Ph. D. Dissertation in Engineering

Government Roles in the Development of the Software Industry

- A Longitudinal Study on the Effects of Network Capabilities of Firms and SME Policies -

소프트웨어 산업 발전에서 정부의 역할
: 기업의 네트워크 역량과 중소기업 정책 효과에 대한 종단 연구

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Government Roles
in the Development of Software Industry

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이 논문을 공학박사학위 논문으로 제출함

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Abstract

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South Korea's rapid growth from the 1970s to the early 1990s is largely due to the industrial structure centered on conglomerates that mainly export high-tech products with supports by the government. However, as the problem of the unbalanced industry structure emerged, support for SMEs has been strengthened, including SME-friendly public procurement policies. Public procurement in the software industry is also regulated by the Software Promotion Act, separate from the National Contract Act or the Procurement Business Act. A major issue pointed out in this public software procurement market was especially for conglomerates' extreme domination. Accordingly, the

government has prevented conglomerates from participating in the public software procurement market since 2013, and prohibited multi-layered subcontracting practices from 2016. This study focused on the structural characteristics representing the network capabilities of firms, which have been frequently used in strategic management theory and organizational ecology, but difficult to systematically track dynamic changes over time. From 2008 to 2018, financial data of 2,665 major software firms with annual sales of more than 5 billion won and tax invoice transaction data had been consolidated. In the present study the effect of network capabilities on firm growth was dynamically analyzed, the net effect of the restriction system on participation of conglomerates (2013) on labor productivity was analyzed, and the net effect of the multi-layered subcontracting prohibition system (2016) on labor productivity and revenue growth was analyzed. As a result, it was found that integration, brokerage, and hierarchical trading network capabilities had a positive effect on revenue growth, but collaboration capabilities had a rather negative effect on the short term growth. In addition, in the software industry, unlike the manufacturing industry such as the automobile industry, the horizontal cooperation structure has a positive effect on productivity increase rather than the multi-layered vertical cooperation structure. Demand is important to the growth of a firm, but excessive measures such as excluding specific participants in a market may be poisonous to SMEs' productivity improvement and further growth. When creating a public procurement market environment that is the foundation for fostering target industries and firms, a government should concern not only the unique characteristics of the industry,

but also the fact that roles and capabilities of firms are heterogeneous and their collaboration structure is important.

Keywords: Government, Conglomerates, SME, Software, Network Capabilities

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Chapter 1. **Introduction**

1.1 **Research Background and Objectives**

In the history of modern capitalism, major governments have not only solved market failures but also created markets and provided demand. They have also built an innovative system that actively invests in uncertain technologies to benefit the private sector. South Korea's growth formula is consistent with this system and has allowed the country to experience remarkable economic growth. The total gross domestic product (GDP) of South Korea has increased a lot in the past 60 years (Statistics Korea, 2019).

Recently, an unbalanced dualistic industry structure centred on conglomerates has become the new normal. In 2017, the top 500 conglomerates' revenues account for 118.06% of South Korea's total GDP, which is approximately two times higher than 62.7% of the United States' GDP (Economic Reform Research Institute, 2018). In 2018, the average earnings of conglomerates are 1.7 times higher than those of small- and medium-sized enterprises (SMEs).

Therefore, the present study examined the government's role in business, especially through SME-friendly policies. According to South Korea's constitution, the government fundamentally supports industry promotion, economic growth, and fair trade. In particular, this study focused on firms' interactions and two unique Korean SME(hereafter K-SME) policies in the software industry. It determined the conditions and ways of implementing government policies to foster SMEs, focusing on industrial characteristics, such as firms'

interactions in the software industry. The previous studies related to this topic are very scarce and are conducted from a sporadic and unintegrated perspective. In the present study, the data, the application area (i.e., software industry), and the method used are new.

To elaborate the two focal K-SME policies in the context of generalised hierarchical subcontracting structure and unbalanced development led by conglomerates that exploited partner SMEs, the first legal amendment was enacted to exclude the participation of conglomerates in the public market in 2013, but this was for the software industry only. In 2016, a legislative system for prohibiting multilayered subcontracting was enacted.

Due to the nature of the software industry, which is a comprehensive knowledge industry, the structure of collaboration among participating firms is very important. So the focus of the present paper is on the structural characteristics that represent firms' network capabilities, which have been frequently used in strategic management theory and organisational ecology but have been difficult to employ in systematically tracking dynamic changes over time. Operationally defined, network capability includes information integration capability (measured by closeness centrality), brokerage capability (measured by betweenness centrality), collaboration capability (measured by a clustering coefficient), and hierarchical transaction capability (measured by average distance). To measure network capability, the financial data of 2,665 major software firms with annual sales of more than 5 billion won from 2008 to 2018 were constructed, and the above four indicators were derived through a network analysis methodology based on the tax invoice transaction data to form a panel.

The present study analysed the effect of four types of network capability on the dynamic growth of firms using the system generalised method of moments. It analyses the net effect of the restriction policy on the participation of conglomerates in 2013 on labour productivity and profitability using the panel difference-in-differences method. It also identifies subcontractors from prime contractors based on the hierarchical transaction distance to analyse the net effect of the prohibiting multilayered subcontracting policy in 2016 on the labour productivity and revenue growth by applying the panel difference-in-differences method. Further, this paper presents outlines in Chapter 1, literature reviews in Chapters 2, 3, and 4, and the conclusion in Chapter 5.

1.2 **Outlines of the Overall Integrated Research Framework**

The software industry in focus has unique industry characteristics. The software industry is a representative knowledge industry and plays a key role in knowledge creation, utilisation, and dissemination to each economic entity, including individuals, firms, and governments. Compared to other industries, the software industry is knowledge-intensive and high-value-added; its research and development (R&D) and intellectual labour inputs are massive.

According to the Lippoldt and Stryszowski (2009), the two key features of software are non-embodiment and complementarity and such nature influences aspects of the software sector innovation: cumulative development, and short life cycle. Non-embodiment refers to an attribute that requires little or very little cost to be paid for

reproducing the products and services developed. Complementary products and services require other products and services and co-evolution with other products and services is also required. Typically, software requires hardware products, and one software requires another complementary software. Software also has a strong cumulative nature. Completed and recently developed software will take a very different form from earlier software. However, any software has the cumulative nature of self-reinforcement without persisting as software that was initially created. The technology cycle is very short. Software is rarely used for a long period of time, and the horizontal and vertical technological changes in software products and services are very fast.

Software industry is differentiated from other industry in terms of network structures, network externalities, economies of scale, switching costs, lock-in effects, and free-riding issues (Cho and Cho, 2014).

In the network structure, individual products at each level or sector do not have their own utility but rather combine with each other on the network to create utility for consumers. The characteristic of the network structure is that software for each division in a network is a substitute for other products in the same division but has no choice but to remain as a supplement of products in different divisions. Software does not have economic value when used alone and is a commodity that consumes one system by complementing hardware, applications, and user capabilities. Katz and Shapiro (1994) referred to this as system competition.

The network effect refers to the effect that the value or utility of individual users and

the total value of a network increase as the number of users of the network increases. This is called network externality. Katz and Shapiro (1994) classified network externality into two types: direct and indirect. Direct network externality directly results from an increasing number of people consuming the same product. Telecommunication networks represented by telephone and fax, online services, and the Internet are typical examples of direct network externalities. Indirect network externality refers to the increasing value of a product as the number or type of complementary goods and services increases. Computer services are a prime example of indirect network externalities. The external effects of a network are interpreted as economies of scale occurring on the demand side compared to economies of scale mentioned from the perspective of production. The repetitive nature of externalities intensifies economies of scale on the demand side, which in turn, causes the market to become monopolistic. The global operating system market has a very strong monopoly market structure. Although the overall market structure for application software is very competitive, in the case of individual software, the fact that a few products dominate the market is largely due to network externalities in the software market.

The economies of scale mean that large-scale fixed costs are required for software production, but variable and marginal costs are hardly incurred. In software, almost all investments are concentrated in the R&D stage before the product is produced, and there is usually only negligible marginal cost, such as the copy cost, to mass-produce the software once it is developed as a product. In the case of industries with economies of

scale, it is highly possible that industrial structural characteristics will be monopolistic. This is because in a market where economies of scale exist, the ‘size’ of the market serves as a very important competitiveness measure, so products with more users have quality competitiveness. Also, unit production costs are lowered to provide products at lower prices; this is price competitiveness. Therefore, for latecomers to enter the existing market, a strategy of creating a new market with differentiated or advanced technologies is very important.

