical study on the Korean manufacturing industry, this study reaffirms comprehensive innovation behavior investigated in previous studies by determining factors that significantly influence innovation and behavior. From empirical findings on the Korean business environment, this study provides sustainable implications for the current era.

On the other hand, although the aims of this study focus on the identification of comprehensive innovation behavior by using DT that is highly predictable and easily interpretable, the nature of DT regarding a non-parametric analysis makes it difficult to comprehend the in-depth underlying mechanism of innovation behavior. Thus, it is worthwhile to validate the hypotheses constructed based on the significant findings from DT. In advance, regional and sectoral factors are particularly identified in the success and failure of innovation in this study, in addition to the role of R&D, which is the most significant and important factor, and factors, such as firm size and age, which are intrinsic general factors of the firm involving R&D. In addition, concerning successful innovative firms, these regional and sectoral factors related to the target market are determined to influence the innovation behavior of focal firms. Therefore, this study subsequently tests the hypotheses that there are differences in innovation success according to the region and sector.

The rest of this article is organized as follows. In Section 2, the previous relevant studies in the domain of innovation are introduced. In Section 3, data, variables, research framework, methodology, and the model used in this study are presented. Section 4 presents the empirical results of the DT analysis model and discusses the findings derived from them. Section 5 constructs and verifies hypotheses derived from the findings in Section 4. Section 6 provides the implications drawn from the findings and future directions of the research.

2. Literature Review

Innovation has been understood and defined in different contexts according to the time and circumstances of previous studies as concepts of invention, exploitation, implementation, and commercialization [16,18,19,29]. It has been operationally defined with various proxy measures. This has made it difficult to maintain consistency in innovation measurement and interpret results across empirical studies with different perspectives in different contexts. Previous studies have identified the main influencing factors determining the innovative behavior along with its definition [18,19,30–34]. It is claimed that the definition and measurement of innovation in the literature is highly theoretical [35]. Additionally, it has been claimed that these cannot be straightforwardly applied to businesses [35,36], as they are complex and include diverse influencing factors [18,19,26,37]. It was claimed that a common overall innovation measurement framework does not exist [18,19].

Thus, standardized guidance for measuring innovation needs to be used to maintain consistency and to facilitate comparativeness with another context [19,21,38]. Hence, the Organization for Economic Co-operation and Development (OECD) has provided guidelines through the Oslo Manual
for measuring innovation and related factors in the international perspective. It has been standardized and applied empirically worldwide [38]. The KIS has also been developed on the basis of the Oslo Manual. It has been conducted since 2003, biennially or triennially, by the Science and Technology Policy Institute (STEPI). The KIS is the national authorized statistics approved by “Statistics Korea,” which is a central government agency. It has been well-conducted over the past two decades by trained facilitators to measure innovation activities with high quality. The survey questionnaires of “KIS: manufacturing industry” have been consistent over time. Accordingly, this study can design a longitudinal research framework and produce consistent results in the manufacturing industry.

Based on the Oslo Manual, related innovation factors involving not only contextual factors, but also intrinsic ones can be considered from theoretical, managerial, and political perspectives.

In this study, innovation is defined as “the implementation of a new or significantly improved product, or process, a new marketing method, or a new organizational method in business practice, workplace organization or external relations,” according to the guidance of the third edition of the Oslo Manual in 2005 (fourth edition was published in 2018 in which the definition of innovation was changed) [38]. The data used in this study are obtained from the “KIS: manufacturing industry” in 2014 and 2016, which are based on the third edition of the Oslo Manual. In this sense, innovation activities are defined as “including all scientific, technological, organizational, financial and commercial steps which actually lead, or are intended lead, to the implementations of innovations,” as per the third edition of the Oslo Manual [38].

Concerning the identification of innovative behavior, extrinsic and intrinsic determinants have been empirically explored in various perspectives. Extrinsic determinants are related to a firm’s business environment. The main extrinsic factors comprise the industry to which the firm belongs and the region where it is located. The other factors are related to the cooperative networking environment involving knowledge or technology flow. Additionally, market-related factors were noticeably examined for innovation behavior.

It is widely accepted that industry and regional characteristics are significant to innovation behavior. Examinations have revealed that the industry factor has significantly affected innovation in terms of technological dynamism, demand growth, and industrial structure. Concerning technological dynamism, it is found that high-tech industries are more innovative than traditional ones [29,39–42]. Concerning testing the demand-pull theory, demand growth has a significant positive impact on innovation [43–45]. Regarding industrial structure, the empirical results are diverse. Industry concentration is found to have a negative [45–47] or positive [48,49] effect. Additionally, other studies showed a bell-shaped [50] or an insignificant [43,51–53] relationship between innovation and industry concentration. The regional factor is found to have had a significant impact on innovative capacity [29,54–59]. Concerning location characteristics of proximity to partners, which increases cooperation with suppliers, customers, and universities, it was found to positively influence innovation [42,58,60–63]. Proximity facilitates tacit knowledge transfer [64,65] and reduces communication costs [66]. Cooperative networking could be understood as a corporate capability, but it is more reasonable to be considered in relation to the business environment [35,62,67–69]. Several studies show that the correlation between innovation and interaction with networking partners is positive [58,62,67–71]. However other studies identified that it is not significant [50,72]. Despite these conflicting findings, it is consciously accepted that cooperative networking helps a firm to bridge gaps in its information, scientific knowledge, resources, and competencies [61]. Market focus plays an important role in product success [18,73–75]. Demand and supply determine the success of a business [45,67,74,76]. Hence, target market characteristics, including customer type and customer feedback, affect innovative behavior for product and business success [18,77–79]. These market-related factors have driven firms’ innovative behavior, such as detecting customer needs [22,69,80–82], advertising [47,83], and elaborating marketing strategies [79,84]. Although there are some negative or insignificant effects of industrial and regional characteristics as well as cooperative networking and market characteristics on innovation, their positive effects are widely accepted from the perspective of
promoting innovation \cite{18,19,24,55,61,63,79}. This study considers these extrinsic innovation-related factors, and information on these factors are collected in the KIS.

Intrinsic determinants of innovation have mainly been studied in the view of capability theory by organizational theorists since the late 1960s \cite{69}. It could be categorized into the following: (1) The general characteristics of a firm, (2) innovative capability, and (3) innovative activities.

Although a firm’s general characteristics, size, age, and ownership have been determined, but these have not provided an understanding of the precise prescription of innovation. Concerning the relationship between firm size and innovation, there have been conflicting results. The main arguments are as follows. On the one hand, small firms have an advantage in the management of innovation \cite{85}. On the other hand, large firms have more resources to innovate than small ones \cite{86–91}. Another study revealed two different relationships, which are U-shaped and hump-shaped in the case of German, France, and Belgium firms in the 1980s \cite{92}. It is argued that this phenomenon might be influenced by other factors, such as industry condition and structure \cite{92}. The debate on these Schumpeter Mark I and II hypotheses \cite{93,94} is still being explored. There are also arguments about the relationship between firm age and innovation. On the one hand, firms accumulate the experience and knowledge to innovate with age \cite{95,96}. On the other hand, older firms resist innovation by establishing procedures with a stable barrier \cite{97}. This claim of two positions has not been verified sufficiently. Thus, hasty generalization cannot further our understanding. Regarding ownership, results were also mixed. It is revealed that foreign ownership is positively correlated with innovation \cite{44,52,98}, whereas it was found that foreign ownership had a rather negative \cite{52,72,99}, or insignificant \cite{100,101} impact on innovation. These arguments lie between the viewpoint of a lack of important management in a foreign-owned firm and that of compensation for the advanced management of knowledge for innovation from the foreign parent \cite{18}.

Concerning a firm’s innovative capability, R&D capability has been mainly examined. R&D capability is related to the firm’s financial and organizational capacity \cite{51}. The capacity in this sense refers to employees, including R&D personnel, and investment resources, which have a relationship with budget and cost. For example, the R&D personnel ratio and R&D investment (e.g., R&D intensity) have a positive effect on innovation \cite{102,103}. Additionally, the R&D budget is a factor influencing innovation \cite{35,104–106}. However, given that R&D cost is limited and secured, these factors are not enough to explain innovation \cite{107}. Although investment in innovation leads to innovation performance \cite{57} and R&D-related factors are good representatives of organizational capacity \cite{61}, these cannot contribute toward a firm’s overall innovative capability \cite{18}. It is also argued that all innovations are not based on R&D \cite{19}.

Concerning the firm’s innovative activities, R&D activities have been mostly examined. R&D is accepted to be the most important determinant of innovation \cite{18,19,35,57,61,62,67,74,102–105,108–112}. The manner in which R&D activities are performed can be categorized into in-house R&D, cooperative R&D, and external R&D. In-house R&D constitutes the major channel for carrying out R&D activities, and it is considered the most crucial factor of innovation for the manufacturer. In-house R&D naturally supports a firm to develop new products or processes \cite{62,67,110,113}. It also provides the capability to absorb external knowledge and technologies \cite{18,19,50,112,114–116} and to cooperate with different organizations, such as universities and research institutions \cite{9,55,62,63,67,69,71,108,109,117}. By engaging in cooperative R&D, firms gain access to complementary technologies or knowledge \cite{114,118,119}, and they can improve the probability of success of an innovation project \cite{120–123}. However, the instability and risks associated with R&D cooperation cannot lead to successful innovation \cite{124–129}. Firms that have limited resources and capabilities for internal R&D consider external R&D \cite{130–132}. Subsequently, they expand the possibility to develop new products with commercial success \cite{133–135}. However, absorption capacity was found to be essential for complementing external R&D \cite{136}. The role of external R&D for innovation by itself and its complementarity with internal R&D remains inconclusive \cite{130,137}. While some findings of the effects of cooperative and external R&D are still being debated, the role of R&D for innovation has been
widely accepted. Meanwhile, innovation is not only driven by R&D, and R&D activities cannot reflect the firm’s innovative capability [18,19,107,138]. In terms of business management, non-R&D activities are divided into the following six categories [38]: (1) Acquiring machine, tool, software, and building for operational management; (2) procuring external knowledge to develop new product or to improve process; (3) providing job training for educated, qualified, and experienced personnel; (4) undertaking market launching activities for new product penetration; (5) undertaking design activities for new product development; and (6) performing other activities.

This study considers these intrinsic innovation-related factors along with extrinsic ones to investigate innovative behavior because all these factors have been shown to be important determinants of innovation in the literature. These are summarized in Table 1.

**Table 1. Examples of the main determinants of innovation in the literature.**

| Category                  | Sub-Category                        | Main Determinants                       | Main Results and Arguments                                      | Relevant References |
|---------------------------|-------------------------------------|----------------------------------------|-----------------------------------------------------------------|---------------------|
| Extrinsic determinants    | Industry                            | Technological dynamism                 | High-tech industries are more innovative than the traditional one | [29,39–42]          |
|                           | Demand growth                       |                                        | Positive                                                        | [43–45]             |
|                           | Industrial structure                |                                        | Negative                                                        | [45–47]             |
|                           | (industry concentration)            | Positive                               | [48,49]             |
|                           |                                     | Positive (Bell-shaped)                 | [43,51–53]           |
|                           |                                     | Insignificant                          |                                                                  |                     |
| Region                    | Location characteristics of         | Positive                               | It promotes knowledge transfer and reduces communication costs   | [42,58,60–62]       |
|                           | proximity to partners                |                                        | [64–66]             |
| Cooperative networking    | Cooperative networking environment  | Positive                               | It promotes interaction and helps for closing capability gaps    | [50,72]             |
| environment               |                                     | Insignificant                          |                                                                  |                     |
| Market                    | Demand and supply                   | Positive                               |                                                                  | [45,67,74,76]       |
|                           | Target market characteristics       | Positive                               | It drives seeking market needs, advertising, and elaborating     | [18,77,78]          |
|                           | involving customer type and feedback|                                        | market strategies                                               | [22,47,69,79–84]    |
| Intrinsic determinants    | Size                                | Small firms have an advantage          |                                                                  | [85]                |
|                           |                                     | Large firms have an advantage          |                                                                  | [86–91]             |
|                           |                                     | U- or hump-shaped                      |                                                                  | [92]                |
|                           | General characteristics of a firm   | Older firms have an advantage          |                                                                  | [95,96]             |
|                           | Age                                 | Younger firms have an advantage        |                                                                  | [97]                |
|                           | Ownership                           | Positive                               |                                                                  | [44,52,98]          |
|                           |                                     | Negative                               |                                                                  | [52,72,99]          |
|                           |                                     | Insignificant                          |                                                                  | [100,101]           |
Factors that are shown in the literature as affecting innovation are presented from a viewpoint of factors that affect innovation success or innovation performance. This innovation success or performance is mostly measured by patents [35,139–142], R&D intensity [105,140], and number of innovations (e.g., new product development or commercialization) [25,31,77,143–147]. These measurements focus entirely on the innovation itself, from mostly a technological perspective. Given the importance of innovation in business management, it is essential to look at the relationship between the firm’s financial performance and innovation [7,148–151]. Financial performance is defined as the earnings of a business through the sale of innovative products in the market [18]. For financial performance measurement, proxy measures, such as return on investment with innovation [152] and new-to-market and new-to business sales [150], are used. However, these studies examined the impact of technological innovation on financial performance. A study that examines the differences between companies with good financial performance and those with poor financial performance, among successful innovators, is still lacking. In this respect, this study attempts to explore the behavioral difference between groups contributing to sales through innovation and those without a contribution.

Additionally, there is a lack of research on the differences between companies that focus on R&D activities and those that focus on non-R&D activities, among successful innovators. Therefore, it would be worthwhile to identify differences in the innovation behavior among these groups by distinguishing successful innovators based on their R&D and non-R&D activities.

3. Research Design

3.1. Data and Variables

This study aims to identify sustainable influencing factors on innovation and behavior by using DT analysis with various innovation variables, based on a single structured framework, in the Korean business environment. Hence, the “Korean Innovation Survey (KIS): manufacturing industry” in 2014 and 2016 is used to analyze the behavior of manufacturers in Korea from a longitudinal perspective. The survey questionnaires of the “KIS: manufacturing industry” have been consistent over time. Based on this, the longitudinal analytical framework is structured in this study. The “2014 KIS” and “2016 KIS” contain firm-level data on the innovation-related activities from 2011 to 2013 and from 2014 to 2015, respectively.

Since the KIS is well-known for its reliability and the focal point on innovation, it has been used in the field of empirical innovation studies in Korea [153–157]. Concerning the representativeness of
the national innovation activities of the KIS sample data on the manufacturing industry, the sample frame comes from the recent nationwide business survey by the National Statistical Office (NSO). It is stratified by the multistage-stratified-systematic-sampling based on the Korea Standard Industry Code (KSIC) and the number of employees in the firm. The Neyman allocation method was used for sample allocation. The 2014 KIS of the manufacturing industry covers 4075 manufacturers taken from a sample frame of 46,101 firms in the period from 2011 to 2013. The 2016 KIS of the manufacturing industry covers 4000 manufacturers taken from a sample frame of 49,704 firms in the period from 2013 to 2015. Manufacturers were categorized into 23 industrial sectors in the ninth version of KSIC, in which KSIC 10 to 33 fall under the manufacturing sector, except KSIC 12 (manufacturers of tobacco products). Firms were defined in 17 regions comprising 7 metropolitan cities, including the capital city, 1 special self-governing city, 8 provinces, and 1 special self-governing province.

In the KIS, firms were asked to indicate their status related to innovation and innovation activities. Basically, they were questioned about the success or failure of the innovation of products and processes. In this study, innovation success is defined as “an implementation of a new or significantly improved product or process.” Regardless of whether firms succeeded in innovation, they were commonly questioned about the following items in each category. In the category of the firm’s general information in terms of corporate capabilities for innovation, the following items were asked: (1) Form of the firm (legal unit); (2) statutory types (by the size of the employees from the sample frame); (3) designation status (in the Korean context); (4) listed status (in the Korean stock market); (5) size (sales, exports, and employee); and (6) age. Additionally, data on the sector to which the firm belonged, in terms of the KSIC at the two-digit-code level, was taken from a sample frame. The firms were also questioned about their regional location. Regarding the general R&D status, data regarding the “ratio of R&D personnel” and “manner of R&D activities” were collected. Concerning external factors that affect innovation, data on the “main target market” and “main customer types” were collected. These variables, measurement responses and descriptions, and scale are shown in Table 2, and their details are shown in Table A1 of Appendix A. Details of the sector variables as KSIC’s industrial codes on the manufacturing industry are listed in Table A3 of Appendix B.