Moreover, the software industry has an industrial structure in which costs incurred in addition to the price when converting products to be used, that is, consumption conversion costs, are relatively large, so conversion costs and locking effects exist. When consumers, such as individuals and companies, change from one software to another, even if the functions are similar, learning costs are incurred, and because the software has the characteristics of an experience product, high conversion costs due to information asymmetry are incurred. Accordingly, the software has a locking effect that fixes the consumer to the existing product.

Although software development involves R&D competition, the developed product can be easily copied, so market failure is possible due to free riding. In general, market failure due to free rides means taking institutional supplementary measures to resolve the failure through a patent system that protects intellectual property rights. However, when there is network externality as in the case of software, it is highly possible that such a patent system will block the network externality that occurs between competitors, thereby

lowering corporate profits and consumer utility. When the patent system is introduced, the external effects of demand among compatible competitors disappear. Therefore, in the software industry, it is very important to seek a new policy that considers both the problem of lowering incentives for technology development due to free rides and the problem of consumer utility that is decreased by the limited compatibility due to the intellectual property system.

Considering the major software industry characteristics, the present study targeted the traditional software industry, including packaged software and IT service only. Internet service, gaming, and application platforms are derived from the definition and distinction of the traditional software industry, and they contain all the major features of both modern and traditional software industries. Moreover, in the public software procurement market, which is the major part of the integrated panel data of the study, items such as Internet services and gaming software are rarely traded. Based on this industry definition, the present study expanded the firm-level integrated research framework of Nham and Hoang (2011) to consider industry characteristics and policy changes. Nham and Hoang (2011) proposed a conceptual comprehensive framework that integrated all three theories (industrial organisation, organisational economics, and resource-based view) in strategic management to explain a firm's performance in one industry as follows:

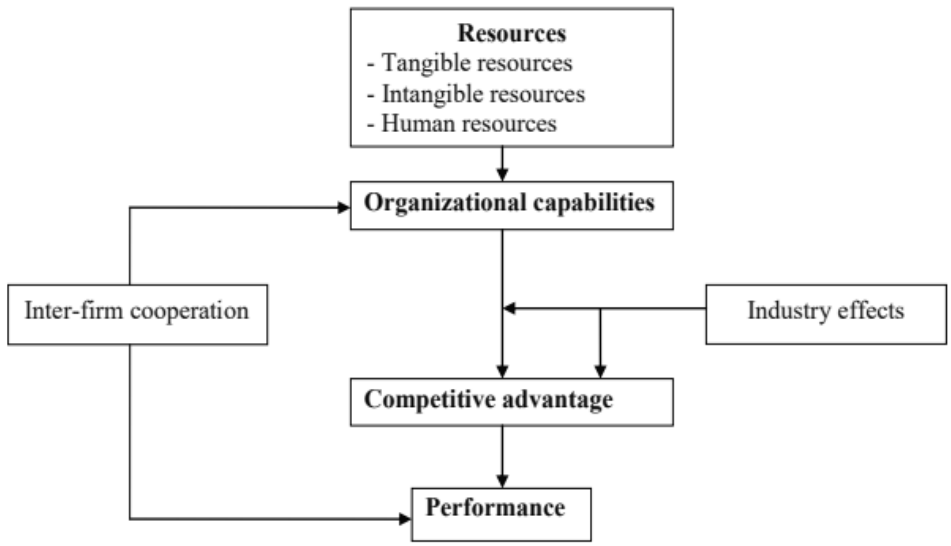

Figure 1.2.1 A Comprehensive Framework Integrated Strategic Management Theories Proposed by Nham and Hoang (2011)

The framework is not a simple combination of three theories; it explains the proper mechanism. The present study found gaps between the framework and the realities. Further examination is needed such that inter-firm cooperation also impacted by industry characteristics. The present study identified four different network capability indicators for an inter-firm cooperation construct. Also, it identified three different organisational and financial performance indicators: labour productivity, revenue growth, and profitability. Furthermore, government interventions, such as SME policies, that impact firm interactions should be considered carefully. The expanded comprehensive framework is depicted as follows:

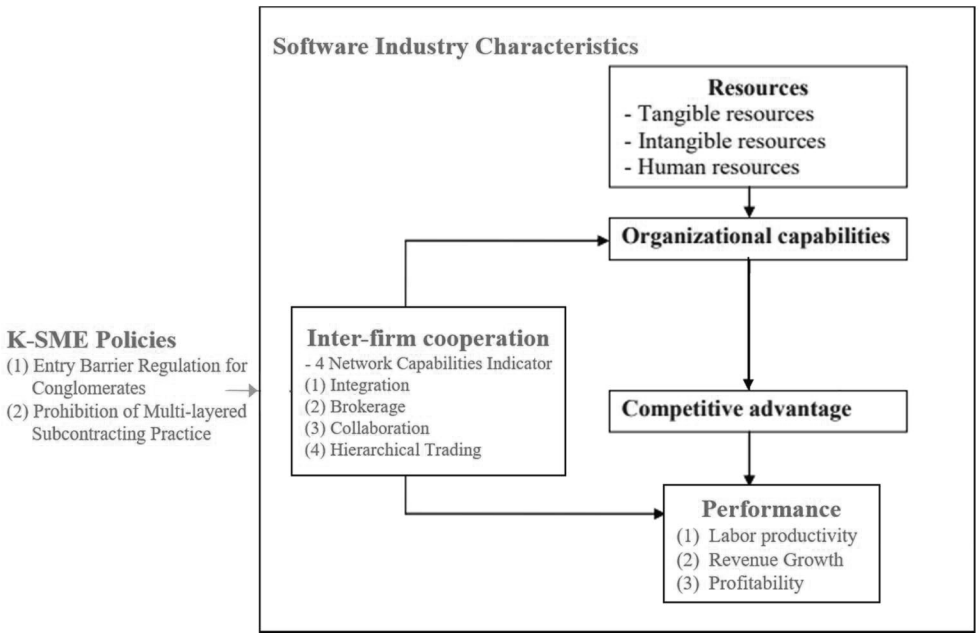

Figure 1.2.2 Expanded Integrated Research Framework from Nham and Hoang (2011)

Chapter 2. The Impact of Network Capabilities on a Firm's Growth

2.1 Literature Review

2.1.1 Penrosian Resource-Based View Theory

Economists have developed theories by identifying the ground truths about the gaps between existing studies and the reality (Kuhn, 1962). The field of strategic management research stemmed from Porter's 'Five Forces framework' (1980), which began with observations of the phenomenon that industries vary in profitability. This framework follows the traditional structure-behaviour-outcome perspective and has been verified and solidified by various theoretical and empirical follow-up studies. Later, the phenomenon of long-term differences in profitability within the same industry was highlighted (Lippman and Rumelt, 1982; Rumelt, 1991; Pisano, 2017). Many firms in the same industry with similar strategies performed very differently. This led to the development of a resource-based theory rooted in Penrose (Teece, 1982; Wernerfelt, 1984; Montgomery and Wernerfelt, 1988; Barney, 1991; Amit and Schoemaker, 1993). The resource-based theory was intended to explain the differences in management performance in an industry with firm-specific resources, such as tangible, intangible, and human resources that are inimitable (e.g., technology, capability, reputation, and brands). In the 1990s, empirical and case studies of product development and performance (Garvin, 1988; Hayes and

Clark, 1986; Clark and Fujimoto, 1990; Pisano, 1996; Iansiti, 1998) demonstrated that some entities were better at creating and developing capabilities that lead to sustained competitive advantage (Pisano, 2017). These entities could also update their skills and build entirely new capabilities. Furthermore, it was found that resources were rather dynamic.

2.1.2 Organisational Economics Theory

Organisational economics is one of the major perspectives of strategic management study, with the unit of analysis at the firm level, not at the industry level (Hoskisson et al., 1999). Organisational economics focuses on identifying the behaviour or organisational methods of economic activities, which minimise the costs of governance to maximise performance (Combs and Ketchen, 1999). The various intra-firm exchanges and inter-firm contracts or alliances observed in reality (e.g., vertical integration, joint ventures, equity acquisitions, alliances, subcontracting, outsourcing, franchising, and licensing) describe alternative methods of exchanging goods and services in the context of selfish behaviour, other goals, and incomplete information (Combs and Ketchen, 1999). There are two theories in organisational economics: transaction-cost theory (Wiliamson, 1975) and agency theory (Fama, 1980). These two theories, particularly the former, are based on the insight that an entity exists because the transaction costs for managing inter-firm economic exchanges are often greater than the costs for managing intra-firm economic exchanges (Coase, 1937). The transaction-cost theory focuses on the characteristics of

exchanges that encourage managers to have a firm boundary (e.g., full ownership through vertical integration), share with others (e.g., collaboration, subcontracting, joint ventures, franchises, and licenses), or exchange in the market (Combs and Ketchen, 1999). Given their nature, specific resources are more costly to relocate to alternative use unlike general-purpose resources (Wiliamson, 1991). Under certain conditions, resource specificity facilitates sharing or cooperation between entities (Wiliamson, 1983). If two firms in a partnership contract have to invest in a particular resource, the resource forms interdependence, reducing the incentive for each partner to participate in opportunism, thereby decreasing the cost of cooperation (Dyer, 1996). Thus, one-sided investments in specific assets should lead to full ownership, but mutual investments under specific contracts can facilitate cooperation (Combs and Ketchen, 1999).

The second perspective, the positivist agency theory, focuses on the exchange in which one party, the principal, entrusts responsibility to the other party, the agent (Eisenhart, 1989). Agents, usually self-interested, are expected to seek their own goals, not those of the principal. As a result, the principal entity should use resources to monitor and control the behaviour of its agents (e.g., employees, managers, and cooperative partners). The monitoring costs depend on the extent to which information about agents' performance is readily available and can be evaluated effectively (Eisenhardt, 1989). In situations where direct monitoring costs are high, the principal often replaces monitoring activities with incentives that stimulate agents' objectives rather than direct supervision (Eisenhardt, 1989). Moreover, forcing an agent to hold an equity position in an operation

under control in some particular types of cooperation is a common way of rebalancing the agent's objective (Phan and Hill, 1995).

2.1.3 Theory of Network Capabilities and Firm Performance

On the extension of the strategic management theory and organisational ecological perspective, existing studies provided a theoretical basis that the network's structural characteristics, which are summarised as centrality and structural hole, changed over time and that the change had a significant impact on the growth and performance of the company (Coleman, 1988; Burt, 1992; Ahuja, 2000; Koka and Prescott, 2002; Powell et al., 1999). Discussions on issues such as a structural hole, indirect relationships, and sparse networks highlight potential possibilities to benefit from intermediation and diversity within the network. However, research on network structure analysis has not given a consistent view of the impact of the network structure on corporate performance (Kim et al., 2014). Inconsistent views are such that the nature of the network that promotes innovation in the biotechnology industry is the cause of low productivity in the steel industry (Barrass and Madhavan, 1996), or the number of patents decreases at the same time (Ahuja 2000), although innovation is increased by structural holes (Zaheer and Bell, 2005). From a network perspective, companies would rather take advantage of the resources that other companies in the network have (Park and Kang, 2014). Networks provide knowledge related to business, and mutual cooperation through relationships

among partners helps to cope with changes in knowledge over time and develop new knowledge. The changes in relationships achieved through collaboration within the network allow companies within the network to acquire knowledge. Network capabilities mean the ability to build, maintain, and utilise relationships with external firms, which have a significant impact on strategic decision-making (Teece, Pisano, and Shuen, 1997). Networks are known as one strategic alternative to overcome inherent limitations and resource constraints, particularly the liability of smallness (Kwon, 2004; McDougall et al., 1994; Coviello and McAuley, 1999). Network capabilities help create a competitive advantage by linking corporate resources with those of companies in the network and enabling access to intangible resources, such as strategic knowledge or technology held by partner companies. However, studies in the past have rarely considered a network's characteristics according to the temporal change by looking at the network's static side. In other words, it is very meaningful to look at the changes in corporate performance due to dynamic capacity changes in the network.

2.2 Research Model and Hypothesis

2.2.1 Operational Definition of Network Capabilities and Hypothesis Setting

Network capabilities can be measured by structural indicators in the supply network, and the present study identified four different subcategorical capabilities from previous literatures: integration, brokerage, collaboration, and hierarchical trading capabilities. The

network structure can be analysed mainly in twofold: position of nodes and linking layout or characteristics. Integration and brokerage capabilities are measured through centrality, which represents the influence and power among the network's structural indicators. In other words, centrality is the degree to which one node strategically occupies an important position in the network connection structure. There are two important detailed indicators of this centrality. Closeness centrality is affected by the network's layout and the number of links relative to the number of potential links. Closeness centrality shows how fairly close a node is to another node. Integration capabilities can be defined operatively by this closeness centrality; the larger this value is, the easier it is to gain access to information power (Kim et al., 2014). Brokerage capability is defined as betweenness centrality, the ability to establish relationships and bridge connections (Kim et al., 2014). Betweenness centrality captures behaviours as a hub in a way that is not reflected in closeness centrality. Betweenness centrality captures the broker activity bridging structural holes (Cross and Cummings, 2004). It was also found that betweenness centrality was positively related to innovation and managerial performance (Brass, 1984; Mehra et al., 2001). In addition, the collaboration capability represents the hierarchical nature of the transaction network. The clustering coefficient, whether the network is single-layered or multilayered, makes it possible to determine whether the partnership is direct or indirect, which can be called the degree to form a cluster (Schilling and Phelps, 2007). This is the rate at which affiliated partners of a particular company collaborate directly with each other. The higher the value, the higher the ability

to collaborate. On the other hand, the hierarchical trading capability looks at how many steps it takes from the intermediate goods or component technology supplier to the final goods supplier through the average distance (Ha, Hong, and Kim, 2016).

To elaborate the measures in detail one by one, integration capability is measured by closeness centrality. The larger this value is, the easier it is to gain access to information power (Kim et al., 2014). The closeness centrality averages the length of the shortest path from node A to other nodes except A and takes that value as reciprocal based on the assumption that the more important nodes will have a shorter path to reach the other.

$$C_c(V_i) = 1/\ (1/(N-1)\ \Sigma_{i\neq j} l_{ij}) = N\text{-}1/(\Sigma_{i\neq j} l_{ij}) \cdots\cdots \text{Eq. (2.2.1.1)}$$

Brokerage capability is the ability to establish relationships and bridge connections (Kim et al., 2014) measured by betweenness centrality. Betweenness centrality is a look at how nodes except A pass through A as they move to other nodes, indicating the importance of node A at the rate at which A is included in the shortest path of X-Y for X and Y nodes, not A.

$$C_B(V_i) = \Sigma_{j<k}(g_{jk}(V_i)/\ g_{jk}) \cdots\cdots \text{Eq. (2.2.1.2)}$$

Collaboration capability is the capability to form a cluster (Schilling and Phelps, 2007). This is the rate at which affiliated partners of a particular firm collaborate directly with each other; the higher the value, the higher the ability to collaborate. Collaboration

capability is measured by local clustering coefficients. The local clustering coefficient tells you how clustered the network is, which is based on transitivity. If A→ B and B→ C, then A→ C. If this is satisfied, A, B, and C are clustered and have a trilateral relationship. The equation below calculates the proportion of connected pairs out of two of all neighbours in i. In the case of a random graph, the clustering coefficient becomes closer to zero as the graph becomes larger. Therefore, high clustering coefficients can be seen as a distinct graph between nodes.

$$C_{cl}(V_i) = |\{(v_x , v_y) \mid A_{ix,} A_{iy,} A_{xy} , x \neq y\}| / |\{(v_x , v_y) \mid A_{ix,} A_{iy,} , x \neq y\}| \cdots\cdots\cdots\cdots \text{Eq. (2.2.1.3)}$$

Hierarchical trading capability is the number of hierarchical transactions with other entities, such as subcontracting (Jung and Hong, 2015), measured by average distance. Trading hierarchies are the average length of the shortest path to nodes other than single node A to A, indicating how much, on average, they have the number of transactions.

$$Avg(d_{ij}^{k}) = 1/n \, \Sigma_{j=1}^{n} \min_{j,k\in\{1,2,\ldots,N\}} \{d_{ij}^{k-1}, d_{ik}^{k-1} + d_{kj}^{k-1}\} (i \neq j, \text{ where } i\in\{1,2,\ldots,N\} \cdots\cdots \text{Eq. (2.2.1.4)}$$

This paper dynamically analyses the impact of above-mentioned network capabilities on firms' growth. For software firms, the process of brokerage or accessing and integrating information from other companies, collaboration capabilities, and hierarchical trading capabilities are very important (Kim et al., 2014; Schilling and Phelps, 2007; Korea Institute for Industrial Economics and Trade, 2016; Jung and Hong, 2015).