Companies that succeeded in innovation were asked the following items. Concerning innovation activities, the following items were asked: (1) Whether or not eight types of innovation activities were implemented, (2) cost of each innovation activity, and (3) budget source of each innovation activity. In terms of knowledge flow and their relationship, the following items were asked: (1) Information sources used for innovation, (2) whether or not cooperative activity was carried out, (3) cooperative partner if the cooperative activity was carried out, and (4) the best cooperative partner if the firm had a cooperative partner. Concerning innovation outcomes, the firm was questioned about its “contribution of innovation to sales.” These variables, measurement description and responses, and types are shown in Table 3, and their details are shown in Table A2 of Appendix A.
Table 2. Summary of the variables in the general information of 2014 Korean Innovation Survey (KIS) and 2016 KIS.

| Category         | Variable                              | Measurement Responses and Description | Type     |
|------------------|---------------------------------------|---------------------------------------|----------|
| General status   | Form of firm                          | Independent company                   | Nominal  |
|                  |                                        | Affiliates of a domestic company      |          |
|                  |                                        | Affiliates of a foreign company       |          |
|                  | Statuary types (by the size of employee from sample selection) | Large-sized company | Nominal  |
|                  |                                        | Medium-sized company                   |          |
|                  |                                        | Small-sized company                    |          |
|                  | Designation status (in Korean context) | Venture company                        | Nominal  |
|                  |                                        | InnoBiz (certificated as innovative small and medium-sized firm) |          |
|                  | Listed status (in Korean stock market) | KOSPI                                 | Nominal  |
|                  |                                        | KOSDAQ                                |          |
|                  |                                        | n/a                                   |          |
| Size status      | Size of sales and exports             | Level of actual annual value over the last three years | Ordinal  |
|                  | Size of employee                      | Level of actual annual value over the last three years | Ordinal  |
| R&D status       | Ratio of R&D personnel                | Level of the percentage of R&D personnel in the last year | Ordinal  |
|                  | Manner of R&D activities              | Operation by R&D institutes           | Nominal  |
|                  |                                        | Dedicated department                  |          |
|                  |                                        | Irregular operation if necessary      |          |
|                  |                                        | Not implemented                       |          |
| Market status    | Main target market                    | Domestic                              | Nominal  |
|                  |                                        | Asia                                  |          |
|                  |                                        | Europe                                |          |
|                  |                                        | North America                         |          |
|                  |                                        | Others                                |          |
|                  | Main customer types                   | Private company                       | Nominal  |
|                  |                                        | Government and public sector          |          |
|                  |                                        | Individual customer                   |          |
|                  |                                        | Overseas market                       |          |
|                  |                                        | Others                                |          |
| Another status   | Region                                | Region (17 areas)                     | Nominal  |
|                  | Age                                   | Age                                   | Interval |

### Table 3. Summary of the variables for the successful innovative firm.

| Variable                              | Measurement Responses and Description                                      | Type      |
|---------------------------------------|-----------------------------------------------------------------------------|-----------|
| Success of innovation                 | Success on the innovation of product or process                             | Nominal   |
| Contribution to the sales             | Percentage of contribution from innovation for the sales of the last year  | Ratio     |
| R&D activities (whether or not)       | - Performing in-house R&D                                                   | Nominal   |
|                                       | - Performing cooperative R&D                                                 |           |
|                                       | - Performing external R&D                                                   |           |
| Innovation activities                 | - Acquisition of machine, tool, software, and building                      | Nominal   |
|                                       | - Buying external knowledge                                                 |           |
| Non-R&D activities (whether or not)   | - Performing job training                                                  |           |
|                                       | - Performing market launching activities                                   |           |
|                                       | - Performing design activities                                              |           |
|                                       | - Performing others                                                        |           |
| Level of total innovation cost        | Level of the total cost for innovation activities performed in the last year| Ordinal   |
| Innovation Cost                       | % level for In-house R&D                                                    | Ordinal   |
|                                       | % level for External R&D                                                    | Ordinal   |
|                                       | % level for Acquisition of machine, tool, software, and building            | Ordinal   |
|                                       | % level for Buying external knowledge                                       | Ordinal   |
| Source of budget                      | - Owned capital                                                            | Nominal   |
|                                       | - Affiliate fund                                                           |           |
|                                       | - Government fund                                                          |           |
|                                       | - Loan                                                                     |           |
|                                       | - Stock Issuance                                                           |           |
|                                       | - Corporate Bond fund                                                      |           |
|                                       | - No expenditure                                                           |           |
| Information source for innovation     | - In-house or within the affiliate                                          | Nominal   |
|                                       | - Supplier                                                                 |           |
|                                       | - Private customer                                                         |           |
|                                       | - Public customer                                                          |           |
|                                       | - Competitors in the same sector                                           |           |
|                                       | - Private service firms                                                    |           |
| Implementation                        | Whether or not                                                             | Nominal   |
| Cooperative activities                | Cooperative partner                                                       | Nominal   |
|                                       | Affiliates                                                                |           |
|                                       | Supplier                                                                  |           |
|                                       | Private customer                                                          |           |
| Best cooperative partner              | Competitors in the same sector                                             | Nominal   |
|                                       | Private service firms                                                     |           |
|                                       | Higher educational institutes                                              |           |
|                                       | Institutes of government, public, and private sector                       |           |
|                                       | Conference, exhibition, and fair                                           |           |
|                                       | Professional journal and publications                                       |           |
|                                       | Industrial association                                                     |           |

### 3.2. Methodologies

Traditional statistical methods in innovation research have been restricted by characteristics of the innovation study data, although they intended to consider the overall factors. This study aims to solve this shortcoming by considering the overall factors in innovation by using DT analysis. This method allows the usage of various proxy measures comprising categorical and numerical variables in a single frame statistically.

Classification tree analysis and regression analysis are the two principal types of DT. The classification and regression tree (CART), chi-squared automatic interaction detection (CHAID), quick, unbiased, efficient statistical tree (QUEST), C5.0, and C4.5 are the most commonly used DT algorithms. The CHAID algorithm is capable of processing both continuous and categorical predictive (or independent) variables along with the target (or dependent) variables. Thus, CHAID develops decision trees for both the classification-type and regression-type prediction problems, regardless of whether the dependent variable is a nominal or a continuous numerical variable. Additionally, the
The CHAID algorithm is a nonparametric procedure that requires no assumption of the underlying data; for example, it does not require the data to be normally distributed [28,158–162].

In the CHAID algorithm, the F test is used if the dependent variable is continuous, and the chi-square test is used if it is categorical. The CHAID algorithm uses a multi-way splitting strategy, thereby creating interpretable models compared to CART [158,159]. Beginning with a root node that includes all cases, the tree branches are divided into different child nodes. CHAID is not a binary tree algorithm, and hence it can produce more than two categories at any level in the tree that differs from other decision tree algorithms. The criterion for branching (or partitioning) is selected after examining all possible values of all available predictive variables (at the Bonferroni-adjusted p-value of the statistical significance level). In the terminal nodes, a grouping of cases is obtained, such that the cases are as homogeneous as possible with respect to the value of the dependent variable.

Based on the advantage of the CHAID algorithm in terms of application and interpretation, this study used the CHAID algorithm by employing IBM SPSS 22. The settings in this study are as follows: (1) The value of the maximum tree depth is set autonomously; (2) both the splitting significant value and the merging significant value are set at 0.05; (3) the maximum number of recursive calculation is set at 100; (4) the misclassification cost is set to the same value for all categories; (5) the missing value is treated as not valid but missing; and (6) the minimum size of the parent and child nodes are set to be 100 and 50 cases, respectively.

In terms of validation, cross-validation is a general method used to estimate the unbiased accuracy of a predictive model’s performance in practice [28,159,162]. Ten-fold cross-validation is widely used in the data mining field since empirical studies have demonstrated that 10 constitutes an “optimal” number of folds [163]. It creates a fine balance between the sampling bias in terms of diversification of training and testing subsamples and demonstrating the time taken to build the model and test activities. In 10-fold cross-validation, the dataset is randomly separated into 10 mutually exclusive subsets of approximately equal sizes. The models are built and trained first and then tested, and the process is repeated 10 times. At each iteration, the model is trained on nine folds, combining training data that includes 90% of the total dataset. Additionally, it is tested on the remaining fold, which is 10% of the total dataset. The estimate of the cross-validation of the overall accuracy of the model is calculated by averaging the 10 individual accuracy measures that come from each fold. For the performance measure of prediction models, a coincidence matrix is used. It contains the actual and predicted classifications created by the model [164]. The overall accuracy is defined as the percentage of records that are correctly predicted by the model. In this study, a 10-fold cross-validation method is used to estimate the performance and overall accuracy. Additionally, the ratio of the number of true positive, which means the ratio of the correctly predicted case, is provided for each model.

3.3. Research Framework

The first research objective is to explore the overall behavior that affects the success and failure of an innovation. The second objective is to investigate the behavior of successful innovative firms in terms of innovation activities and contribution to sales. These two research objectives are presented in the research framework, as shown in Figure 1.
1. In Module 2, each model has different target variables according to each of their corresponding purposes, which involve innovation contribution and innovation activities. The variables for which data is commonly collected, regardless of whether firms succeeded in innovation, are used in Module 1. In Module 2, variables that were asked only of successful innovative firms and those used in Module 1 are used.

In order to gain recent comprehensive knowledge of factors influencing the innovation and behavior of the manufacturing industry, based on the latest KIS data, a sustainable perspective through a longitudinal analysis framework is developed, as seen in Figure 1. It is structured to examine the longitudinal consistency and variation based on the two consecutive 2014 and 2016 KIS.

The first module (Module 1) consists of two models, and the second module (Module 2) consists of eight models, as shown in Table 4. “Innovation success and failure” is used as a target variable in Module 1. In Module 2, each model has different target variables according to each of their corresponding purposes, which involve innovation contribution and innovation activities. The variables for which data is commonly collected, regardless of whether firms succeeded in innovation, are used in Module 1. In Module 2, variables that were asked only of successful innovative firms and those used in Module 1 are used.

Table 4. Models with target and input variables.

| Module | Perspective | Year | Model | Target Variable | Input Variable |
|--------|-------------|------|-------|-----------------|---------------|
| 1 (success and failure) | Overall | 2014 2016 | Overall in 2014 Overall in 2016 | Innovation success and failure | All variables in Table 2 |
| 2 (successful innovative firm) | Contribution to sales | Whether or not | 2014 2016 | Contribution to sales | All variables in Tables 2 and 3 (without the variable of success of innovation) |
| | Innovation activity | | 2014 2016 | Innovation activity | Class of innovation activity manners |
| | R&D activity | | 2014 2016 | R&D activity | Class of R&D activity manners |

Notes: * Independent variables related to innovation activities in Table 3 are excluded.

4. Results and Discussion

4.1. Overall Influencing Factors and Behaviors between Innovation Success and Failure

Table 5 summarizes the case statistics and results of the two models of Module 1. This table presents influencing factors at the significance level of 0.05. It also provides the overall accuracy as well as the predicted accuracies of the success and failure classes.
Table 5. Case statistics and DT results of Module 1.

| Year | Number of Cases | Result | Accuracy |
|------|-----------------|--------|----------|
|      | Total | Success | Failure | Overall | Success | Failure |
| 2014 | 4075  | 967     | 3108    | 79.4%   | 40.2%   | 91.6%   |
|      |        | Ratio of R&D personnel; Manner of R&D activities; Size of exports (one year ago); Statuary types |
| 2016 | 4000  | 1616    | 2384    | 79.4%   | 71.2%   | 85.0%   |
|      |        | Manner of R&D activities; Size of employee (one year ago); Sector; Firm age; Size of sales (two years ago); Size of employee (three years ago); Region; Listed status (Korean stock market) |

Based on the 10-fold cross-validation, the overall forecasting accuracies of the models in 2014 and 2016 are the same at 79.4%. These accuracy levels are relatively high, close to 80%. Accuracies of the success class of each model are 40.2% and 71.2%, respectively. Accuracies of the failure class are 91.6% and 85.0%, respectively. Basically, based on the general information of firms, it is very complicated to forecast successful innovation. However, the accuracy levels of the classifications between innovation success and failure demonstrate the quality of the model. Additionally, the overall accuracy levels appear stable, coming from cross-validation and the big data scale. Thus, it allows us to conclude that these DTs are rational and sustainable. These results indicate that the general information of firms used in KIS, which are related to the general resources of capability for innovation, can distinguish innovation success from failure. Especially, these significant influencing variables obtained from the results of the DT analysis can effectively filter out firms that are more likely to fail in innovation.

At the national level, in the order of significance, factors affecting innovation success and failure in 2014 are found as follows: Ratio of R&D personnel; manner of R&D activities; size of exports (one year ago); and statutory types. In 2016, the following factors are found to be significant influencing ones: Manner of R&D activities; size of employee (one year ago); sector; firm age; size of sales (two years ago); size of employee (three years ago); region; and listed status. The results of these two models are much different from each other. The success class in 2016 was larger than that in 2014. It could be interpreted that the data in 2016 provides enough evidence for forecasting the success class compared to 2014. Nevertheless, the factor of the manner of R&D activities is identified to be a significant factor influencing successful innovation over 2014 and 2016 from a longitudinal viewpoint.

Concerning the behavior between innovation success and failure, the results of DT in 2014 and 2016 are shown in Figures A1 and A2 in Appendix C. First, examining Figure A1 in 2014, DT starts with the first parent node of the ratio of R&D personnel. In the case wherein the value of the ratio of the R&D personnel is zero, which means an absence of R&D personnel, 98.8% of firms had failed in innovation. In the case wherein no R&D activity was carried out under the above condition (the absence of R&D personnel), entire firms failed in innovation. However, 16.1% of the cases of firms irregularly operating R&D if necessary, succeeded in innovation in the above group. In other cases, wherein the value of ratio of R&D personnel was not zero, factors of statutory types and exports level mostly explained the success and failure of innovation. Especially, the factors of the ratio of R&D personnel and statutory types (in terms of size) are presented in the third layer. These results indicate that these factors mostly explain the behavior of innovation success and failure, given that firms have R&D personnel. Comprehensively, the higher the ratio of R&D personnel and the bigger the firm size, the greater the success realized by firms will be. It reaffirms the arguments that R&D personnel affects positively [102,103] and that large firms have an advantage [86–91].

Second, investigating Figure A2 in 2016, DT starts with the first parent node of the manner of R&D activities. Of the 31% of firms with R&D institutes, 73.5% succeeded in innovation. In the case in which no R&D activity was carried out, only 7% of firms succeeded in innovation. This result reaffirms the argument that the role of the R&D organization is very important for the success of innovation, and this role should coincide with the capacity of the firm to perform R&D [18,19,35,57,61,62,67,69,74,102–105,108–112]. In the case of firms having R&D institutes to carry out R&D, the larger the employee size, the higher the success rate will be. The success rate is 57.6%, 73.1%,
and 85.0% in the case of firms with less than 50 employees, 50 and 99 employees, and 99 employees, respectively. In the case of firms having R&D institutes with less than 100 employees, regional differences are identified between innovation success and failure. While in firms having R&D institutes with more than 99 employees, the success rate varies depending on the listed status in the Korean stock market. In these respects, the findings of this study support the observations that firm size positively affects innovation [86–91], innovation is influenced by regional differences [42,58,60–62,64–66], and R&D is crucial for innovation [18,19,35,57,61,62,67,69,74,102–105,108–112].