Therefore, this study establishes a hypothesis that network capabilities would have substantially helped software firms to increase their sales performance.

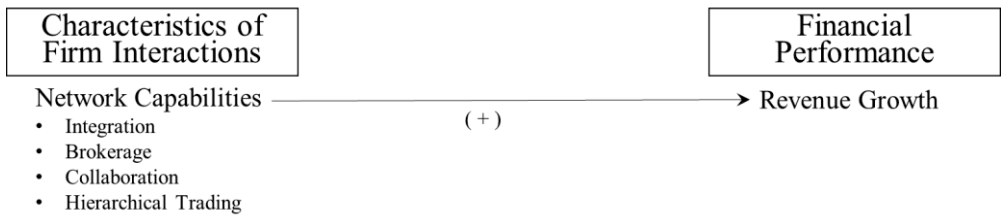

Figure 2.2.1 Conceptualised Research Model and Hypothesis

H1: The integration network capabilities of software firms will have a positive impact on revenue growth.

H2: The brokerage network capabilities of software firms will have a positive impact on revenue growth.

H3: The collaboration network capabilities of software firms will have a positive impact on revenue growth.

H4: The hierarchical trading capabilities of software firms will have a positive impact on revenue growth.

2.2.2 Extended Model of Firm Growth

The general and simple model of growth concerning the firms' size can be described as follows (Geroski, 1999; Geroski and Gugler, 2004; Ra and Shin, 2015).

$$\Delta \ln S_i(t) = \psi_i(t)(\ln S_i^*(t) - \ln S_i(t-1)) + \varepsilon_i(t) \quad \cdots\cdots \text{Eq. (2.2.2.1)}$$

where $S_i(t)$ represents the size (sales) of the firm i at time t, S_i^* represents the long-term steady-state size (sales) of firm i. $\psi_i(t)$ is the speed of firm i that grows toward S_i^*, where $S_i^*(t) \neq S_i^*(t)$ and $\varepsilon_i(t)$ is a normally distributed *iid* white noise process. To specify the exogenous determinants of $S_i^*(t)$ with observable network capabilities information, we can write two different models as follows:

$$\ln S_i^*(t) = c + \beta_1 Integration_i(t-1) + \beta_2 Brokerage_i(t-1) + \beta_3 Collaboration_i(t-1) + \beta_4 HierarchicalTrading_i(t-1) + \eta_i(t) \cdots\cdots \text{Eq. (2.2.2.2)}$$

where $\eta_i(t)$ is a white noise error term and $Integration_i(t-1)$, $Brokerage_i(t-1)$, $Collaboration_i(t-1)$, $HierarchicalTrading_i(t-1)$, and the interaction terms $Collaboration_i(t-1)$ and $HierarchicalTrading_i(t-1)$ are observable exogenous drivers of $S_i^*(t)$, lagged one period to avoid endogeneity concerns caused by reverse causality. The following equation is derived by substituting equation (2.2.2.2) in expression (2.2.2.1).

$$\Delta \ln S_i(t) = c\psi_i(t) + \beta_1 \psi_i(t) Integration_i(t-1) + \beta_2 \psi_i(t) Brokerage_i(t-1) + \beta_3 \psi_i(t) Collaboration_i(t-1) + \beta_4 \psi_i(t) HierarchicalTrading_i(t-1) + \psi_i(t)\eta_i(t) - \psi_i(t)\ln S_i(t-1)) + \varepsilon_i(t) \cdots\cdots \text{Eq. (2.2.2.3)}$$

and by expanding it to include a lag dummy variable if there are public contract sales and a control variable specifying the firm's age,

$$\ln S_i(t) - \ln S_i(t\text{-}1) = \alpha_0 + \alpha_1 Integration_i(t\text{-}1) + \alpha_2 Brokerage_i(t\text{-}1) + \alpha_3 Collaboration_i(t\text{-}1) + \alpha_4 HierarchicalTrading_i(t\text{-}1) - \alpha_5 \ln S_i(t\text{-}1) + \alpha_6 \ln Age_i(t) + \alpha_7 PublicRevenue_i(t\text{-}1) + \delta_i + \lambda_i + \psi_i(t)\eta_i(t) + \varepsilon_i(t) \quad \cdots\cdots \text{Eq. (2.2.2.4)}$$

The signs of α1, α2, α3, and α4 are expected to be positive (+). In other words, the increase in network capabilities means that it is easy to access and collaborate on corporate knowledge and information, which promotes firm growth.

In case we add an interaction term between the collaboration capability and the nominal age range categorised as 1 (0–9 years), 2 (10–19 years), and 3 (20+ years) to examine how the collaboration capability show a different impact with respect to the age range, the model would be expanded to the following:

$$\ln S_i(t) - \ln S_i(t\text{-}1) = \alpha_0 + \alpha_1 Integration_i(t\text{-}1) + \alpha_2 Brokerage_i(t\text{-}1) + \alpha_3 Collaboration_i(t\text{-}1) + \alpha_4 HierarchicalTrading_i(t\text{-}1) - \alpha_5 \ln S_i(t\text{-}1) + \alpha_6 \ln Age_i(t) + \alpha_7 PublicRevenue_i(t\text{-}1) + \alpha_8 ageRange_i(t\text{-}1) + \alpha_9 Collaboration_i * ageRange_i(t\text{-}1) + \delta_i + \lambda_i + \psi_i(t)\eta_i(t) + \varepsilon_i(t) \cdots\cdots \text{Eq. (2.2.2.5)}$$

Since the panel data contains time series data and cross-sectional data of individual firms at the same time, there is a very high possibility that there is heteroscedasticity or autocorrelation in the error term. Among the variables that cannot be observed are time-invariant and specific unobservables or environmental time-specific unobservables at a certain point in time. If not properly controlled, these could bias the estimator. In addition, if the lagged dependent variable of the dependent variable is included as an explanatory variable, it is positively correlated with the error term. Therefore, simple Ordinary Least Squares (OLS) estimation can affect the standard error and result in inducing an

ineffective estimator (Eun, 2015). Therefore, in the panel analysis, if it can be assumed that the error term is not correlated with the explanatory variables, it is used as an error component model. If it is correlated, the unique characteristics of the analysis company are considered dummy variables and included in the model. The probability model is theoretically not suitable for this study because the unique characteristics of each firm that influence growth cannot be interpreted as homogeneous. It is not possible to accurately estimate the influence of explanatory variables that do not change very much over time in the process of a within transformation that differentiates the mean. Moreover, in the firm-level panel data, exogenous and dependent variables that reveal the system's characteristics, it is reasonable to interpret that there is a relationship or mutual relationship, that is, endogeneity. When the heterogeneity between firms and the endogenous problem between variables are not considered, a bias estimation is made. Therefore, to control the endogenous generation of these explanatory variables and obtain a coincidence estimate, it is necessary to use the method of estimating the instrumental variable (IV).

In this study, due to the characteristics of the panel data, the logarithmic value of revenue at a specific point in time was considered to be endogenous to the measured explanatory variable. Therefore, the generalised method of moment (GMM), a dynamic panel analysis model, was further considered. As for GMM estimations, assumptions about distribution are not required as in the Maximum Likelihood Estimation (MLE), and the reliability of the analysis is high because it is not affected by the distribution

characteristics of data, such as heteroscedasticity and autocorrelation. If heteroscedasticity is present, the GMM estimator is more efficient than the simple IV estimator (Baum, Schaffer, and Stillman, 2003). In this study, GMM, analysed based on the two-step analysis method proposed by Arellano and Bond (1991), was used. When estimating parameters through the fixed-effect panel model, there is a possibility of generating an endogeneity problem by a residual that shows a fixed effect inherent to the firm. Therefore, to overcome this bias estimation error, a two-step GMM method using instrument variables was applied. This method uses a first-order differential equation to remove the residual, which is a firm-specific fixed effect, and estimates the parameters based on the moment conditions using instrument variables. The moment condition verifies whether or not the orthogonality condition $E[\varepsilon t, Zt]= 0$ is satisfied. Zt means a vector of instrument variables. In this study, when the revenue growth was set as a dependent variable, the lagged logarithmic value of revenue variables and yearly dummy variables were used as instrument variables. Since the reliability of the estimate depends on how appropriately the instrument variable is adopted and used, a two-stage test is required. First, there is only one endogenous explanatory variable, but since more than one instrument variable is used, the overidentifying constraint on whether the instrument variables satisfy both the momentum conditions and the error term. The Sargan and Hansen-J tests are mainly used. In the case of the Sargan test, if the number of instrument variables is greater than the number of panel groups, there may be a problem in reliability. So, in this study, we will look at the results through the Hansen-J test. This is to test if the

null hypothesis that 'the instrumental variable is valid' cannot be rejected (p-value of 0.05 or more), the over-identification constraint is appropriate, and the instrumental variable used can be judged as appropriate (Kim and Min, 2010; Jeon, 2014). Second, it is necessary to test the autocorrelation of the residual difference. This is a serial correlation test for residuals, and the absence of serial correlation indicates that all lag explanatory variables are instrumental variables. If there is no autocorrelation in the error term of the original model before being differentiated, first-order autocorrelation exists but second-order autocorrelation does not exist.