Concerning the cases in which R&D activity is not carried out, 18% of firms with 100 to 499 employees were successful. Under the above condition (no R&D activities with 100 to 499 employees), 28.4% of firms over 17 years of age and 10.6% of those under 17 years of age were successful. It indicates that, even though there is no R&D activity, the larger the firm size and the older the firm age, the greater the success of the firms will be. It supports the arguments that large firms have an advantage [86–91] and that older firms have an advantage [95,96] with successful innovation. Meanwhile, under the same condition that no R&D activity was carried out, 5.6% of firms with relatively low employees (less than 100) were successful. Among them, 13.6% of the firms belonging to the low-technology industry, such as the food processing (KSIC 10), printing and reproduction of recorded media (KSIC 18), and furniture manufacturing (KSIC 32) industries, were successful. Their success rate was relatively higher than the other industries. Based on this, for the low-technology industry, it can be interpreted that innovation is achieved in a different way from R&D. This behavior is also found in other branches wherein irregular R&D is carried out, if necessary, in the first layer. Under the above condition, firms belonging to middle- and low-technology industries, such as the food processing industry (KSIC 10); apparel, clothing accessories, and fur articles’ manufacturers (KSIC 14); and the manufacturers of leather, luggage, and footwear (KSIC 15), showed a higher success rate of 83% when compared to firms belonging to other industries, such as manufacturers of medical, precision and optical instruments, watches, and clocks (KSIC 27); manufacturers of electrical equipment (KSIC 28); manufacturers of other machinery and equipment (KSIC 29); and manufacturers of pharmaceuticals, medicinal, chemical, and botanical products (KSIC 21), which showed a 43.5% success rate. In this respect, this result identifies that firms belonging to the low-technology industry prefer other innovation activities than R&D. This finding supports the sectoral difference in innovation behavior [29,39–45].

The primary objective of this article is to find sustainable factors influencing innovation success. From the overall perspective at a national level, longitudinal common influencing factors over the years and variation over time are shown in Table 6. The factor of the manner of R&D activities is determined as a sustainable influencing factor. This finding reafirms the argument that the role of the R&D organization is very important for the success of innovation, and this role should coincide with the capacity of the firm to perform R&D [18,19,35,57,61,62,67,69,74,102–105,108–112]. Additionally, the findings of this study confirm the significance of the influencing factors, such as the ratio of R&D personnel [102,103], exports size [61,67,96,108,150], statuary type (in terms of size), employee size [85–92], sector [29,39–45], firm age [95–97], sales size [74,77,78,103,150], and region [29,42,54–62,64–66], which have been determined in previous studies and have undergone changes over time.

Table 6. Summary of sustainable influencing factors and variations over time from an overall perspective.

| Category | Year | Sustainable Influencing Factors | Variation over Time |
|----------|------|---------------------------------|---------------------|
| Overall  | 2014 | Manner of R&D activities        | Ratio of R&D personnel | Exports level | Statuary type |
|          | 2016 | Employee size level             | Age                 | Sales level  | Region        |
|          |      | Sectors                         |                      |              | Listed status |
4.2. Factors and Behaviors Influencing Successful Innovative Firms

4.2.1. Contribution of Innovation

To investigate the factors and behavior influencing successful innovative firms, in the order of significance, innovation contribution, case statistics, accuracies, and results at the significance level of 0.05 are presented in Table 7. The overall forecasting accuracies of the models on innovation contribution in 2014 and 2016 are 85.16% and 84.79%, respectively, as seen in Table 7.

Table 7. Case statistics and DT results of innovation contribution models.

| Model          | Year | Number of Cases | Missing | Results | Accuracy |
|----------------|------|-----------------|---------|---------|----------|
|                |      | Total | Contribution | No contribution | Overall | Contribution | No contribution |
| Contribution to sales | 2014 | 856  | 729  | 127  | 111 | 85.16% | 100.00% | 0.00% |
|                | 2016 | 1236 | 1048 | 188  | 380 | 84.79% | 100.00% | 0.00% |

These accuracy levels are relatively high. However, accuracies for the contribution and no-contribution cases of the models are 100.00% and 0.00%, respectively. These prediction models clearly identified successful innovative firms based on their contribution to sales in terms of their behavior. However, these models could not identify successful innovative firms that did not contribute to sales. These results indicate that successful innovative firms contribute via innovation to sales [150,152].

Factors influencing innovation contribution in 2014 are as follows, in the order of significance: Market launch activities; using information from the public customer; using information from a higher educational institute; in-house R&D; and using information from the private customer. A DT result examining the behavior between groups with and without a contribution to sales in 2014 is shown in (a) of Figure A3 in Appendix C. The (a) of Figure A3 starts with the first parent node of market launch activities. In the case wherein no market launch activities were carried out, information from the public customer and higher educational institute mainly distinguished the groups. Meanwhile, in the case wherein market-launch activities were carried out, in-house R&D and information from the private customer mainly distinguished the groups. These results, first, indicate that firms carrying out in-house R&D with information from the private customer emphasize more on R&D than on marketing. Second, it indicates that firms emphasize marketing by using information from the public customer. Third, firms, which do not use information from the public customer, focus on information from higher educational institutes. These results imply that an innovation’s contribution to sales is influenced by target market characteristics in terms of the public or private sector, which also affect the behavior of R&D activity [22,47,69,80–84].

In 2016, the significant influencing factors are identified as follows: Cost for acquiring a machine, tool, software, and building (level of percentage); source of budget; and using information from in-house or within the affiliate. A DT result of the innovation contribution model in 2016 is shown in (b) of Figure A3 in Appendix C. The (b) of Figure A3 starts with the first parent node of the cost for acquiring a machine, tool, software, and building; this is followed by branches divided by the nodes of source of budget and using information from in-house or within the affiliate. In the case...
of the low percentage of the cost for acquiring machine, tool, software, and building, firms that used information from in-house or within the affiliate are more likely to contribute to sales based on innovation. This result indicates that innovation increases the sales contribution to firms, which do not invest heavily in assets and focus on using their own information for innovation. Comprehensively, these results imply that firms’ strategical behavior related to in-house R&D, marketing, and investment on assets based on the characteristics of the target market affects contribution to sales from innovation. It is consistent with the claim that market characteristics drive a firm to seek market needs and to advertise [22,47,69,79–84,115] and that R&D investments positively affect innovation [35,104–106].

Another objective of this study is to find sustainable factors and behavior influencing successful innovators in terms of their contribution to sales. Among all the variables, intrinsic innovation activity-related factors are identified to significantly influence innovation behavior compared to the extrinsic factors that are related to the general innovation capacity of the firm. Although there have been no precise common factors, over the years, common categorical factors have served as the information source. It indirectly supports the arguments that cooperative networking for bridging information gaps among partners promotes innovation [58,61–63,67–71]. These findings are summarized in Table 8.

Table 8. Summary of the influencing factors from the perspective of innovation’s contribution to sales.

| Category          | Year  | Sustainable Factors                                                                 | Variation over Time |
|-------------------|-------|-------------------------------------------------------------------------------------|---------------------|
| Contribution to sales | 2014  | - Information activity (market launching activity, in-house R&D)                     |                     |
|                   | n/a   | - Information source (private customer; public customer; higher educational institutes) |                     |
|                   | 2016  | - Level of activity cost (acquisition of machine, tool, software, and building)     |                     |
|                   |       | - Source of budget                                                                   |                     |
|                   |       | - Information source (in-house or within the affiliate)                              |                     |

4.2.2. Innovation Activities

Table 9 presents case statistics, accuracies, and results of the innovation activity models at the significance level of 0.05, in the order of significance. These models aim to identify the behavior of firms by emphasizing a mix of R&D and other R&D activities.

Table 9. Case statistics and DT results of innovation activity models.

| Model          | Year  | Number of Cases | Results                                                                 |
|----------------|-------|-----------------|-------------------------------------------------------------------------|
| Innovation activity | 2014  | 967 722 146 76 23 | Manner of R&D activities; Using information from competitors in the same sector; Statutory types; Using information from professional journal and publications; Using information from in-house or within the affiliate; Using information from conference, exhibition, and fair |
| 2016           | 1616 1134 285 189 8 | 74.7% 100.0% 0.0% 0.0% 0.0% | |
| Year           | Results | Accuracy |                         |
|                |         | Over-All | R&D and Non-R&D Activities Only | R&D and Non-R&D Activities Only | Non-R&D Only | No Activities |
| 2014           | Manner of R&D activities; Sector; Using information from private customer; Total Innovation cost (level of one year ago); Region | 79.0% 89.1% 48.1% 68.8% 0.0% |
The overall accuracies of the innovation activity models in 2014 and 2016 are 74.7% and 79.0%, respectively, as seen in Table 9. As a result, a total 71.9% (74.2% in 2014 and 70.2% in 2016) of successful innovative firms carried out both R&D and non-R&D activities. In 2014, the model is biased to fit the class of R&D and non-R&D activities; subsequently, the prediction accuracy of this class is 100% and the accuracies for others are 0%. It means that the difference between each class is very small, as seen in Figure A4 in Appendix C; this leads to the prediction that successful innovative firms carried out all innovation activities, including R&D and non-R&D activities, in 2014.

This section aims to identify the sustainable factors and behavior influencing successful innovators in terms of innovation behavior. Although a result of the model in 2014 does not provide sufficient evidence of the behavioral difference between classes of innovation activities, the result of the model in 2016 indicates that successful innovative firms exhibit a different behavior involving R&D and non-R&D activities. As a result of the observation and prediction on each class of the two models, it is reasonable and worthwhile to explore the result of the model in 2016 to identify the difference in behavior and to focus on those between the classes of R&D activities only and non-R&D activities only in 2016.

Factors influencing innovation activities in 2016 are found as follows, in the order of significance: Manner of R&D activities; sector; using information from the private customer; total cost for innovation activities in the last year (level of percentage); and region. The DT result of the model in 2016 is shown in Figure A5 in Appendix C. Figure A5 starts with the first parent node of the manner of R&D activities. In the case of firms having an R&D institute, 78.8% of the firms carried out both R&D and non-R&D activities, 18.4% of the firms carried out only R&D activities, and 2.5% of the firms carried out only non-R&D activities.

Among the firms having R&D institutes, 46.8% of firms, which belong to the middle-technology industry, such as manufacturers of rubber and plastics products (KSIC 22), manufacturers of fabricated metal products, except the manufacturers of machinery and furniture (KSIC 25), and manufacturers of other transport equipment (KSIC 31), carried out only R&D activities. Under the above conditions, 74.3% of the firms carried out only R&D activities, among those that spent less than 0.5 BW on the total innovation cost. Meanwhile, under the same conditions, 85.9% of the firms carried out both R&D and non-R&D activities, among those that spent more than 0.5 BW on the total innovation cost. Overall, firms spending more than 0.5 BW on the total innovation cost carried out both R&D and non-R&D activities, as seen in Figure A5. This finding indicates that even if firms have a research institute, innovation activities vary according to industrial characteristics in coherence with the argument that the technological dynamism of an industry affects innovation [29,39–42]. It also indicates that firms prefer carrying out only R&D activities at a relatively low cost across the industries. Especially, firms belonging to electronic component and computer manufacturing industries and to visual, sound, and communication equipment industries (KSIC 26) showed different behavior, based on the regional characteristics. In the metropolitan areas, such as Seoul, Incheon, Daejeon, Daegu, Gwangju, and Ulsan of Korea, 39.7% of firms carried out only R&D activities. Whereas 1% of firms in another area carried out only R&D activities, and 99% of the firms carried out both R&D and non-R&D activities. It can be interpreted that regional characteristics in terms of a well-established business environment, such as a metropolitan area, can help firms reduce efforts for non-R&D activities along with cost. Therefore, firms can concentrate on R&D. This finding supports previous findings [42,58,60–62,138] that regional characteristics affect a firm’s behavior pertaining to innovation activities.

Examining a branch in which the firms did not conduct any R&D, 69.7% of firms conducted non-R&D activities. However, looking at firms that conducted R&D with a dedicated department or those that carried out R&D irregularly, if necessary, the behavior of innovation activities differed with industrial sub-sectors. Among the firms having a dedicated department for R&D, 53.5% of the firms belonging to the low or middle-technology sectors carried out only R&D activities; these sectors included manufacturers of chemicals and chemical products, except pharmaceuticals and medicinal chemical (KSIC 20) manufacturers, manufacturers of rubber and plastic products (KSIC 22),
manufacturers of fabricated metal products, except machinery and furniture (KSIC 25) manufacturers, and manufacturers of electrical equipment (KSIC 28). In other cases, 87.7% of the firms belonging to other sectors carried out both R&D and non-R&D activities. Meanwhile, among the firms that carried out R&D irregularly if necessary, 61% of the firms carrying out only non-R&D activities belonged to low-technology sectors, such as manufacturers of apparel, clothing accessories, and fur articles (KSIC 14); manufacturers of pulp, paper, and paper products (KSIC 17); manufacturers of food products (KSIC 10); and manufacturers of other transport equipment (KSIC 31). These findings indicate and support that firms’ behaviors associated with innovation activities differ according to industrial characteristics in terms of technological dynamism, in line with previous studies [29,39–42]. Even though it belongs to the low-technology sector, firms with a dedicated department for R&D still conduct R&D activities. However, more than half of the firms have an occasional R&D focus on non-R&D activities. Although a sustainable influencing factor is not identified, it is found that the main mode of conducting R&D [18,19,35,57,61,62,69,74,102–105,108–112], as well as the industrial [29,39–42] and regional [42,58,60–62] differences in technological dynamism, play a major role in the behavior of innovation activities.

4.2.3. R&D Activities

Table 10 presents case statistics, accuracies, and results of R&D activity models at the significance level of 0.05, in the order of significance. These models aim to identify the behavior of firms by emphasizing a mix of R&D activities in terms of in-house and cooperative R&D.

| Model       | Year | Number of Cases | Total | In-House R&D only | In-House and Cooperative R&D | Cooperative R&D only | No R&D Activities |
|-------------|------|-----------------|-------|-------------------|-----------------------------|----------------------|--------------------|
| R&D activity | 2014 | 967             | 509   | 508               | 51                          | 99                   |
|             | 2016 | 1616            | 1186  | 209               | 24                          | 197                  |

| Year | Results                                                                 | Accuracy |
|------|-------------------------------------------------------------------------|----------|
| 2014 | Manner of R&D activities; Using information from institutes of government, public, and private sector; Using information from conference, exhibition, and fair; Using information from in-house or within the affiliate; Using information from supplier | 61.8% 92.3% 35.4% 0.0% 19.2% |
| 2016 | Manner of R&D activities; Sector; Using information from private customer; Using information from professional journal and publications; Size of employee (level of one year ago), Statutory types, Using information from private service firms | 78.5% 95.8% 0.0% 0.0% 67.5% |

The overall accuracies of the R&D activity models in 2014 and 2016 are 61.8% and 78.5%, respectively, as seen in Table 10. A total 65.6% (52.6% in 2014 and 73.4% in 2016) of the successful innovative firms conducted in-house R&D only, while 2.9% (5.3% in 2014 and 1.5% in 2016) of these firms carried out cooperative R&D only. The 31.9% ratio of firms that carried out both in-house and cooperative R&D in 2014 is relatively higher than the one in 2016 at 12.9%. As a result, both models are biased to fit the class of in-house R&D only; subsequently, the prediction accuracies for this class are 92.3% and 95.8%, respectively. This result means that the firms carrying out in-house R&D exhibit distinctly different behavior when compared to the ones carrying out other R&D activity types. Based
on the results of the two models, as seen in Table 10, it is worthwhile to compare the behavior of classes between in-house R&D only and in-house and cooperative R&D in 2014, and to those between in-house R&D only and no-R&D activities in 2016.

DT results on the behavior between groups of the R&D activity class are shown in Figures A6 and A7 in Appendix C. In 2014, Figure A6 started with the first parent node of the manner of R&D activities. In the case of firms having an R&D institute, 41.9% of the firms carried out both in-house and cooperative R&D. Among firms having an R&D institute, 74.1% of the firms using information from institutes of the government, public, and private sector (IGPPS) carried out both in-house and cooperative R&D, while 30.2% of the firms that did not use such information carried out both R&D activities. Under the conditions of having an R&D institute and using information from IGPPS, 83.7% of the firms that used information from a conference, exhibition, and fair (CEF) carried out both in-house and cooperative R&D, while 59.2% of the firms that did not use such information from a CEF carried out both R&D activities. However, 67.7% of the firms using information from in-house or within the affiliate (IHWA) carried out in-house R&D only, under the conditions of having an R&D institute and not using IGPPS. These behaviors indicate that the majority of firms having R&D institutes focused on carrying out in-house R&D only with their own information or from information within the affiliate. However, some firms having R&D institutes carried out cooperative R&D with information from IGPPS and CEF as well as in-house R&D. It can be interpreted that, for conducting innovation, firms that carried out both in-house and cooperative R&D seek to collect other information from external R&D-related institutes and the most contemporary competitive information from CEF rather than market-related information. Additionally, in the case of firms having a dedicated R&D department at the first branch and those not using information from the supplier at the second branch, 80.5% of the firms used information from IHWA. This result also supports the behavior that firms having a dedicated R&D department carried out in-house R&D only with information from IHWA. From the above findings, cooperative R&D activities are carried out to close capability gaps for innovation [61], and it helps innovation [63,118–123]. However, R&D institutes or R&D departments are required to complement cooperative R&D [63,130–132,136,137].

In 2016, Figure A7 also starts with the first parent node of the manner of R&D activities. In the case of firms having an R&D institute or a dedicated R&D department at the first branch, a majority of those firms (79.9%) carried out in-house R&D only through overall branches without using information from the private customer, private service firms, and professional journal and publications. Firms using this information carried out cooperative R&D. These results indicate that firms having an R&D institute or a dedicated R&D department carried out in-house R&D only based on own capability to innovate without cooperation. It can be interpreted that successful innovative firms do not prefer cooperative R&D due to its instability and risks [124–129]. In another case of firms that did not have a channel to carry out R&D at another first branch, the result clearly shows that 72.3% of those firms did not carry out any R&D at all. Additionally, in the case of firms irregularly carrying out R&D, if necessary, at the first branch, 29.8% of those firms did not conduct any R&D activities at all. Especially, under the above condition, 61% of firms belonging to the low-technology sectors did not perform any R&D activity, including food processors (KSIC 10); manufacturers of apparel, clothing accessories, and fur articles (KSIC 14); manufacturers of pharmaceuticals, medicinal chemical, and botanical products (KSIC 21); and manufacturers of pulp, paper, and paper products (KSIC 17). Meanwhile, 81.2% of the firms that belong to other sectors carried out in-house R&D only. This finding indicates that firms’ behavior of R&D activities differ according to industrial characteristics in terms of technological dynamism [29,39–42]. Even though it belongs to the low-technology sector, 39% of the firms that irregularly carried out R&D if necessary still carried out both in-house and cooperative R&D. Concerning the identification of sustainable influencing factors and behavior in terms of R&D activity, the manner of R&D activities is determined to influence innovation behavior. Additionally, some types of information sources for innovation were examined, such as IHWA, CEF, and IGPPS.
other factors identified comprise the sector, employee size, and statuary type at other local branches. These are shown in Table 11.

Table 11. Summary of influencing factors from the perspective of the R&D activity class.

| Category       | Year | Sustainable Factors                                                                 | Variation over Time |
|----------------|------|--------------------------------------------------------------------------------------|---------------------|
| R&D activity   | 2014 | · Manner of R&D activities                                                           | Information source (institutes of government, public, and private sector; conference, exhibition, and fair; in-house or within the affiliate; supplier) |
|                | 2016 | · Sector                                                                             | Employee size level - Statuary type |
|                |      | · Information source (private customer; private service firm; professional journal and publications) |                      |

Based on the above analyses of DT, it is also found that the main way of carrying out R&D plays a major role in the behavior pertaining to innovation [18,19,35,57,61,62,67,69,74,102–105,108–112]. Additionally, successful innovative firms prefer to conduct their own in-house R&D rather than cooperative R&D with their own information source. It indirectly supports the characteristics of instability and risks of cooperative R&D for innovation [124–129]. However, other findings support that firms carrying out cooperative R&D seek information [62,80,165–167] related to, not the market, R&D for the closing of capability gaps [61]. Additionally, it reaffirms that an internal capability for R&D is required to complement cooperative R&D [114,130–132,136,137].

5. Regional and Sectoral Differences of Innovation

5.1. Hypotheses on Regional and Sectoral Differences of Innovation

The main goals of this study are the identification of the overall innovation behavior of firms from both the perspectives of success and failure of innovation, and successful innovative firms by considering all innovation activities of a firm with all their intrinsic and extrinsic characteristics by using DT, which is highly predictable and easily interpretable. According to these goals, comprehensive knowledge on innovation behavior is acquired, but the nature of DT involving a non-parametric analysis makes it difficult to comprehend the in-depth underlying mechanism of innovation behavior. Therefore, theoretically and managerially meaningful factors according to the important findings derived from the result of this study can be validated in terms of traditional statistical methodology, and this could provide some grounds for innovation scholars.

From the result of Module 1 in Section 4, the role of R&D involving factors of R&D organization and R&D personnel is determined as the most significant and crucial factor for innovation success; this finding is reasonably and preliminarily natural. In relation to this, firm age and firm size, which are related to the factors of the exports level, statuary type (in terms of firm size), and employee size, are also identified as significant influencing factors, which are intrinsic factors of the firm with regard to its general characteristics. These factors, such as R&D, firm size, and firm age, have been heavily investigated, in relation to their in-depth impact and mechanism on innovation, statistically by scholars and their positive roles in the domain of innovation study are greatly accepted [18,19,35,57,61,62,67,69,74,77,78,85–89,92,95–97,102–105,108–112,150].

On the other hand, regional and sectoral factors are particularly identified to be significant influencing factors on the behavior of innovation success and failure. Additionally, with regard to successful innovative firms, it is found that their innovation behavior is affected by these regional and sectoral factors in relation to the target market. According to the literature review in Section 2 of this study, these regional and sectoral factors were investigated in relation to their characteristics on the impact of innovation. However, there are some negative or insignificant effects of industrial and regional characteristics on innovation. In addition, these factors are mainly considered under their specific relationship with innovation, such as industrial structure and regional proximity. Concerning
a sectoral factor, in more detail, sectoral innovation studies were mostly conducted for figuring out the sectoral landscape and its particular characteristics in specific sectors of each country by qualitative and descriptive analysis [168–170]. Concerning regional innovation study, the relationship and networks of institutes, such as a university, government, and industry institutions, and their roles in the regional innovation ecosystem under different contexts have been mainly emphasized through qualitative and descriptive analysis [171–176], as well as sectoral research approaches. Especially, in those studies, it is preliminarily assumed that there is a significant difference between sectors or regions statistically, but it was not tested.

Therefore, it is worthwhile to identify the differences of the distribution of innovation success and failure regarding the regional and sectoral difference of innovation in light of the significant findings from the DT analysis in this study and the shortcomings of previous studies. For this goal, the following hypotheses are constructed.

Hypothesis 1 (H1). There is a difference in innovation success and failure between sectors.

Hypothesis 2 (H2). There is a difference in innovation success and failure between regions.

Hypothesis 3 (H3). There is a difference in innovation success across sectors and regions.

Although a binomial logistic regression analysis on the innovation success and failure, as a dependent variable, could be used as advanced analysis to clarify the relationship contained in the contingency table, the model cannot be built due to the different independent variable types and scales in KIS. In this regard, to verify the hypotheses, the cross-tabulation analysis (CA) and chi-square ($\chi^2$) test are used because both the dependent variable and independent variable are categorical variables measured in the nominal scale, such as success and failure as a dependent variable, and region and sector as an independent variable, respectively. CA is used to aggregate and jointly display the distribution of two or more variables by tabulating their results one against the other in a two-dimensional grid. It uses a process of creating contingency tables from the multivariate frequency distribution of variables, which are presented in a matrix format. Regarding assumptions for usage of the $\chi^2$ test, data is satisfied with independent observations, not a biased sample, mutually exclusive on observations in all categories. Regarding H3, when applying CA, the observation of innovation success across the sectors and regions is used because the observation of success and failure of innovation across the sectors and regions cannot be included at the same time.

5.2. Hypotheses Testing Result and Discussion on Regional and Sectoral Differences of Innovation

The summary of CA and $\chi^2$ test results are presented in Table 12. The CA results of six models between sectors, between regions, and across sectors and regions in 2014 and 2016 are shown in Tables A4–A9 in Appendix D. Concerning H1 and H2, the value of $\chi^2$ is calculated by an asymptotic method depending on the satisfaction with an assumption of CA through the $\lambda$ measure according to the dependent and independent variables, which are nominal. Concerning H3, the value of $\chi^2$ is computed by the Monte-Carlo method depending on the dissatisfaction, with the assumption that cells with an expected count less than 5 should not exceed 25% of the total.

These results support all hypotheses at a significance level of 0.001 in 2014 and 2016 as seen in Table 12. From these results, it can be concluded that there are significant differences on innovation success and failure between sectors, and between regions over the years. Also, it is affirmed that there is a difference in innovation success across sectors and regions. In addition, when comparing the degree of difference between the sectoral and regional effect of success and failure of innovation, values of the contingency coefficient in each year indicate that the sectoral difference is significantly larger than the regional difference over the years, with a $p$-value of 0.000. Moreover, the contingency coefficients of the linkage between each sector and region in each year demonstrate a greater impact on the success of innovation than the effects of each continuously at a significance level of 0.01. Based on the overall CA
and \( \chi^2 \) test results, it is found that the distributions of success and failure between sectors, and between regions, as well as the distribution of innovation success across sectors and regions, are firmly diverse.

Table 12. Summary of hypotheses testing results.

| Hypothesis                  | Perspective         | Year | Total Valid Case | Pearson \( \chi^2 \) | Sig. | Contingency Coefficient | Sig. | Result               |
|-----------------------------|---------------------|------|------------------|-----------------------|-----|------------------------|-----|-----------------------|
| H1                          | Sectoral difference | 2014 | 4075\(^1\)       | 216.766 *             | 0.000 ** | 0.225                  | 0.000 ** | Accepted             |
|                             |                     | 2016 | 4000 \(^1\)      | 340.875 *             | 0.000 ** | 0.280                  | 0.000 ** | Accepted             |
| H2                          | Regional difference | 2014 | 4075 \(^1\)      | 83.088 *              | 0.000 ** | 0.141                  | 0.000 ** | Accepted             |
|                             |                     | 2016 | 4000 \(^1\)      | 169.460 *             | 0.000 ** | 0.202                  | 0.000 ** | Accepted             |
| H3                          | Sectoral and regional difference | 2014 | 967 \(^2\)       | 616.200 *             | 0.000 *** | 0.624                  | 0.003 *** | Accepted     |
|                             |                     | 2016 | 1616 \(^2\)      | 1123.935 *            | 0.000 *** | 0.602                  | 0.000 *** | Accepted             |

\(^1\) analysis value: success and failure of innovation; \(^2\) analysis value: success case; * \( p \)-value < 0.001; ** asymptotic significance; *** Monte Carlo significance.

Concerning the sectoral innovation study, previous studies have evolved that mainly focus on how sectoral differences influence innovation and shape its sectoral pattern in terms of technological dynamism involving the technology regime and trajectories, and knowledge flow based on sectoral taxonomy, such as Pavitt’s taxonomy [177–179]. Findings of this study statistically provide a rigid ground of sectoral diversity to establish innovation policies, which should take different approaches to design an institutional system to support innovation according to the innovation mechanisms and patterns, and characteristics of innovation players from the perspective of the sectoral innovation system [180]. However, in linkage to regional diversity, findings on sectoral and regional connectivity imply that differentiation of innovation is more magnified in conflict with the prominences of the sectoral regime rather than regional characteristics in the sectoral innovation system [181]. In this respect, this finding is more consistent with the perspective of the regional innovation system, which has focused on network and cooperative learning within the regional ecosystem in the specific sectors, such as the milieu of innovation or innovation clusters [64,182–184]. It can be attributed to a well-established local business environment in terms of cooperative networking between innovation actors with government supporting programs for specific regional sectors [57,60–62]. Overall, based on the identification of sectoral and regional differences on innovation success and failure across all sectors and regions statistically, their significant impact on innovation is reaffirmed, and it provides a basic ground for the sectoral and regional innovation system in the current business landscape.

6. Implications and Conclusions

After the SAPPHO project for testing generalizations regarding innovation success and failure was conducted by SPRU during the 1970s [15–17], innovation studies have evolved and gradually focused on specific subjects to identify in-depth mechanisms of innovation behavior [18–21,23]. However, previous innovation studies have been tied down by the characteristics, types, and empirical scope of innovation data with statistical methodology; this limitation is also attributed to the various definitions of innovations and proxy measurements on innovation. Although the general consensus on influencing factors and behavior has been widely accepted, there are conflicting arguments or insignificant conclusions drawn in different contexts. They also lack comprehensive and sustainable perspectives.

This study contributes toward expanding the methodological landscape with advanced data mining methodology; it also increases the feasibility of using innovation data on a large scale. It also contributes toward obtaining the overall significant influencing factors in a single framework by considering all the variables together, which are determined from previous studies. It also maintains international consistency based on the guidance of the Oslo manual. Unlike previous studies that focused on micro perspectives with various controversies, this study takes a comprehensive approach toward investigating sustainable factors and behavior, based on a macro and single statistical framework by using DT with 10-cross validation.

Concerning factors and behaviors influencing innovation success and failure at a national level, R&D is crucial for innovation success in terms of the capacity for carrying out R&D. As a result, the
role of R&D [18,19,35,57,61,62,67,74,102–105,108–112] and the ratio of R&D personnel [102,103] positively affect the success of innovation. Even if there is no R&D activity, the result of this study supports the arguments that the larger the firm size [86–91] and the older the firm age [95,96], the greater the success achieved by firms will be. Concerning firm size, findings in this study are consistent with previous studies that the employee size level [85–92], sales level [74,77,78,103,150], and exports level [61,67,96,108,150] significantly affect the success of innovation. Additionally, it is witnessed that innovation behavior is affected by regional [42,58,60–62,64–66] and sectoral [29,39–45] differences. Concerning the industrial differences, it is inferred that firms belonging to a low-technology industry prefer other innovation activities rather than R&D. Concerning managerial or political implications based on the above findings, this study reemphasizes the importance of preparing and strengthening an overall support program for not only implementing R&D in collaboration with R&D institutes or organizations but also for increasing the number of R&D personnel employed for innovating products or processes [1,2,111,134,166]. Additionally, in terms of extrinsic factors of the business environment, the regional and sectoral innovation landscape should be focused on to establish and strengthen the innovation support program [1,2,64–66].

Concerning the factors and behaviors of successful innovative firms, this study first observed them in terms of financial contribution. Previous studies have dealt with the financial performance of innovation [7,18,148–152], but they did not cover the factors and behaviors of differences between high and low innovation contributions of groups to financial performance. As a result, this study identified the influencing factors and four types of behavior between those groups. The first type of firms with a financial contribution from innovation focuses on in-house R&D with information from the private customer. The second type focuses on marketing with information from the public customer. The third type focuses on using information from higher educational institutes. The last type focuses on their own information and does not invest heavily in assets. These findings show that the behavior related to activity and information use [62,80,165–167] for innovation is influenced by target market characteristics. It is consistent with the argument that market characteristics drive firms to seek market needs and to advertise [22,47,69,79–84]. Overall, intrinsic innovation activity-related factors are identified to exert a significant influence on innovation behavior rather than the extrinsic factors related to the general innovation capacity of firms, in terms of innovation’s contribution to financial performance. To increase the contribution of innovation to a firm’s financial performance, a policy should be implemented to level up the information environment and to build a public or private system to provide diverse market information. Additionally, managers should strengthen the activity to seek information corresponding to the target market to which the firm belongs.