The moment estimation principle rests on the assumption that the instruments satisfy the conditional moment restrictions $E[Z_i \mu_i(t)] = 0$. The GMM estimator based on these moment conditions minimises the following quadratic form, where the population moments have been replaced with their sample counterparts:

$$Min_{\emptyset}[1/N \sum_{i=1}^{N} Z_i \mu_i(t)]' W_N [1/N \sum_{i=1}^{N} Z_i \mu_i(t)], \quad \text{Eq. (2.2.2.6)}$$

Where $\mu_i(t) = \ln S_i(t) - \ln S_i(t\text{-}1) - \alpha_0 - \alpha_1 Integration_i(t\text{-}1) - \alpha_2 Brokerage_i(t\text{-}1) - \alpha_3 Collaboration_i(t\text{-}1) - \alpha_4 HierarchicalTrading_i(t\text{-}1) + \alpha_5 \ln S_i(t\text{-}1) - \alpha_6 \ln Age_i(t) - \alpha_7 PublicRevenue_i(t\text{-}1)$, and W_N is a positive definite weighting matrix. An efficient GMM estimator is obtained by replacing W_N with $1/N \sum_i \sum_{i=1}^{N} Z_i' \overline{\mu_i(t)} \overline{\mu_i(t)}' Z_i$.

2.3 **Variables and Data**

2.3.1 **Definition of Variables**

Table 2.3.1 presents the variables and their descriptions used in this study with references. Mainly, the study defined revenue change by a year y as a dependent variable. The four network capability indicators and previous year's revenue are explanatory variables.

Table 2.3.1 Definition and Descriptions of Variables in the Analysis

Classification	Variable	Definition	Description and Measures	Reference
Dependent Variable	y	Revenue change by a year	Logarithmic value of the sales – Logarithmic value of the previous year's sales lnSi(t) - lnSi(t-1)	Ra and Shin (2015)
Explanatory Variable	L.lgrev	Previous year's revenue	Logarithmic value of the previous year's sales scale	Ra and Shin (2015)
	Integration	Closeness centrality	Closeness centrality of the previous year	Kim et al. (2014)
	Brokerage	Betweenness centrality	Betweenness centrality of the previous year	
	Collaboration	Clustering coefficient	Clustering coefficient of the previous year	Schilling and Phelps (2007)
	Hierarchical Trading	Average number of transactions	Average number of transactions of the previous year	Jung and Hong (2015)
	Collaboration* ageRange	Interaction term	Interaction between Collaboration and ageRange	

Control Variable	lgage	Age	Logarithmic value of the firm age after the foundation	Ra and Shin (2015)
	ageRange	Range of age	1: 0–9 years 2: 10–19 years 3: 20+ years	
Dummy Variable	publicrev	Public contract sales	Whether to have public market sales in the previous year	Lee and Jung (2018)
Instrument Variable	i.year	Year dummy	Year dummy variable	Eun (2015); Ra and Shin (2015)
	L2/10.lgrev	Level time lag variable for lgrev	Time lag variable of lgrev	Eun (2015); Ra and Shin (2015)

2.3.2 **Data**

For analysis, the transaction data, public software procurement service contract data, and financial data of 2,665 major software companies are combined and constructed. The analysis data was collected through public data released by the Korea Public Procurement Service after purchasing transaction and financial data from Korea Enterprise Data Co., Ltd., a credit rating agency.

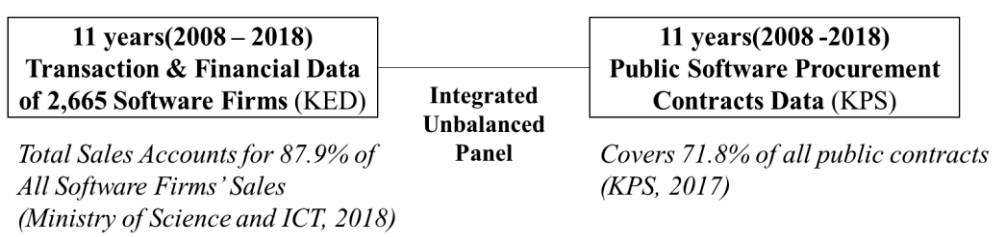

Figure 2.3.1 Data Collection and Integration

Korea Enterprise Data Co., Ltd., is a company that collects the intercompany sales and purchase tax calculation sheets and conducts a company's credit evaluation. Using the tax invoice data, it shows how often and at what scale one company deals with other companies. This study analyses the transaction and financial data of 2,665 software companies with annual sales of 5 billion Won or more, and with the Korea Standard Industry Code(KSIC) of computer programming services (62010), computer system consultancy and computer facilities management activities (6202), and system software and applications development/publishing (58220) from 2008 to 2018. The total number of purchase transactions was about 4 million, and the number of sales transactions was about 8 million.

The public project participation data of software companies were extracted from the contract information of the Korea e-Procurement System, a platform that announces bids for all public projects of 100 million or more according to the Procurement Service Act, company information, public contract amount by year, and the number of public contracts. This data was integrated with Korea Enterprise Data, and the public sales of 2,665 software companies with annual sales of more than 5 billion won amounted to 2.245 trillion won, about 71.8% of the 3.126 trillion Won budget for outsourced customised software development projects or packaged software purchases in the public sector as of 2017. The remaining 28.2% of the total business size of less than 100 million won is

estimated to be carried out by small businesses, which are not included in the sample of Korean corporate data above. In fact, companies with less than 5 billion won, which are classified as small businesses, account for 76% (2013) of the number of companies, but their total sales account for 3.9 trillion won (2016), 12.1% of all software companies' sales (Ministry of Science and ICT, 2018).

2.4 **Result of Empirical Analysis**

2.4.1 **Descriptive Statistics**

The first sample collected for this study is an unbalanced panel of financial and trading network data from the 2,665 software companies with sales of more than 5 billion won and whose transaction data exist between 2008 and 2018. The data consists of 33,563 observations.

Table 2.4.1 shows the descriptive statistics of the major variables used in the analysis.

Table 2.4.1 Descriptive Statistics of the Major Variables

Variable	Observations	Average	S.D.	Min	Max
y	33,563	0.089	0.498	-5.623	16.060
Previous Year's Sales (ln)	21,863	14.573	1.379	0	19.265
Age (ln)	33,563	1.798	0.876	0	4.007
Integration Capability	33,563	0.146	0.070	0	0.288
Brokerage Capability	33,563	0.000	0.001	0	0.043

Collaboration Capability	33,563	0.097	0.147	0	1
Hierarchical Trading Capability	33,563	3.295	1.555	0	8.811
ageRange	33,563	1.408	0.555	1	3
Dummy of Public Sales	33,563	0.363	0.481	0	1

2.4.2 **Analysis Result**

Tables 2.4.2 and 2.4.3 summarise the estimation results of two models stated above. For both models, the present study applied OLS, instrument variable two-stage least squares (IV 2SLS) fixed effect, and GMM.