To fulfill the lack of studies on the difference in the nature of a firm’s innovation behavior to engage in R&D and non-R&D activities, this study identified their behavioral characteristics in terms of the overall innovation activity. Generally, firms prefer implementing R&D activities at a low cost across sectors. However, in low-technology sectors, firms prefer non-R&D activities. Additionally, well-established business environments, such as metropolitan areas, help firms reduce non-R&D activities as well as associated costs. The aforementioned findings of this study on innovation behavior reaffirm that the main way of carrying out R&D [18,19,35,57,61,62,67,74,102–105,108–112], the industrial difference with the technological dynamism [29,39–42], and regional characteristics of a well-established business environment [42,58,60–62] play a major role in the behavior associated with innovation activities. In terms of the overall R&D activity involving in-house R&D, cooperative R&D, and no R&D with higher resolution, this study found that a majority of firms having R&D institutes focus on carrying out in-house R&D only with their own information. However, it is also witnessed that some firms having R&D institutes carry out cooperative R&D with external R&D-related information. As a result, these findings support the claim that successful innovative firms do not prefer cooperative R&D due to its instability and risks [124–129]. This finding is also consistent with claims that cooperative R&D activities are carried out to close the capability gaps for innovation [61]. However, an absorptive capacity, such as R&D institutes or a dedicated R&D department, is required to
complement cooperative R&D [114,130–132,136,137]. Concerning managerial or political implications, it should mainly prepare and strengthen an R&D support program in terms of the R&D budget as well as establish a business environment for non-R&D activity for both in-house R&D and cooperative R&D [1,2,64–66,138].

According to the main objectives, this study reaffirmed the roles of significant factors influencing innovation, such as R&D, size, and age, that are claimed in previous studies, and investigated the firm’s behavior in intrinsic innovation activities from an overall perspective. In addition, sector and region are identified as significant factors affecting innovation success and failure, and the firm’s behavior is affected by the characteristics of these factors in relation to the target market. Subsequently, the differences of innovation success between sectors, regions, and across the sectors and regions were verified statistically, which was preliminary assumed but was not tested in previous studies. This provides ground for sectoral and regional diversity for scholars studying the sectoral and regional innovation system in the current business landscape. Careful discriminatory approaches should be taken to design an innovation system according to the innovation mechanisms and patterns, and characteristics of innovation players from the perspectives of the sectoral and regional innovation system [182,184].

The findings and implications presented in this study are beneficial to understand factors influencing innovation and behavior, from a comprehensive and sustainable viewpoint; especially, the DT methodology allows various types of innovation data to be addressed together in a single statistical framework. Despite the contribution, this study carries a limitation. The underlying mechanism involving DT as a non-parametric analysis is difficult to comprehend. Additionally, methodologically, there is room for enhancing the predictive power by altering the algorithm conditions in terms of tree depth, recursive calculation level, misclassification cost adjustment, the node scale related to the data class and size, and data balancing to avoid overfitting and underfitting. Even though it can interpret results easily, highly predict performance with 10-fold cross-validation, and allow unrestricted application without requiring underlying assumptions on data distribution, an in-depth scenario-based analysis of DT is required to fathom the ambiguous mechanism of innovation behavior. Theoretically and practically, different categorical classification principles and their levels can be considered to develop a research framework for other research questions. More extended or detailed standards of the innovation spectrum can be applied to specific research scopes from political and managerial viewpoints.

Furthermore, the approach of this study to shed light on the comprehensive knowledge of innovation behavior has important implications for scholars investigating innovation behavior. Most of the existing studies on innovation focus on in-depth behavior with narrow research scopes based on advanced statistical methodologies. Hence, over time, there have been conflicts in innovation behavior in the overall business landscape with different contexts. Additionally, it is important to understand factors influencing innovation and innovation behavior continuously from a contemporary perspective. In this sense, during each contemporary period, future studies can be replicated by applying the DT methodology from a comprehensive perspective. With guidance from the Oslo Manual, such studies, conducted at a global level, must maintain international consistency. For comparativeness, these studies must refer to the revised fourth edition of the Oslo Manual. Future studies should collect and use a large sample in time series and in multiple cross-country settings to improve the sustainability of the results of the analysis and draw a more generalizable consensus.

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### Appendix A

#### Table A1. Variable codes, description, value, response, and type in Modules 1 and 2.

| Variable Code | Measurement Description | Variable Value | Response | Type |
|---------------|-------------------------|----------------|----------|------|
| KIS 2014      | KIS 2016                |                |          |      |
| Q 1_1         | Form of firm            | Independent company | 1 | Nominal |
| Q 1_2         | Statutory types (by the size of employee from sample selection) | Large-sized company | 1 | Nominal |
| Q 1_3_1       | Designation status on corporative certification in Korea | Venture company | 1 | Nominal |
| Q 1_3_2       |                           | KOSPI           | 1 | Nominal |
| Q 1_3_3       |                           | KOSDAQ          | 2 | Nominal |
| Q 1_4         | Listed status in Korean stock market | KOSPI | 1 | Nominal |
| Q 1_5         | Listed status in Korean stock market | KOSDAQ | 2 | Nominal |
| Q 1_6         | Listed status in Korean stock market | KOSDAQ | 3 | Nominal |
| Q 2_1_1       | size of sales            | Level of actual sales in three years ago | 0. None | Ordinal |
| Q 2_1_2       |                           | Level of actual sales in two years ago | 1. ~1 BW | Ordinal |
| Q 2_1_3       |                           | Level of actual sales in one year ago | 2. 1 BW–5 BW | Ordinal |
| Q 2_2_1       | size of exports          | Level of actual exports in three years ago | 3. 5 BW–10 BW | Ordinal |
| Q 2_2_2       |                           | Level of actual exports in two years ago | 4. 10 BW–50 BW | Ordinal |
| Q 2_2_3       |                           | Level of actual exports in one year ago | 5. 50 BW–100 BW | Ordinal |
| Q 3_1_1       | size of employee         | Level of actual employee in three years ago | 1. ~49 | Ordinal |
| Q 3_1_2       |                           | Level of actual employee in two years ago | 2. 50–99 | Ordinal |
| Q 3_1_3       |                           | Level of actual employee in one year ago | 3. 100–299 | Ordinal |
| Q 3_1_6       | Ratio of R&D personnel  | Level of percentage of R&D personnel in the last year | 4. 300–499 | Ordinal |
| Q 3_1_7       |                           | Level of percentage of R&D personnel in the last year | 5. 500– | Ordinal |
| Q 5_1         | Main regional target market in the world (multiple response) | Domestic | If yes, 1; else, blank | Nominal |
| Q 5_2         |                           | Asia            | If yes, 2; else, blank | Nominal |
| Q 5_3         |                           | Europe          | If yes, 3; else, blank | Nominal |
| Q 5_4         |                           | North America   | If yes, 4; else, blank | Nominal |
| Q 5_5         |                           | Others          | If yes, 5; else, blank | Nominal |
| Q 6           | Manner of R&D activities (main ways performing R&D) | R&D institutes | 1 | Nominal |
| Q 7           | Main customer types      | Private company | 1 | Nominal |
| Q 8_1         | Industrial code          | 23 codes in the manufacturing industry are in Appendix B | Code number | Nominal |
| Q 8_2         | Region (17 area)         | Seoul, busan, daejeon, daegu, incheon, gwangju, sejong, ulsan, Gyeonggi, Chungcheongbuk, Chungcheongnam, Gyeongnam, Jeollabuk, Jeollnam, Jeju | Region name | Nominal |
| Age           | Firm age                 | Firm age | Number | Interval |
Table A2. Variable codes, description, value, response, and type in Module 2 (added on Module 1).

| Variable Code | Measurement Description | Variable Value | Response | Scale |
|---------------|--------------------------|----------------|----------|-------|
| KIS 2014 KIS 2016 | Description | Value | | |
| Q 18_1 In-house R&D | Performing in-house R&D in last three years | If yes, 1; else, 2 | Nominal |
| Q 18_2 Cooperative R&D | Performing cooperative R&D in last three years | | |
| Q 18_3 External R&D | Performing external R&D in last three years | | |
| Q 18_4 Acquiring machine, tool, software, and building | Acquiring machine, tool, software, and building in last three years | | |
| Q 18_5 Procuring external knowledge | Procuring external knowledge in last three years | | |
| Q 18_6 Providing job training | Providing job training in last three years | | |
| Q 18_7 Market launching activities | Market launching activities in last three years | | |
| Q 18_8 Design activities | Design activities in last three years | | |
| Q 18_9 Others | Others in last three years | | |
| Q 19_1 Total innovation cost for all innovation activities in the last year | Level of total cost for innovation activities in the last year | 0. None | Ordinal |
| Q 19_2 Level of percentage of each innovation activity cost | Level of percentage of cost on in-house R&D | 0. 0% | |
| Q 19_3 Level of percentage of cost on external R&D | 1. ~25% | | |
| Q 19_4 Level of percentage of cost on acquisition of machine, tool, software, and building | 2. 26%~50% | | |
| Q 19_5 Level of percentage of cost on buying external knowledge | 3. 51%~75% | | |
| Q 20 Source of budget in the last three years | Level of percentage of cost on others | 4. 76%~100% | Nominal |
| Q 20 Owned capital | d.k. unknown | | |
| Q 20 Affiliate fund | | | |
| Q 20 Government fund | | | |
| Q 20 Loan | | | |
| Q 20 Stock Issuance | | | |
| Q 20 Corporate Bond fund | | | |
| Q 20 No expenditure | | | |
| Q 20 Others | | | |
| Q 20 | | | |
| Q 21 a1 In-house or within the affiliate | In-house or within the affiliate | | Nominal |
| Q 21 a2 Supplier | Supplier | In 2014, use or not | Nominal |
| Q 21 a3 Private customer | Private customer | If yes, 1; else, 2 | |
| Q 21 a4 Public customer | Public customer | In 2016, Use and importance | |
| Q 21 a5 Competitors in the same sector | Competitors in the same sector | 0. No use | |
| Q 21 a6 Private service firms | Private service firms | 1. Use and low importance | |
| Q 21 a7 Higher educational institutes | Higher educational institutes | 2. Use and middle importance | |
| Q 21 a8 Institutes of government, public, and private sector | Institutes of government, public, and private sector | 3. Use and high importance | |
| Q 21 a9 Conference, exhibition, and fair | Conference, exhibition, and fair | | |
| Q 21 a10 Professional journal and publications | | | |
| Q 21 a11 Industrial association | | | |
| Q 21 b Cooperative activities | Whether or not cooperative activity implement | If yes, 1; else, 2 | Nominal |
| Q 23 a Cooperative partner | | | Nominal |
Table A2. Cont.

| Variable Code | Measurement Description | Variable Value | Response | Scale |
|---------------|-------------------------|----------------|----------|-------|
| KIS 2014 | KIS 2016 | Affiliates | 1 | |
| | | Supplier | 2 | |
| | | Private customer | 3 | |
| | | Public customer | 4 | |
| Q 24 | Best cooperative partner | Competitors in the same sector | 5 | |
| | | Private service firms | 6 | |
| | | Higher educational institutes | 7 | |
| | | Institutes of government, public, and private sector | 8 | |

Appendix B

Table A3. Industrial code on the manufacturing industry.

| Code | Description |
|------|-------------|
| 10 | Manufacture of food products |
| 11 | Manufacture of beverages |
| 13 | Manufacture of textiles, except apparel |
| 14 | Manufacture of wearing apparel, clothing accessories and fur articles |
| 15 | Manufacture of leather, luggage and footwear |
| 16 | Manufacture of wood and of products of wood and cork; except furniture |
| 17 | Manufacture of pulp, paper and paper products |
| 18 | Printing and reproduction of recorded media |
| 19 | Manufacture of coke, briquettes and refined petroleum products |
| 20 | Manufacture of chemicals and chemical products; except pharmaceuticals and medicinal chemicals |
| 21 | Manufacture of pharmaceuticals, medicinal chemical and botanical products |
| 22 | Manufacture of rubber and plastics products |
| 23 | Manufacture of other non-metallic mineral products |
| 24 | Manufacture of basic metals |
| 25 | Manufacture of fabricated metal products, except machinery and furniture |
| 26 | Manufacture of electronic components, computer; visual, sounding and communication equipment |
| 27 | Manufacture of medical, precision and optical instruments, watches and clocks |
| 28 | Manufacture of electrical equipment |
| 29 | Manufacture of other machinery and equipment |
| 30 | Manufacture of motor vehicles, trailers and semitrailers |
| 31 | Manufacture of other transport equipment |
| 32 | Manufacture of furniture |
| 33 | Other manufacturing |
Appendix C

Figure A1. DT result of an overall model in 2014.

Figure A1. DT result of an overall model in 2014.
Figure A2. DT result of an overall model in 2016.
Figure A3. DT results of (a) a contribution model in 2014 and (b) a contribution model in 2016.
Figure A4. DT result of an innovation activities model in 2014.
Figure A5. DT result of an innovation activities model in 2016.
Figure A6. DT result of an R&D activities model in 2014.
Figure A7. DT result of an R&D activities model in 2016.
### Appendix D

**Table A4.** Cross-tabulation between sectors and innovation success and failure in KIS 2014.

| Sectors | Failure | Innovation | Total | Success | Innovation | Total |
|---------|---------|------------|-------|---------|------------|-------|
| Count   | Expected | % Within | Count   | Expected | % Within | Count   | Expected | % Within | Count   | Expected | % Within |
|         | Count   | % of Total | Count   | % of Total | % of Total | Count   | % of Total | % of Total | Count   | % of Total | % of Total |
| 10      | 158     | 5.1%      | 82      | 57.0     | 8.5%      | 240     | 240.0     | 5.9%      | 100.0   | 5.9%      | 100.0     |
| 11      | 12      | 0.4%      | 6        | 4.3      | 0.6%      | 18      | 18.0      | 0.4%      | 100.0   | 0.4%      | 100.0     |
| 12      | 145     | 4.7%      | 23      | 39.9     | 2.4%      | 168     | 168.0     | 4.1%      | 100.0   | 4.1%      | 100.0     |
| 13      | 97      | 3.1%      | 13      | 26.1     | 1.3%      | 110     | 110.0     | 2.7%      | 100.0   | 2.7%      | 100.0     |
| 14      | 27      | 0.9%      | 9       | 8.5      | 0.9%      | 36      | 36.0      | 0.9%      | 100.0   | 0.9%      | 100.0     |
| 15      | 33      | 1.1%      | 7       | 9.5      | 0.7%      | 40      | 40.0      | 1.0%      | 100.0   | 1.0%      | 100.0     |
| 16      | 81      | 2.6%      | 12      | 22.1     | 1.2%      | 93      | 93.0      | 2.3%      | 100.0   | 2.3%      | 100.0     |
| 17      | 55      | 1.8%      | 8       | 14.9     | 0.8%      | 63      | 63.0      | 1.5%      | 100.0   | 1.5%      | 100.0     |
| 18      | 16      | 13.0%     | 4       | 4.0      | 0.1%      | 17      | 17.0      | 0.4%      | 100.0   | 0.4%      | 100.0     |
| 19      | 109     | 3.5%      | 64      | 41.1     | 6.6%      | 173     | 173.0     | 4.2%      | 100.0   | 4.2%      | 100.0     |
| 20      | 25      | 41.9%     | 30      | 13.1     | 3.1%      | 55      | 55.0      | 1.3%      | 100.0   | 1.3%      | 100.0     |
| 21      | 237     | 7.6%      | 63      | 71.2     | 6.5%      | 300     | 300.0     | 7.4%      | 100.0   | 7.4%      | 100.0     |
| 22      | 136     | 4.4%      | 29      | 39.2     | 3.0%      | 165     | 165.0     | 4.0%      | 100.0   | 4.0%      | 100.0     |
| 23      | 154     | 5.0%      | 26      | 42.7     | 2.7%      | 180     | 180.0     | 4.4%      | 100.0   | 4.4%      | 100.0     |
| 24      | 424     | 13.6%     | 83      | 120.3    | 8.6%      | 507     | 507.0     | 12.4%     | 100.0   | 12.4%     | 100.0     |
| 25      | 218     | 7.0%      | 115     | 79.0     | 11.9%     | 333     | 333.0     | 8.2%      | 100.0   | 8.2%      | 100.0     |
| 26      | 86      | 109.1%    | 57      | 33.9     | 5.9%      | 143     | 143.0     | 3.5%      | 100.0   | 3.5%      | 100.0     |
| 27      | 165     | 199.8%    | 97      | 62.2     | 10.0%     | 262     | 262.0     | 6.4%      | 100.0   | 6.4%      | 100.0     |
| 28      | 436     | 435.5%    | 135     | 135.5    | 14.0%     | 571     | 571.0     | 14.0%     | 100.0   | 14.0%     | 100.0     |
| 29      | 249     | 244.8%    | 72      | 76.2     | 7.4%      | 321     | 321.0     | 7.9%      | 100.0   | 7.9%      | 100.0     |
| 30      | 144     | 117.5%    | 10      | 36.5     | 1.0%      | 154     | 154.0     | 3.8%      | 100.0   | 3.8%      | 100.0     |
| 31      | 45      | 45.0%     | 14      | 14.0     | 1.4%      | 59      | 59.0      | 1.4%      | 100.0   | 1.4%      | 100.0     |
| 32      | 56      | 51.1%     | 11      | 15.9     | 1.1%      | 67      | 67.0      | 1.6%      | 100.0   | 1.6%      | 100.0     |
| Total   | 3108    | 3108.0%   | 967     | 967.0    | 100.0%    | 4075    | 4075.0    | 100.0%    | 100.0   | 100.0%    | 100.0%    |
### Table A5. Cross-tabulation between sectors and innovation success and failure in KIS 2016.