Table 2.4.2 Estimation Results of Eq. (2.2.2.4)

y	**OLS**			**IV 2SLS, FE**			**Two-Step System GMM**		
	Coef.	**Pr(>|t|)**		**Coef.**	**Pr(>|t|)**		**Coef.**	**Pr(>|t|)**	
Sales (ln) (t-1)	-0.215	0.000	***	-1.029	0.000	***	-1.153	0.000	***
Age (ln)	-0.092	0.000	***	0.422	0.000	***	-0.168	0.037	**
Integration Capability (t-1)	1.196	0.000	***	0.632	0.000	***	7.426	0.054	*
Brokerage Capability (t-1)	57.178	0.000	***	23.126	0.000	***	1762.665	0.000	***
Collaboration Capability (t-1)	-0.235	0.000	***	-0.123	0.000	***	-3.018	0.054	*
Hierarchical Trading Capability (t-1)	0.005	0.046	**	0.010	0.000	***	0.290	0.017	**
ageRange (t-1)				0.085	0.000	***	0.708	0.024	**
Constant	3.296	0.000	***	omitted			omitted		
Observations	21,863			20,524			21,863		
Adj. R-square	0.2292			0.4920					

Breusch–Pagan / Cook–Weisberg Test	137482.14(0.000)***		
Over-identification Test		0.0753	0.147
AR(1)			0.000
AR(2)			0.269
F stat	434.28	469.11	136.86

Note. ①*** means statistically significant at 1%, ** at 5%, and * at 10%.

② The annual dummy used as an instrumental variable was included in the analysis, but t he results were not presented.

Table 2.4.3 Estimation Results of Eq. (2.2.2.5)

y	OLS			IV 2SLS, FE			Two-Step System GMM		
	Coef.	**Pr(>|t|)**		**Coef.**	**Pr(>|t|)**		**Coef.**	**Pr(>|t|)**	
Sales (ln) (t-1)	-0.217	0.000	***	-1.145	0.000	***	-1.147	0.000	***
Age (ln)	-0.195	0.000	***	0.541	0.000	***	-0.433	0.015	**
Integration Capability (t-1)	1.210	0.000	***	0.854	0.000	***	13.760	0.001	***
Brokerage Capability (t-1)	54.295	0.000	***	26.111	0.000	***	1467.903	0.000	***
Collaboration Capability (t-1)	0.011	0.884		0.130	0.073	*	-4.888	0.006	***
Hierarchical Trading Capability (t-1)	0.005	0.045	**	0.013	0.000	***	0.497	0.000	***
Collaboration (t-1) * ageRange (t-1)	-0.176	0.001	***	-0.191	0.000	***	1: 0	(empty)	
							2: 0.565	0.808	
							3: -1.905	0.849	
ageRange (t-1)	0.208	0.000	***	0.028	0.014	**	1: 0	(empty)	
							2: 0.947	0.044	**
							3:-2.516	0.122	
Constant	3.256	0.000	***	0	Omitted		0	Omitted	

Observations	21,863	20,524	21,863
Adj. R-square	0.2432	0.4147	
Breusch–Pagan / Cook–Weisberg Test	136654.25(0.000)***		
Over-identification Test		0.1684	0.374
AR(1)			0.000
AR(2)			0.113
F stat	414.26	353.91	106.61

Note. ①*** means statistically significant at 1%, ** at 5%, and * at 10%.

② The annual dummy used as an instrumental variable was included in the analysis, but t he results were not presented.

After the Breusch–Pagan or Cook–Weisberg test for heteroscedasticity, the present study found that heteroscedasticity is present in both models. In the IV 2SLS fixed-effect model, estimates are efficient and statistics are consistent for homoscedasticity only. Therefore, we should go over the more efficient GMM estimator.

When analysing the results centred on equation (2.2.4), integration, brokerage, and hierarchical trading capabilities positively affect the firm growth, while collaboration capability negatively affects it. When applied to the system GMM, the previous year's sales, the four explanatory variables for the previous year's network capabilities, and the dummy variable of the previous year's public sales were treated as endogenous variables or predetermined variables. Each year, the dummy and time lag variables of the logarithmic value of the revenue were used as instrumental variables. The Hansen-J test

results show that the instrumental variables used were selected properly because they failed to reject the null hypothesis at a significant level within 5% and that the AR(2) test shows that they do not have autocorrelations at the secondary level at least.

When analysing the results of equation (2.2.5), integration, brokerage, and hierarchical trading capabilities positively affect the firm growth, while collaboration capability negatively affects the firm growth. The interaction terms between collaboration capability and age range did not show significant results. Interpreting the age range term's estimation results, it can be said that the bigger collaboration of SMEs lasted more than 20 years, resulting in the lower firm growth.

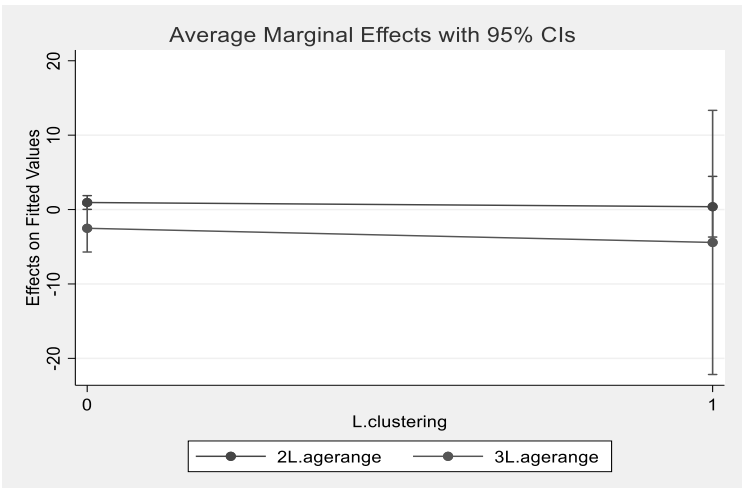

Figure 2.4.1. Graph of Interactions for Model 2.2.2.5

Given the robustness of the model and the consistency of the results, the results of the verification of the study's hypotheses can be summarised as follows:

Table 2.4.4 Hypothesis Test Results

Hypothesis	H1(+)	H2(+)	H3(+)	H4(+)
Empirical Result	(+)	(+)	(-)	(+)

For the opposite result of hypothesis 3, some existing literature suggested that the innovative benefits of collaboration are not immediately realised and are achieved with a deeper time lag (Schilling and Phelps, 2007; Stuart, 2000). Collaboration capability implies a potential long-term relationship among three firms; these firms in a triad structure know each other. Even though the software industry gets mature and has more than 50 years of history, the industry innovation patterns are found to be short-cycled (Kim et al., 2013) and vary from 6 months to 4–5 years. Therefore, the potential long-term relationship's embeddedness would impact the growth of software firms in a restricted manner.

2.5 **Academic and Policy Implications**

The present study dynamically analysed the impact of network capabilities on firm growth. In an extension of the theoretical view that incorporates the strategic management theory represented by the resource-based theory and organisational ecology, it was confirmed that network capability is also a major variable that explains the firm growth's heterogeneity. Network capabilities could be identified in four different ways by their ability to mediate other firms or access and integrate information from other firms, collaborative capabilities, and hierarchical trading capabilities (Kim et al., 2014; Schilling

and Phelps, 2007; Korea Institute for Industrial Economics and Trade 2016; Jung and Hong, 2015). Network capabilities identified in four categories were expected to impact the firm growth positively (Kim et al., 2014; Schilling and Phelps, 2007; Korea Institute for Industrial Economics and Trade, 2016; Jung and Hong, 2015). Kim et al. (2014) measured the impact of integration and brokerage network capabilities on innovation cluster's dynamic growth only. Schilling and Phelps (2007) focused on the impact of collaboration and hierarchical trading network capabilities on patent generation. Jung and Hong (2015) also measured the impact of partial network capabilities focusing on hierarchical trading capabilities on firm performance. Kim et al. (2014) considered innovation regional cluster's dynamic growth but only focused on partial network capabilities. Schilling and Phelps (2007) dealt with collaboration and hierarchical trading capabilities only and further assessed the impact on patent generations, which is misleading and unimportant in the software industry compared to the other industry. The estimation result of the present study showed that integration, brokerage, and hierarchical trading capabilities positively impacted the firm growth, but the higher the collaboration capability, the lower the yearly firm growth. In the previous literatures, the high level of collaboration capability had positive impact on patent generation and firm performance, but the present study showed that it can rather negatively impact on the yearly firm revenue growth for SMEs. If a collaboration relationship is established, the changes in performance depend on the clusters, not the single firm unit. Therefore, the innovation benefits of collaboration are not immediately realised and are achieved with a deeper time

lag (Schilling and Phelps, 2007; Stuart, 2000). According to the perspective of existing research looking at network capabilities, firms try to use the resources of other companies in the network and to exploit and develop their own resources. This also suggests that performance also needs to be measured per cluster (Kim et al., 2014). From this study's comprehensive perspective, network capabilities can be classified into four subcategories that have different impacts on firm growth. The present study detected a gap in the previous literature, showing inconsistent views on network capabilities' impact on firm performance. Network capabilities promote firm innovation and can cause low productivity and patent generations (Barrass and Madhavan, 1996; Ahuja, 2000; Zaheer and Bell, 2005; Kim et al., 2014; Schilling and Phelps, 2007; Jung and Hong, 2015). These inconsistent views could stem from other types of unobserved network capabilities. An expanded, comprehensive identification of network capabilities was suggested in this chapter. Company managers should carefully apply the recombination of four different network capabilities, especially when conflicting decisions are required at the same time; long-term collaborations are necessary, while short-term revenue growth is important in this fiercely competitive environment. In the software industry, where patent generation is relatively unimportant and short-term revenue growth is more important due to the short technology cycle, a strategy that takes advantage of the network structure represented by integration, brokerage, and hierarchical capabilities is effective in achieving the target sales. Also, the formation of horizontal and mutually beneficial clusters negatively impacts short-term sales growth. This means that various government policies, such as

fostering software-specialised technology firms, encouraging joint contracts (e.g., consortiums), restricting conglomerate firms' participation, and restricting multilayered subcontracting, should be planned differently depending on the target period (short-term or long-term).