| Sectors | Failure | Success | Total |
|---------|---------|---------|-------|
|         | Count   | Expected Count | % Within Innovation | % Within Sector | % of Total | Count | Expected Count | % Within Innovation | % Within Sector | % of Total |
| 10      | 98      | 124.6    | 4.1%    | 46.9%    | 2.5%    | 111 | 84.4    | 6.9%    | 53.1%    | 2.8%    | 209 | 209.0    | 5.2%    | 100.0% |
| 11      | 14      | 11.9     | 0.6%    | 70.0%    | 0.4%    | 6   | 8.1     | 0.4%    | 30.0%    | 0.2%    | 20   | 20.0     | 0.5%    | 100.0% |
| 12      | 109     | 74.5     | 4.6%    | 87.2%    | 2.7%    | 16  | 50.5    | 1.0%    | 12.8%    | 0.4%    | 125  | 125.0    | 3.1%    | 100.0% |
| 13      | 78      | 68.5     | 3.3%    | 67.8%    | 2.0%    | 37  | 46.5    | 2.3%    | 32.2%    | 0.9%    | 115  | 115.0    | 2.9%    | 100.0% |
| 14      | 16      | 16.1     | 0.7%    | 59.3%    | 0.4%    | 11  | 10.9    | 0.7%    | 40.7%    | 0.3%    | 27   | 27.0     | 0.7%    | 100.0% |
| 15      | 16      | 19.7     | 0.7%    | 48.5%    | 0.4%    | 17  | 13.3    | 1.1%    | 51.5%    | 0.4%    | 33   | 33.0     | 0.8%    | 100.0% |
| 16      | 56      | 54.8     | 2.3%    | 60.9%    | 1.4%    | 36  | 37.2    | 2.2%    | 39.1%    | 0.9%    | 92   | 92.0     | 2.3%    | 100.0% |
| 17      | 34      | 25.0     | 1.4%    | 81.0%    | 0.9%    | 8   | 17.0    | 0.5%    | 19.0%    | 0.2%    | 42   | 42.0     | 1.1%    | 100.0% |
| 18      | 16      | 11.3     | 0.7%    | 84.2%    | 0.4%    | 3   | 7.7     | 0.2%    | 15.8%    | 0.1%    | 19   | 19.0     | 0.5%    | 100.0% |
| 19      | 99      | 97.7     | 4.2%    | 60.4%    | 2.5%    | 65  | 66.3    | 4.0%    | 39.6%    | 1.6%    | 164  | 164.0    | 4.1%    | 100.0% |
| 20      | 6       | 17.3     | 0.3%    | 20.7%    | 0.2%    | 23  | 11.7    | 1.4%    | 79.3%    | 0.6%    | 29   | 29.0     | 0.7%    | 100.0% |
| 21      | 226     | 217.5    | 9.5%    | 61.9%    | 5.7%    | 139 | 147.5   | 8.6%    | 38.1%    | 3.5%    | 365  | 365.0    | 9.1%    | 100.0% |
| 22      | 96      | 78.7     | 4.0%    | 72.7%    | 2.4%    | 36  | 53.3    | 2.2%    | 27.3%    | 0.9%    | 132  | 132.0    | 3.3%    | 100.0% |
| 23      | 158     | 123.4    | 6.6%    | 76.3%    | 4.0%    | 49  | 83.6    | 3.0%    | 23.7%    | 1.2%    | 207  | 207.0    | 5.2%    | 100.0% |
| 24      | 314     | 240.8    | 13.2%   | 77.7%    | 7.9%    | 90  | 163.2   | 5.6%    | 22.3%    | 2.3%    | 404  | 404.0    | 10.1%   | 100.0% |
| 25      | 154     | 214.6    | 6.5%    | 42.8%    | 3.9%    | 206 | 145.4   | 12.7%   | 57.2%    | 5.2%    | 360  | 360.0    | 9.0%    | 100.0% |
| 26      | 94      | 99.5     | 3.9%    | 56.3%    | 2.4%    | 73  | 67.5    | 4.5%    | 43.7%    | 1.8%    | 167  | 167.0    | 4.2%    | 100.0% |
| 27      | 41      | 152      | 9.4%    | 53.1%    | 3.8%    | 134 | 115.5   | 8.3%    | 46.9%    | 3.4%    | 286  | 286.0    | 7.2%    | 100.0% |
| 28      | 258     | 340.3    | 10.8%   | 45.2%    | 6.5%    | 313 | 230.7   | 19.4%   | 54.8%    | 7.8%    | 571  | 571.0    | 14.3%   | 100.0% |
| 29      | 200     | 238.4    | 8.4%    | 50.0%    | 5.0%    | 200 | 161.6   | 12.4%   | 50.0%    | 5.0%    | 400  | 400.0    | 10.0%   | 100.0% |
| 30      | 31      | 51       | 2.1%    | 75.0%    | 1.3%    | 17  | 27.5    | 1.1%    | 25.0%    | 0.4%    | 68   | 68.0     | 1.7%    | 100.0% |
| 31      | 31      | 21.5     | 1.3%    | 86.1%    | 0.8%    | 5   | 14.5    | 0.3%    | 13.9%    | 0.1%    | 36   | 36.0     | 0.9%    | 100.0% |
| Total   | 2384    | 2384.0   | 100.0%  | 59.6%    | 59.6%   | 1616| 1616.0  | 100.0%  | 40.4%    | 40.4%   | 4000 | 4000.0   | 100.0%  | 100.0% |
Table A6. Cross-tabulation between regions and innovation success and failure in KIS 2014.

| Region          | Innovation Total | Failure | Success | Total |
|-----------------|------------------|---------|---------|-------|
|                 | Count | Expected Count | % Within Region | % of Total | Count | Expected Count | % Within Region | % of Total | Count | Expected Count | % Within Region | % of Total | % of Total |
| Busan           | 303   | 289.1 | 79.9% | 9.7% | 7.4% | 76     | 89.9 | 20.1% | 7.9% | 1.9% | 379     | 379.0 | 100.0% | 9.3% | 9.3% |
| Chungcheongbuk   | 133   | 135.0 | 75.1% | 4.3% | 3.3% | 44     | 42.0 | 24.9% | 4.6% | 1.1% | 177     | 177.0 | 100.0% | 4.3% | 4.3% |
| ChungCheongnam   | 162   | 159.4 | 77.5% | 5.2% | 4.0% | 47     | 49.6 | 22.5% | 4.9% | 1.2% | 209     | 209.0 | 100.0% | 5.1% | 5.1% |
| Daegu           | 146   | 144.9 | 76.8% | 4.7% | 3.6% | 44     | 45.1 | 23.2% | 4.6% | 1.1% | 190     | 190.0 | 100.0% | 4.7% | 4.7% |
| Daejeon         | 69    | 77.8  | 67.6% | 2.2% | 1.7% | 33     | 24.2 | 32.4% | 3.4% | 0.8% | 102     | 102.0 | 100.0% | 2.5% | 2.5% |
| Gwangju         | 43    | 42.7  | 76.8% | 1.4% | 1.1% | 13     | 13.3 | 23.2% | 1.3% | 0.3% | 56      | 56.0  | 100.0% | 1.4% | 1.4% |
| Gwangju         | 77    | 72.5  | 81.1% | 2.5% | 1.9% | 18     | 22.5 | 18.9% | 1.9% | 0.4% | 95      | 95.0  | 100.0% | 2.3% | 2.3% |
| Gyeongbuk       | 232   | 212.8 | 83.2% | 7.5% | 5.7% | 47     | 66.2 | 16.8% | 4.9% | 1.2% | 279     | 279.0 | 100.0% | 6.8% | 6.8% |
| Gyeonggi        | 874   | 900.0 | 74.1% | 28.1% | 21.4% | 306    | 280.0 | 25.9% | 31.6% | 7.5% | 1180    | 1180.0 | 100.0% | 29.0% | 29.0% |
| Gyeongnam       | 283   | 264.7 | 81.6% | 9.1% | 6.9% | 64     | 82.3 | 18.4% | 6.6% | 1.6% | 347     | 347.0 | 100.0% | 8.5% | 8.5% |
| Incheon         | 139   | 149.5 | 79.9% | 4.5% | 3.4% | 57     | 46.5 | 29.1% | 5.9% | 1.4% | 196     | 196.0 | 100.0% | 4.8% | 4.8% |
| Jeju            | 3     | 5.3   | 42.9% | 0.1% | 0.1% | 4      | 1.7   | 57.1% | 4.4% | 0.1% | 7       | 7.0   | 100.0% | 0.2% | 0.2% |
| Jeollabuk       | 110   | 96.1  | 87.3% | 3.5% | 2.7% | 16     | 29.9 | 12.7% | 1.7% | 0.4% | 126     | 126.0 | 100.0% | 3.1% | 3.1% |
| Jeollabum       | 86    | 79.3  | 82.7% | 2.8% | 2.1% | 18     | 24.7 | 17.3% | 1.9% | 0.4% | 104     | 104.0 | 100.0% | 2.6% | 2.6% |
| Sejong          | 5     | 5.3   | 71.4% | 0.2% | 0.1% | 2      | 1.7   | 28.6% | 2%   | 0.0% | 7       | 7.0   | 100.0% | 0.2% | 0.2% |
| Seoul           | 315   | 363.8 | 66.0% | 10.1% | 7.7% | 162    | 113.2 | 34.0% | 16.8% | 4.0% | 477     | 477.0 | 100.0% | 11.7% | 11.7% |
| Ulsan           | 128   | 109.8 | 88.9% | 4.1% | 3.1% | 16     | 34.2 | 11.1% | 1.7% | 0.4% | 144     | 144.0 | 100.0% | 3.5% | 3.5% |
| Total           | 3108  | 3108.0 | 76.3% | 100.0% | 76.3% | 967    | 967.0 | 23.7% | 100.0% | 23.7% | 4075    | 4075.0 | 100.0% | 100.0% | 100.0% |
Table A7. Cross-tabulation between regions and innovation success and failure in KIS 2016.

| Region         | Failure        | Innovation     | Total           |
|----------------|----------------|----------------|-----------------|
|                | Count | Expected Count | % Within Region | % of Total | Count | Expected Count | % Within Region | % of Total | Count | Expected Count | % Within Region | % of Total |
| Busan          | 128   | 147.8          | 5.4%            | 51.6%       | 120   | 102.2          | 7.4%            | 48.4%       | 248   | 248.0          | 6.2%            | 100.0%     |
| Chungcheongbuk  | 87    | 103.1          | 3.6%            | 50.3%       | 86    | 69.9           | 5.3%            | 49.7%       | 173   | 173.0          | 4.3%            | 100.0%     |
| Chungcheongnam  | 114   | 133.5          | 4.8%            | 50.9%       | 110   | 90.5           | 6.8%            | 49.1%       | 224   | 224.0          | 5.6%            | 100.0%     |
| Daegu           | 87    | 118.0          | 3.6%            | 43.9%       | 111   | 80.0           | 6.9%            | 56.1%       | 198   | 198.0          | 5.0%            | 100.0%     |
| Daejeon         | 33    | 46.5           | 1.4%            | 42.3%       | 45    | 31.5           | 2.6%            | 57.7%       | 78    | 78.0           | 2.0%            | 100.0%     |
| Gwangju         | 55    | 53.6           | 2.3%            | 61.1%       | 35    | 36.4           | 2.2%            | 38.9%       | 90    | 90.0           | 2.3%            | 100.0%     |
| Gyeongbuk       | 197   | 187.7          | 8.3%            | 62.5%       | 118   | 127.3          | 7.3%            | 37.5%       | 315   | 315.0          | 7.9%            | 100.0%     |
| Gyeonggi        | 887   | 770.6          | 37.2%           | 68.6%       | 406   | 522.4          | 25.1%           | 31.4%       | 1293  | 1293.0         | 32.3%           | 100.0%     |
| Gyeongnam       | 272   | 243.2          | 11.4%           | 66.7%       | 136   | 164.8          | 8.4%            | 33.3%       | 408   | 408.0          | 10.2%           | 100.0%     |
| Incheon         | 149   | 193.7          | 6.3%            | 45.8%       | 176   | 131.3          | 10.9%           | 54.2%       | 325   | 325.0          | 8.1%            | 100.0%     |
| Jeju            | 2     | 2.4            | 0.1%            | 50.0%       | 2     | 1.6            | 0.1%            | 50.0%       | 4     | 4.0            | 0.1%            | 100.0%     |
| Jeollabuk       | 60    | 53.0           | 2.5%            | 67.4%       | 29    | 36.0           | 1.8%            | 32.6%       | 89    | 89.0           | 2.2%            | 100.0%     |
| Jeollabuk       | 62    | 54.2           | 2.6%            | 68.1%       | 29    | 36.8           | 1.8%            | 31.9%       | 91    | 91.0           | 2.3%            | 100.0%     |
| Seoul           | 115   | 152.6          | 4.8%            | 44.9%       | 141   | 103.4          | 8.7%            | 55.1%       | 256   | 256.0          | 6.4%            | 100.0%     |
| Ulsan           | 90    | 78.7           | 3.8%            | 68.2%       | 42    | 53.3           | 2.6%            | 31.8%       | 132   | 132.0          | 3.3%            | 100.0%     |
| Total           | 2384  | 2384.0         | 100.0%           | 59.6%       | 1616  | 1616.0         | 100.0%           | 40.4%       | 4000  | 4000.0         | 100.0%           | 100.0%     |
| Region          | Count | Expected Count | % within region | % within sector | % of Total |
|-----------------|-------|----------------|-----------------|-----------------|------------|
| **Busan**       |       |                |                 |                 |            |
| Count           | 2     | 0              | 4               | 2               | 3          |
| Expected Count  | 6.4   | 0.5            | 1.8             | 1.0             | 0.7        |
| % within region | 2.6%  | 0.0%           | 5.3%            | 2.6%            | 3.9%       |
| % within sector | 2.4%  | 0.0%           | 17.4%           | 154%            | 33.3%      |
| % of Total      | 0.2%  | 0.0%           | 0.4%            | 0.2%            | 0.3%       |
| **Chungcheongbuk** |       |                |                 |                 |            |
| Count           | 12    | 0              | 0               | 0               | 0          |
| Expected Count  | 3.7   | 0.3            | 1.0             | 0.6             | 0.4        |
| % within region | 27.3% | 0.0%           | 0.0%            | 0.0%            | 0.0%       |
| % within sector | 14.6% | 0.0%           | 0.0%            | 0.0%            | 0.0%       |
| % of Total      | 1.2%  | 0.0%           | 0.0%            | 0.0%            | 0.0%       |
| **Chungcheongnam** |       |                |                 |                 |            |
| Count           | 7     | 0              | 0               | 0               | 0          |
| Expected Count  | 4.0   | 0.3            | 1.1             | 0.6             | 0.4        |
| % within region | 14.9% | 0.0%           | 0.0%            | 0.0%            | 0.0%       |
| % within sector | 8.5%  | 0.0%           | 0.0%            | 0.0%            | 0.0%       |
| % of Total      | 0.7%  | 0.0%           | 0.0%            | 0.0%            | 0.0%       |
| **Daejeon**     |       |                |                 |                 |            |
| Count           | 1     | 0              | 1               | 2               | 0          |
| Expected Count  | 3.7   | 0.3            | 1.0             | 0.6             | 0.4        |
| % within region | 2.3%  | 0.0%           | 9.1%            | 2.3%            | 4.5%       |
| % within sector | 1.2%  | 0.0%           | 17.4%           | 7.7%            | 8.3%       |
| % of Total      | 0.1%  | 0.0%           | 0.4%            | 0.1%            | 0.2%       |
| **Deokju**      |       |                |                 |                 |            |
| Count           | 0     | 2              | 1               | 0               | 0          |
| Expected Count  | 2.8   | 0.2            | 0.8             | 0.4             | 0.3        |
| % within region | 0.0%  | 6.1%           | 3.0%            | 0.0%            | 0.0%       |
| % within sector | 0.0%  | 33.3%          | 4.3%            | 0.0%            | 0.0%       |
| % of Total      | 0.0%  | 0.2%           | 0.1%            | 0.0%            | 0.0%       |