Chapter 3. The Policy Effect of Excluding Conglomerates' Participation on Labour Productivity of Target SMEs

3.1 Literature Review

3.1.1 Roles of the Korean Government: SME Policy and Public Procurement

3.1.1.1 Comprehensive Policy for SMEs in Korea

Storey and Greene (2010) emphasised that the government and corporate development have a critical role in growing small businesses relatively quickly.

Korea is making efforts to grow SMEs through its policies. Its efforts include aspects of industry policy for growth and fair competition policy to address the market failure by mitigating information asymmetry and adverse conditions. The roles, types, and means of the SME policy can be categorised as shown in Table 1 in terms of what kind of support is provided to SMEs subject to the policy (Bennett, 2014; Storey, 2003; Wapshott and Mallett, 2018). In defining the role of the government as regulators, promotors, motivators, suppliers, and consumers, the types of policies can be divided into facilitating access to funds or finances, supporting sales and exports, easing administrative burdens, providing space and ecological infrastructure, providing skilled personnel, and supporting the development of new technologies. Table 3.1.1 provides specific policy measures for

each type and example of legal and institutional grounds for supporting 15 small and medium enterprises in Korea.

Table 3.1.1 Types and Means of SME Policy

Type of Policy	Role	Means of Policy	Legal Basis in Korea
Definition of Role	Regulator	Preparation of the basis for the legal system	Framework Act on Small and Medium Enterprises Small and Medium Enterprises Promotion Act
Access to Funds	Promotor	Loan guarantee, deduction, investment	Regional Credit Guarantee Foundation Act
Supporting Market	Consumer	Procurement	Act on Facilitation of Purchase of Small and Medium Enterprise-Manufactured Products and Support for Development of Their Markets
	Regulator	Fair trade (business protection)	Act on the Special Measures for the Protection of and Support for Micro Enterprises Special Act on the Development of Traditional Markets and Shopping Districts Act on Support for Female-owned Businesses Act on the Facilitation of Entrepreneurial Activities of Persons with Disabilities

	Promotor	Overseas advancement (export)	Act on Facilitation of Purchase of Small and Medium Enterprise-Manufactured Products and Support for Development of Their Markets
Ease of Administrative Burden	Regulator	Corporate deregulation	Special Act on the Promotion of Business Conversion in Small and Medium Enterprises
		Easing regulations on start-ups and comeback	Small and Medium Enterprise Cooperatives Act Support for Small and Medium Enterprise Establishment Act
Provision of Infrastructure	Supplier	Joint office, science park, incubator, accelerator	Act on Special Measures for the Promotion of Venture Businesses
Support for New Technologies	Motivator	Support R&D, corporate affiliated research institute, idea contest, etc.	Act on the Promotion of Technology Innovation of Small and Medium Enterprises
Skilled Personnel	Supplier	Support training and recruitment	Act on the Fostering of Self-Employed Creative Enterprises Special Act on Support for Human Resources of Small and Medium Enterprises

Source: Edited from Bennett (2014), Story (2003), and Wapshott and Mallett (2018)

Along with this framework of support for SMEs, the Software Industry Promotion Act defines the government's role in promoting the software industry, which can designate and create software promotion facilities, vitalise startups, receive local governments' support for promotion facilities, train specialists, promote technology development, certify good software, conduct benchmark tests, manage software industry information, assess software business impacts, promote software distribution, promote entry into the overseas market, and provide tax credits, among others, to create an advanced foundation for the software industry. The Act also defines the forecast of public demand as a must, monitoring the duty of the public body for the fair contracts, a deliberative committee on task changes, restriction of unfair subcontracts, payment methods for businesses, a guarantee for the repair of defects, reports of business operators, support for the participation of software SMEs with the restriction of participation of conglomerates and the lowest contract amount, management and supervision of software business and financial cooperative, and so on.

3.1.1.2 Policy for the Entry Restriction on Conglomerates' Participation

Public procurement, in which the government acts as a consumer, is about 160 trillion won as of 2019 in Korea, accounting for about 8% of the total GDP (National Statistical Office, 2020). For OECD countries, the size of the public procurement market accounted for an average of 12% of GDP as of 2017 (Organisation for Economic Co-operation and

Development, 2019). In other words, the public procurement market is also becoming the most essential source of profits for most companies in the recent low-growth phase (Davis and Brady, 2015). Government procurement is also a big part of South Korea's software market. Korea's software market is estimated to be about 11 trillion won, 3.3 trillion won of which is ordered by the government and public institutions, accounting for about 30%. Also, as the laws and rules of these procurement markets are applied to the private market, their impact is crucial not only in terms of amount but also in establishing the market order.

However, in this public software procurement market, the high participation of conglomerates was pointed out as a problem. The share of internal transactions of IT service conglomerates established by affiliates of enterprise groups subject to limitations on mutual investment (hereafter referred to as 'conglomerate') is 61.6%, which has been pointed out as a reason for increasing the exclusive closure of the Korean software market. In this market structure, it came up an issue that SMEs in the software industry find it hard to grow their scale independently and to accumulate the technology by the high share of conglomerates in the public market.

In response, the Korean government (then Ministry of Information and Communication) introduced the 'lowest contract amount' system for participation in public software projects in 2004. The system was designed to prevent conglomerates from monopolizing even small businesses by classifying them into more than 800 billion won in sales and less than 800 billion won and allowing them to participate only in public

software projects with a certain amount or more. Since its introduction, it has continuously reduced the scope of public software projects that large companies can participate in by raising the lowest limit until 2011.

However, despite the increase in the lowest contract amount, the public share of conglomerates rose from 60.6% in 2007 to 76% in 2010. At that time, the purpose of introducing a system to prevent large companies from monopolizing public software projects was overshadowed.

Accordingly, in 2011, the National Assembly proposed a system to restrict the participation of conglomerate firms and passed it in 2012. From January 2013, a system of 'restriction' on conglomerate firms' participation was implemented, prohibiting the participation of mutually restricted companies in public software projects regardless of the project's cost.

3.1.2 Public Procurement and Firm Productivity

Companies participating in public procurement enjoy the effects of the economy of scale as a result of increased production. The Organisation for Economic Co-operation and Development (2018) also points out that public procurement is used as a means of ensuring the growth and survival of companies by creating public demand and forming an early-scale economy to foster small- and medium-sized enterprises. Pyo, Hong, and Kim (2013) considered productivity as a major factor in enhancing the competitiveness of SMEs while emphasizing the impact of economies of scale, information power, and

bargaining power. They also argued that the gap in competitiveness due to economies of scale cannot be resolved with direct government support and is likely to be narrowed through indirect production factors, such as purchasing and market exploitation. Harrison and Rodriguez-Clare (2010) looked at the economies of scale through state-level public procurement. They argued that in developing countries, public procurement policies can give companies and industries growth engines through economic effects of scale. Syverson (2011) argued that demand plays a vital role in explaining productivity and corporate growth dynamics. Pozzi and Schivardi (2016) measured the impact of demand and productivity shock on the growth of firms by separating and measuring the impact of demand and productivity shock on a firm's growth with data on price, input, and output by the firm, asserting that demand heterogeneity is an essential determinant in growth. This means that demand shocks depend on past sales, and companies are more challenged to respond to productivity than demand shocks. It was also argued that the barrier about the ability of an enterprise to allocate efficient resources was not only affected by regulation or government corruption but also by management and corporate capabilities, governance, and control, work attitude, and competition in the product market (Bloom and Van Reenen, 2010; Pozzi and Schivardi, 2016). Meanwhile, Foster, Haltiwanger, and Syverson (2008) argued that start-ups could also be productive if the heterogeneity of demand is adequately matched. Foster, Haltiwanger, and Syverson (2016) then argued that the difference in scale between start-ups and existing firms comes from a fundamental gap in demand rather than a productivity gap. It has also been argued that

demand shocks are critical to scaling growth, especially for start-ups (Lee, 2017; Ferraz, Finan, and Szerman, 2015). In addition, some studies argue that the impact of such demand shocks is significantly positive for companies' short-term growth and does not exceed the current year or two (Ferraz, Finan, and Szerman, 2015; Fadic, 2020).