**Table A8. Cross-tabulation between regions and sectors in KIS 2014.**
| Region    | Count | Expected Count | % within region | % within sector | % of Total |
|-----------|-------|----------------|-----------------|-----------------|------------|
| Gyeonggi  | 120   | 25.9           | 12.8%           | 7.3%            | 12.8%      |
| Gyeongnam | 25.9  | 12.8%          | 7.3%            | 12.8%           | 12.8%      |
| Gyeonnam  | 25.9  | 12.8%          | 7.3%            | 12.8%           | 12.8%      |
| Gyeongbuk | 25.9  | 12.8%          | 7.3%            | 12.8%           | 12.8%      |

**Note:** The table contains data on counts and expected counts for different regions, along with percentages within the region and sector. The last column provides the total percentage of each category.
| Region       | Sector | Count   | Expected Count | % within region | % within sector | % of Total |
|--------------|--------|---------|----------------|-----------------|-----------------|------------|
| Incheon      | 10     | 4       | 4.8            | 7.0%            | 4.9%            | 0.4%       |
|              | 11     | 0       | 0.4            | 0.0%            | 0.0%            | 0.0%       |
|              | 13     | 1       | 1.4            | 0.0%            | 0.0%            | 0.0%       |
|              | 14     | 0       | 0.5            | 0.0%            | 0.0%            | 0.0%       |
|              | 15     | 0       | 0.4            | 0.0%            | 0.0%            | 0.0%       |
|              | 16     | 0       | 0.7            | 0.0%            | 0.0%            | 0.0%       |
|              | 17     | 0       | 0.5            | 0.0%            | 0.0%            | 0.0%       |
|              | 18     | 0       | 1.8            | 1.8%            | 1.8%            | 0.2%       |
|              | 19     | 0       | 3.7            | 17.5%           | 17.5%           | 5.9%       |
|              | 20     | 1       | 1.7            | 3.5%            | 3.5%            | 0.4%       |
|              | 21     | 0       | 10.5%          | 17.5%           | 17.5%           | 0.6%       |
|              | 22     | 0       | 1.2%           | 1.0%            | 1.0%            | 0.0%       |
|              | 23     | 0       | 0.6%           | 1.0%            | 1.0%            | 0.0%       |
| Jeju         | 24     | 0       | 0.0%           | 0.0%            | 0.0%            | 0.0%       |
|              | 25     | 0       | 0.0%           | 0.0%            | 0.0%            | 0.0%       |
|              | 26     | 0       | 0.0%           | 0.0%            | 0.0%            | 0.0%       |
|              | 27     | 0       | 0.0%           | 0.0%            | 0.0%            | 0.0%       |
|              | 28     | 0       | 0.0%           | 0.0%            | 0.0%            | 0.0%       |
|              | 29     | 0       | 0.0%           | 0.0%            | 0.0%            | 0.0%       |
|              | 30     | 1       | 0.0%           | 0.0%            | 0.0%            | 0.0%       |
| Jeollabuk    | 31     | 0       | 0.0%           | 0.0%            | 0.0%            | 0.0%       |
|              | 32     | 0       | 0.0%           | 0.0%            | 0.0%            | 0.0%       |
|              | 33     | 0       | 0.0%           | 0.0%            | 0.0%            | 0.0%       |
| Jeollnam     | 34     | 0       | 0.0%           | 0.0%            | 0.0%            | 0.0%       |
|              | 35     | 0       | 0.0%           | 0.0%            | 0.0%            | 0.0%       |
|              | 36     | 0       | 0.0%           | 0.0%            | 0.0%            | 0.0%       |
|              | 37     | 0       | 0.0%           | 0.0%            | 0.0%            | 0.0%       |
|              | 38     | 0       | 0.0%           | 0.0%            | 0.0%            | 0.0%       |
|              | 39     | 0       | 0.0%           | 0.0%            | 0.0%            | 0.0%       |
| Sejong       | 40     | 0       | 0.0%           | 0.0%            | 0.0%            | 0.0%       |
|              | 41     | 0       | 0.0%           | 0.0%            | 0.0%            | 0.0%       |
|              | 42     | 0       | 0.0%           | 0.0%            | 0.0%            | 0.0%       |
|              | 43     | 0       | 0.0%           | 0.0%            | 0.0%            | 0.0%       |
|              | 44     | 0       | 0.0%           | 0.0%            | 0.0%            | 0.0%       |

Table A8. Cont.
| Sector | Seoul Region Count | Expected Count | % within region | % of Total | Seoul Region % within sector | Ulsan Region Count | Expected Count | % within region | % of Total | Ulsan Region % within sector | Total Count | Expected Count | % within region | % of Total | Total % within sector | % of Total |
|--------|------------------|----------------|-----------------|------------|-----------------------------|--------------------|----------------|-----------------|------------|-----------------------------|------------|----------------|-----------------|------------|-------------------|-----------|
| 10     | 15               | 13.7           | 9.3%            | 1.6%       |                             | 82                 | 82.0           | 8.5%            | 8.5%       |                            | 97         | 115            | 100.0%          | 100.0%     | 100.0%             | 100.0%    |
| 11     | 2                | 1.0            | 0.6%            | 0.2%       |                             | 60                 | 60.0           | 5.6%            | 5.6%       |                            | 70         | 70             | 100.0%          | 100.0%     | 100.0%             | 100.0%    |
| 12     | 7                | 3.9            | 2.4%            | 0.7%       |                             | 70                 | 70.0           | 5.6%            | 5.6%       |                            | 70         | 70             | 100.0%          | 100.0%     | 100.0%             | 100.0%    |
| 13     | 6                | 2.2            | 1.3%            | 0.7%       |                             | 20                 | 20.0           | 1.7%            | 1.7%       |                            | 20         | 20             | 100.0%          | 100.0%     | 100.0%             | 100.0%    |
| 14     | 1                | 1.5            | 0.9%            | 0.1%       |                             | 12                  | 12.0           | 1.0%            | 1.0%       |                            | 12         | 12             | 100.0%          | 100.0%     | 100.0%             | 100.0%    |
| 15     | 2                | 1.5            | 1.2%            | 0.8%       |                             | 30                  | 30.0           | 2.6%            | 2.6%       |                            | 30         | 30             | 100.0%          | 100.0%     | 100.0%             | 100.0%    |
| 16     | 1                | 1.5            | 1.2%            | 0.8%       |                             | 12                  | 12.0           | 1.0%            | 1.0%       |                            | 12         | 12             | 100.0%          | 100.0%     | 100.0%             | 100.0%    |
| 17     | 1                | 1.5            | 1.2%            | 0.8%       |                             | 30                  | 30.0           | 2.6%            | 2.6%       |                            | 30         | 30             | 100.0%          | 100.0%     | 100.0%             | 100.0%    |
| 18     | 1                | 1.5            | 1.2%            | 0.8%       |                             | 12                  | 12.0           | 1.0%            | 1.0%       |                            | 12         | 12             | 100.0%          | 100.0%     | 100.0%             | 100.0%    |
| 19     | 8                | 10.7           | 8.5%            | 6.6%       |                             | 63                  | 63.0           | 5.3%            | 5.3%       |                            | 63         | 63             | 100.0%          | 100.0%     | 100.0%             | 100.0%    |
| 20     | 2                | 5.0            | 3.9%            | 3.1%       |                             | 12                  | 12.0           | 1.0%            | 1.0%       |                            | 12         | 12             | 100.0%          | 100.0%     | 100.0%             | 100.0%    |
| 21     | 1                | 4.9            | 3.7%            | 3.1%       |                             | 12                  | 12.0           | 1.0%            | 1.0%       |                            | 12         | 12             | 100.0%          | 100.0%     | 100.0%             | 100.0%    |
| 22     | 3                | 4.4            | 2.8%            | 2.3%       |                             | 29                  | 29.0           | 2.4%            | 2.4%       |                            | 29         | 29             | 100.0%          | 100.0%     | 100.0%             | 100.0%    |
| 23     | 3                | 4.4            | 2.8%            | 2.3%       |                             | 29                  | 29.0           | 2.4%            | 2.4%       |                            | 29         | 29             | 100.0%          | 100.0%     | 100.0%             | 100.0%    |
| 24     | 14               | 13.9           | 12.3%           | 3.0%       | 8.6%                        | 63                  | 63.0           | 5.3%            | 5.3%       |                            | 63         | 63             | 100.0%          | 100.0%     | 100.0%             | 100.0%    |
| 25     | 1                | 1.0            | 0.8%            | 0.5%       |                             | 12                  | 12.0           | 1.0%            | 1.0%       |                            | 12         | 12             | 100.0%          | 100.0%     | 100.0%             | 100.0%    |
| 26     | 1                | 1.0            | 0.8%            | 0.5%       |                             | 12                  | 12.0           | 1.0%            | 1.0%       |                            | 12         | 12             | 100.0%          | 100.0%     | 100.0%             | 100.0%    |
| 27     | 18               | 15.9           | 12.5%           | 3.0%       | 8.6%                        | 63                  | 63.0           | 5.3%            | 5.3%       |                            | 63         | 63             | 100.0%          | 100.0%     | 100.0%             | 100.0%    |
| 28     | 15               | 13.9           | 12.3%           | 3.0%       | 8.6%                        | 63                  | 63.0           | 5.3%            | 5.3%       |                            | 63         | 63             | 100.0%          | 100.0%     | 100.0%             | 100.0%    |
| 29     | 3                | 3.1            | 2.4%            | 2.0%       |                             | 12                  | 12.0           | 1.0%            | 1.0%       |                            | 12         | 12             | 100.0%          | 100.0%     | 100.0%             | 100.0%    |
| 30     | 1                | 1.0            | 0.8%            | 0.5%       |                             | 12                  | 12.0           | 1.0%            | 1.0%       |                            | 12         | 12             | 100.0%          | 100.0%     | 100.0%             | 100.0%    |
| 31     | 1                | 1.0            | 0.8%            | 0.5%       |                             | 12                  | 12.0           | 1.0%            | 1.0%       |                            | 12         | 12             | 100.0%          | 100.0%     | 100.0%             | 100.0%    |
| 32     | 14               | 13.9           | 12.3%           | 3.0%       | 8.6%                        | 63                  | 63.0           | 5.3%            | 5.3%       |                            | 63         | 63             | 100.0%          | 100.0%     | 100.0%             | 100.0%    |
| 33     | 9                | 8.6            | 6.7%            | 2.7%       |                             | 29                  | 29.0           | 2.4%            | 2.4%       |                            | 29         | 29             | 100.0%          | 100.0%     | 100.0%             | 100.0%    |

Table A8. Cont.
Table A9. Cross-tabulation between regions and sectors in KIS 2016.

| Region          | Count | Expected Count | % within region | % within sector | % of Total |
|-----------------|-------|----------------|-----------------|-----------------|-----------|
| Busan           |       |                |                 |                 |           |
|                 | 11    | 8.2            | 9.2%            | 9.9%            | 0.7%      |
|                 | 1     | 4.8            | 0.8%            | 0.9%            | 0.1%      |
|                 | 1     | 1.7            | 0.0%            | 0.0%            | 0.0%      |
|                 | 0     | 0.8            | 0.0%            | 0.0%            | 0.0%      |
|                 | 1     | 0.7            | 0.0%            | 0.0%            | 0.0%      |
|                 | 1     | 1.1            | 0.0%            | 0.0%            | 0.0%      |
|                 | 2     | 1.7            | 0.0%            | 0.0%            | 0.0%      |
|                 | 6     | 10.3           | 5.0%            | 8.8%            | 0.4%      |
|                 | 1     | 0.8            | 0.0%            | 0.0%            | 0.0%      |
|                 | 1     | 0.7            | 0.0%            | 0.0%            | 0.0%      |
|                 | 7     | 6.7            | 3.6%            | 5.8%            | 0.4%      |
|                 | 5     | 5.4            | 3.6%            | 5.8%            | 0.4%      |
|                 | 1     | 1.0            | 0.0%            | 0.0%            | 0.0%      |
|                 | 13    | 10.0           | 10.0%           | 10.0%           | 1.0%      |
|                 | 30    | 23.2           | 14.0%           | 14.0%           | 1.4%      |
|                 | 10    | 14.9           | 0.7%            | 0.7%            | 0.1%      |
|                 | 3     | 1.6            | 0.1%            | 0.1%            | 0.1%      |
|                 | 2     | 1.3            | 0.1%            | 0.1%            | 0.1%      |
|                 | 0     | 1.3            | 0.1%            | 0.1%            | 0.1%      |
|                 | 2     | 1.4            | 0.1%            | 0.1%            | 0.1%      |
|                 | 0     | 1.4            | 0.1%            | 0.1%            | 0.1%      |
|                 | 0     | 1.4            | 0.1%            | 0.1%            | 0.1%      |
|                 | 0     | 1.4            | 0.1%            | 0.1%            | 0.1%      |
| Chungcheongbuk   |       |                |                 |                 |           |
|                 | 11    | 5.9            | 12.7%           | 12.6%           | 0.7%      |
|                 | 2     | 3.5            | 0.4%            | 0.3%            | 0.1%      |
|                 | 2     | 2.7            | 0.0%            | 0.0%            | 0.0%      |
|                 | 0     | 2.5            | 0.0%            | 0.0%            | 0.0%      |
|                 | 0     | 2.5            | 0.0%            | 0.0%            | 0.0%      |
|                 | 0     | 2.5            | 0.0%            | 0.0%            | 0.0%      |
|                 | 0     | 2.5            | 0.0%            | 0.0%            | 0.0%      |
|                 | 0     | 2.5            | 0.0%            | 0.0%            | 0.0%      |
|                 | 0     | 2.5            | 0.0%            | 0.0%            | 0.0%      |
|                 | 0     | 2.5            | 0.0%            | 0.0%            | 0.0%      |
|                 | 0     | 2.5            | 0.0%            | 0.0%            | 0.0%      |
|                 | 0     | 2.5            | 0.0%            | 0.0%            | 0.0%      |
| Chungcheongnam   |       |                |                 |                 |           |
|                 | 14    | 7.6            | 12.7%           | 12.6%           | 0.9%      |
|                 | 2     | 4.4            | 4.5%            | 4.5%            | 0.3%      |
|                 | 0     | 4.5            | 0.0%            | 0.0%            | 0.0%      |
|                 | 0     | 4.5            | 0.0%            | 0.0%            | 0.0%      |
|                 | 0     | 4.5            | 0.0%            | 0.0%            | 0.0%      |
|                 | 0     | 4.5            | 0.0%            | 0.0%            | 0.0%      |
|                 | 0     | 4.5            | 0.0%            | 0.0%            | 0.0%      |
|                 | 0     | 4.5            | 0.0%            | 0.0%            | 0.0%      |
|                 | 0     | 4.5            | 0.0%            | 0.0%            | 0.0%      |
|                 | 0     | 4.5            | 0.0%            | 0.0%            | 0.0%      |
|                 | 0     | 4.5            | 0.0%            | 0.0%            | 0.0%      |
| Deogu            |       |                |                 |                 |           |
|                 | 4     | 7.6            | 3.6%            | 3.6%            | 0.2%      |
|                 | 0     | 4.5            | 1.8%            | 1.8%            | 0.1%      |
|                 | 0     | 4.5            | 0.0%            | 0.0%            | 0.0%      |
|                 | 0     | 4.5            | 0.0%            | 0.0%            | 0.0%      |
|                 | 0     | 4.5            | 0.0%            | 0.0%            | 0.0%      |
|                 | 0     | 4.5            | 0.0%            | 0.0%            | 0.0%      |
|                 | 0     | 4.5            | 0.0%            | 0.0%            | 0.0%      |
|                 | 0     | 4.5            | 0.0%            | 0.0%            | 0.0%      |
|                 | 0     | 4.5            | 0.0%            | 0.0%            | 0.0%      |
|                 | 0     | 4.5            | 0.0%            | 0.0%            | 0.0%      |
| Deogyang         |       |                |                 |                 |           |
|                 | 2     | 3.1            | 4.4%            | 4.4%            | 0.1%      |
|                 | 0     | 1.8            | 0.8%            | 0.8%            | 0.1%      |
|                 | 0     | 1.8            | 0.0%            | 0.0%            | 0.0%      |
|                 | 0     | 1.8            | 0.0%            | 0.0%            | 0.0%      |
|                 | 0     | 1.8            | 0.0%            | 0.0%            | 0.0%      |
|                 | 0     | 1.8            | 0.0%            | 0.0%            | 0.0%      |
|                 | 0     | 1.8            | 0.0%            | 0.0%            | 0.0%      |
|                 | 0     | 1.8            | 0.0%            | 0.0%            | 0.0%      |
|                 | 0     | 1.8            | 0.0%            | 0.0%            | 0.0%      |
|                 | 0     | 1.8            | 0.0%            | 0.0%            | 0.0%      |

Note: The table shows the cross-tabulation between regions and sectors in KIS 2016. The counts and expected counts are presented for each region, along with the percentages of total counts within each region and sector. The last row represents the percentage of total counts within each sector.
| Region | Count | Expected Count | % within region | % within sector | % of Total |
|--------|-------|----------------|----------------|----------------|------------|
|        | 10    | 11             | 13             | 14             | 15         |
|        | 16    | 17             | 18             | 19             | 20         |
|        | 21    | 22             | 23             | 24             | 25         |
|        | 26    | 27             | 28             | 29             | 30         |
|        | 31    | 32             | 33             | Total          |           |
| Gyeonggi | 19    | 0              | 1              | 1 | 2 | 15 | 2 | 20 | 7 | 34 | 13 | 12 | 17 | 69 | 23 | 49 | 84 | 25 | 2 | 5 | 3 | 406 |
|        | 27.9  | 1.5            | 4.0            | 9.3            | 2.8         |
|        | 4.3   | 9.0            | 2.0            | 16.3           | 5.8         |
|        | 34.9  | 9.0            | 12.3           | 22.6           | 51.8        |
|        | 18.3  | 37.8           | 73.3           | 78.6           | 50.2        |
|        | 52.3  | 5.3            | 4.3            | 4.3            | 1.3         |
|        | 406.0 |               |                |                |             |
|        | 1.2   | 0.2            | 0.1            | 0.0            | 0.0         |
|        | 0.4   | 0.0            | 0.0            | 0.0            | 0.0         |
|        | 0.0   | 0.0            | 0.0            | 0.0            | 0.0         |
|        | 0.0   | 0.0            | 0.0            | 0.0            | 0.0         |
|        | 0.0   | 0.0            | 0.0            | 0.0            | 0.0         |
|        | 0.0   | 0.0            | 0.0            | 0.0            | 0.0         |
|        | 0.0   | 0.0            | 0.0            | 0.0            | 0.0         |

| Region | Count | Expected Count | % within region | % within sector | % of Total |
|--------|-------|----------------|----------------|----------------|------------|
|        | 10    | 11             | 13             | 14             | 15         |
|        | 16    | 17             | 18             | 19             | 20         |
|        | 21    | 22             | 23             | 24             | 25         |
|        | 26    | 27             | 28             | 29             | 30         |
|        | 31    | 32             | 33             | Total          |           |
| Gyeongbuk | 4     | 5              | 0              | 0              | 0          |
|        | 1     | 2              | 1              | 2              | 15         |
|        | 15    | 2              | 0              | 20             | 7          |
|        | 34    | 13             | 12             | 17             | 69         |
|        | 23    | 49             | 84             | 25             | 2          |
|        | 5     | 3              | 406            |               |            |
|        | 27.9  | 1.5            | 4.0            | 9.3            | 2.8         |
|        | 4.3   | 9.0            | 2.0            | 16.3           | 5.8         |
|        | 34.9  | 9.0            | 12.3           | 22.6           | 51.8        |
|        | 18.3  | 37.8           | 73.3           | 78.6           | 50.2        |
|        | 52.3  | 5.3            | 4.3            | 4.3            | 1.3         |
|        | 406.0 |               |                |                |             |
|        | 1.2   | 0.2            | 0.1            | 0.0            | 0.0         |
|        | 0.4   | 0.0            | 0.0            | 0.0            | 0.0         |
|        | 0.0   | 0.0            | 0.0            | 0.0            | 0.0         |
|        | 0.0   | 0.0            | 0.0            | 0.0            | 0.0         |
|        | 0.0   | 0.0            | 0.0            | 0.0            | 0.0         |
|        | 0.0   | 0.0            | 0.0            | 0.0            | 0.0         |
|        | 0.0   | 0.0            | 0.0            | 0.0            | 0.0         |

| Region | Count | Expected Count | % within region | % within sector | % of Total |
|--------|-------|----------------|----------------|----------------|------------|
|        | 10    | 11             | 13             | 14             | 15         |
|        | 16    | 17             | 18             | 19             | 20         |
|        | 21    | 22             | 23             | 24             | 25         |
|        | 26    | 27             | 28             | 29             | 30         |
|        | 31    | 32             | 33             | Total          |           |
| Gyeonggi | 14    | 0              | 0              | 0              | 1          |
|        | 2     | 0              | 1              | 2              | 13         |
|        | 13    | 2              | 1              | 8              | 6          |
|        | 4     | 8              | 35             | 33             | 9          |
|        | 0     | 0              | 0              | 0              | 0          |
|        | 0.0   | 0.0            | 0.0            | 0.0            | 0.0         |
|        | 0.0   | 0.0            | 0.0            | 0.0            | 0.0         |
|        | 0.0   | 0.0            | 0.0            | 0.0            | 0.0         |
|        | 0.0   | 0.0            | 0.0            | 0.0            | 0.0         |
|        | 0.0   | 0.0            | 0.0            | 0.0            | 0.0         |
|        | 0.0   | 0.0            | 0.0            | 0.0            | 0.0         |
|        | 0.0   | 0.0            | 0.0            | 0.0            | 0.0         |

| Region | Count | Expected Count | % within region | % within sector | % of Total |
|--------|-------|----------------|----------------|----------------|------------|
|        | 10    | 11             | 13             | 14             | 15         |
|        | 16    | 17             | 18             | 19             | 20         |
|        | 21    | 22             | 23             | 24             | 25         |
|        | 26    | 27             | 28             | 29             | 30         |
|        | 31    | 32             | 33             | Total          |           |
| Gyeonnam | 9     | 3              | 1              | 1              | 2          |
|        | 15    | 2              | 0              | 20             | 7          |
|        | 34    | 13             | 12             | 17             | 69         |
|        | 23    | 49             | 84             | 25             | 2          |
|        | 5     | 3              | 406            |               |            |
|        | 27.9  | 1.5            | 4.0            | 9.3            | 2.8         |
|        | 4.3   | 9.0            | 2.0            | 16.3           | 5.8         |
|        | 34.9  | 9.0            | 12.3           | 22.6           | 51.8        |
|        | 18.3  | 37.8           | 73.3           | 78.6           | 50.2        |
|        | 52.3  | 5.3            | 4.3            | 4.3            | 1.3         |
|        | 406.0 |               |                |                |             |
|        | 1.2   | 0.2            | 0.1            | 0.0            | 0.0         |
|        | 0.4   | 0.0            | 0.0            | 0.0            | 0.0         |
|        | 0.0   | 0.0            | 0.0            | 0.0            | 0.0         |
|        | 0.0   | 0.0            | 0.0            | 0.0            | 0.0         |
|        | 0.0   | 0.0            | 0.0            | 0.0            | 0.0         |
|        | 0.0   | 0.0            | 0.0            | 0.0            | 0.0         |
|        | 0.0   | 0.0            | 0.0            | 0.0            | 0.0         |
|        | 0.0   | 0.0            | 0.0            | 0.0            | 0.0         |

Table A9. Cont.
Table A9. Cont.

| Region     | Count | Expected Count | % within region | % within sector | % of Total |
|------------|-------|----------------|-----------------|-----------------|------------|
| Incheon    | 7     | 12.1           | 4.0%            | 6.3%            | 0.4%       |
| Jeju       | 1     | 0.1            | 0.0%            | 0.9%            | 0.1%       |
| Jeollabuk  | 8     | 2.0            | 27.6%           | 7.2%            | 0.5%       |
| Jeollan    | 5     | 2.0            | 17.2%           | 4.5%            | 0.3%       |
| Soryeong   | 0     | 1.0            | 0.0%            | 0.0%            | 0.0%       |

| Sector     | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | Total |
|------------|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|-----|------|
| Incheon    | 7  | 0  | 1  | 0  | 0  | 9  | 0  | 0  | 0  | 6  | 2  | 20 | 3  | 7  | 11 | 32 | 2  | 15 | 40 | 17 | 0  | 4  | 0  | 176.0 |
| Jeju       | 1  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 1  | 0  | 1  | 1  | 0  | 2  | 1  | 0  | 2  | 5  | 8  | 2  | 0  | 126.0 |
| Jeollabuk  | 8  | 0  | 0  | 0  | 0  | 1  | 0  | 0  | 0  | 1  | 0  | 0  | 1  | 1  | 0  | 2  | 1  | 0  | 3  | 2  | 5  | 0  | 29.0 |
| Jeollan    | 5  | 0  | 0  | 0  | 0  | 1  | 0  | 0  | 0  | 3  | 1  | 2  | 0  | 2  | 2  | 1  | 0  | 3  | 5  | 1  | 1  | 0  | 29.0 |
| Soryeong   | 0  | 0  | 0  | 0  | 0  | 2  | 0  | 0  | 1  | 1  | 0  | 3  | 0  | 2  | 1  | 0  | 2  | 0  | 0  | 0  | 14.0 |
Table A9. Cont.

| Sector | 10 | 11 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | Total |
|--------|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|-----|
| Seoul  |
| Count  | 6  | 0  | 2  | 36 | 6  | 1  | 6  | 3  | 0  | 5  | 2  | 4  | 2  | 1  | 4  | 33 | 6  | 10 | 12 | 1  | 0  | 0  | 1  | 141 |
| Expected Count | 9.7 | 5  | 1.4 | 3.2 | 1.0 | 1.5 | 3.1 | .7  | .3  | 5.7 | 2.0 | 12.1 | 3.1 | 4.3 | 7.9 | 18.0 | 6.4 | 11.7 | 27.3 | 17.5 | 1.8 | 1.5 | 4  | 141.0 |
| % within region | 4.3% | 0.0% | 1.4% | 25.5% | 4.3% | 0.7% | 4.3% | 21.1% | 0.0% | 3.5% | 1.4% | 2.8% | 1.4% | 0.7% | 2.8% | 23.4% | 4.3% | 7.1% | 8.5% | 0.7% | 0.0% | 0.0% | 0.7% | 100.0% |
| % within sector | 5.4% | 0.0% | 12.5% | 97.3% | 54.5% | 5.9% | 16.7% | 37.5% | 0.0% | 7.7% | 8.7% | 2.9% | 5.6% | 2.0% | 4.4% | 16.0% | 8.2% | 7.5% | 3.8% | 0.5% | 0.0% | 0.0% | 20.0% | 8.7% |
| % of Total | 0.4% | 0.0% | 0.1% | 2.2% | 0.4% | 0.1% | 0.4% | 0.2% | 0.0% | 0.3% | 0.1% | 0.2% | 0.1% | 0.1% | 0.2% | 2.0% | 0.4% | 0.6% | 0.7% | 0.1% | 0.0% | 0.0% | 0.1% | 8.7% |
| Ulsan  |
| Count  | 1  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 1  | 1  | 0  | 4  | 1  | 6  | 3  | 1  | 2  | 1  | 5  | 13 | 3  | 0  | 0  | 42  |
| Expected Count | 2.9 | 2  | 4  | 1.0 | .3  | .4  | 9  | .2  | .1  | 1.7 | .6  | 3.6 | .9  | 1.3 | 2.3 | 5.4 | 1.9 | 3.5 | 8.1 | 5.2 | .5  | .4  | 1  | 42.0 |
| % within region | 2.4% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 2.4% | 2.4% | 0.0% | 9.5% | 2.4% | 14.3% | 7.1% | 2.4% | 4.8% | 2.4% | 11.9% | 31.0% | 7.1% | 0.0% | 0.0% | 100.0% |
| % within sector | 0.9% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 33.3% | 1.5% | 0.0% | 2.9% | 2.8% | 12.2% | 3.3% | 0.5% | 2.7% | 0.7% | 1.6% | 6.5% | 14.3% | 0.0% | 0.0% | 2.6% |
| % of Total | 0.1% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.1% | 0.1% | 0.0% | 0.2% | 0.1% | 0.4% | 0.2% | 0.1% | 0.1% | 0.1% | 0.3% | 0.8% | 0.2% | 0.0% | 0.0% | 2.6% |
| Total  |
| Count  | 111 | 6  | 16 | 37 | 11 | 17 | 36 | 8  | 3  | 65 | 23 | 139 | 36 | 49 | 90 | 206 | 73 | 134 | 313 | 200 | 21 | 17 | 5  | 1616 |
| Expected Count | 111.0 | 6.0 | 16.0 | 37.0 | 11.0 | 17.0 | 36.0 | 8.0 | 3.0 | 65.0 | 23.0 | 139.0 | 36.0 | 49.0 | 90.0 | 206.0 | 73.0 | 134.0 | 313.0 | 200.0 | 21.0 | 17.0 | 5.0 | 1616.0 |
| % within region | 6.9% | 0.4% | 1.0% | 2.3% | 0.7% | 1.1% | 2.2% | 0.5% | 0.2% | 4.0% | 1.4% | 8.6% | 2.2% | 3.0% | 5.6% | 12.7% | 4.5% | 8.3% | 19.4% | 12.4% | 1.3% | 1.1% | 0.3% | 100.0% |
| % within sector | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 2.6% | 1.1% | 0.3% | 100.0% |
| % of Total | 6.9% | 0.4% | 1.0% | 2.3% | 0.7% | 1.1% | 2.2% | 0.5% | 0.2% | 4.0% | 1.4% | 8.6% | 2.2% | 3.0% | 5.6% | 12.7% | 4.5% | 8.3% | 19.4% | 12.4% | 1.3% | 1.1% | 0.3% | 100.0% |
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