The above discussion served as a basis for arguing that public procurement does not merely serve as a demand shock but as a market with unique characteristics, resulting in an accumulation of knowledge of this market and in productivity gains for businesses (Lee and Jung, 2018). Accordingly, Lee and Jung (2018) argued that the impact of public procurement on participating companies led to promotional effects, technical and quality improvement stimuli, effects of alleviating market uncertainty, and economies of scale and learning effects, which eventually led to the growth of companies. The study demonstrated that the higher the procurement dependency, the higher the growth rate in the private market in the future even after controlling the heterogeneous effects of companies.

3.1.3 Public Procurement for Software Landscape Changes in Korea

Looking at the change in the landscape of supply and demand, which has formed the Korean public procurement market for software, the overall demand is organised around maintenance and management, and as the business power of early-comers increases, the

entry of new faces becomes difficult (SPRi, 2020).

The public procurement market for software recorded a high growth rate compared to local and foreign markets at an annual average of 11.8% from 2008 to 2012 and 5.5% from 2013 to 2018. Excluding the year of 2016, it can be expected that the public procurement market has had a positive effect on the long-term survival of software companies compared to the private sector market.

Table 3.1.2 Size of Public Procurement Market for Software (2008–2019), Trillion Won

Year	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Public Procurement Market Size for Software	1.31	1.46	1.72	1.94	2.05	2.29	2.57	2.72	2.72	2.85	2.99	3.31
Growth Rate	47.4%	11.3%	17.7%	12.8%	5.9%	11.6%	12.2%	5.8%	0.2%	4.5%	5.1%	10.5%

Source: Software Development Market Demand in Public Sector (NIPA, 2019)

However, as the maturity of the public sector system increased, the public sector software business environment of firms went to form mainly low-value-added businesses focused on maintenance and management. As shown in the table below, from 2013, the maintenance business exceeded the proportion of the development business, reaching the highest level in 2017 at 69%, and as of 2019, 64% was the maintenance business. Generally, the project value of maintenance and management is lower than that of development projects, so an increase in the weight of maintenance projects means that the

proportion of small-scale projects has increased. In the case of ISP, development, and integration projects, the order-winning company is selected through a process of negotiating technology and prices based on ‘procuring the best value principle’, but in the case of operation and maintenance projects, the selection method based on ‘procuring the lowest price principle’ is applied generally (Korean Public Procurement Service, 2020).

Table 3.1.3 Demand Fragmentation in Public Procurement for Software (2008–2019)

Year	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Development Projects	67%	68%	52%	55%	55%	43%	47%	39%	34%	31%	34%	36%
Operation/Maintenance Projects	33%	32%	48%	45%	45%	57%	53%	61%	66%	69%	66%	64%

Source: Software Development Market Demand in Public Sector (NIPA, 2019)

The number of firms participating in the public procurement market for software, which can be regarded as a proxy for the intensity of competition among suppliers, has increased gradually as barriers to the entry of mid-sized and large firms have increased. Overall, SME participation seems to have increased a lot. Despite the presence of barriers to entry based on the amount of the project, SMEs often participate in small-sized businesses considering the lack of business capabilities or resources, financial bidding requirements for each project amount, and previous references and practices requirements. Therefore, it can be seen that the intensity of competition for small-scale businesses of less than 2 billion won has increased compared to the time period without entry barriers

for bigger firms.

We need to analyse the effect of the target policy in consideration of the change in the business landscape and the context of the institutional change stated above. True experimental design can clearly identify causal relationships, has high internal validity, and can control external environmental factors or exogenous variables, but it is very difficult to use in practice. The reason is that it is difficult to artificially control the research situation in practice. Accordingly, a quasi-experimental design capable of obtaining similar effects was used although it did not reach the experimental design. In this study, through a quasi-experimental design, a treatment group that participated in the public market and a control group that did not participate in the public market are identified to analyse the net effect of the policy.

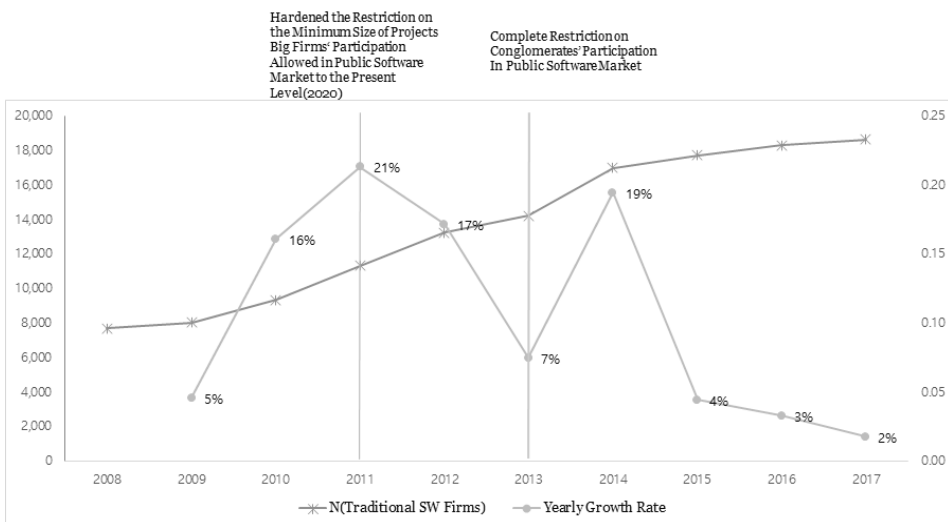

Figure 3.1.1 Number of Firms Participating in the Public Procurement Market for Software

3.2 **Research Model and Hypothesis**

Based on the theoretical background above, this study focuses on the role of the government as a consumer in the software industry and sets up the following hypotheses to see if the Korean government's policy of comprehensive innovative public procurement of SMEs has actually had a positive impact on the labour productivity growth and profitability of enterprises.

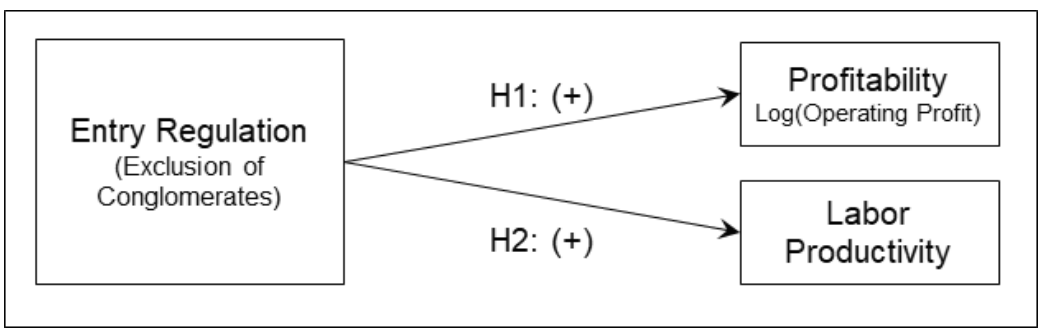

Figure 3.2.1 Research Model and Hypothesis

H1. The restriction policy on conglomerate firms' participation has had a positive impact on the profitability of enterprises.

H2. The restriction policy on conglomerate firms' participation has had a positive impact on the labour productivity of enterprises.

Existing studies have shown that public procurement not only impacts the demands of participating companies (Harrison and Rodriguez-Clare, 2010; Syverson, 2011; Pozzi and

Schivardi, 2016) but also acts as a single market with unique characteristics. As knowledge about this market accumulates, companies would benefit from the productivity, and finally, companies would grow with the promotional, technological, and quality-enhancing stimulus, the effects of mitigating market uncertainty, economies of scale, and learning effect (Lee and Jung, 2018; Utterback, 1994). The public software market is a dedicated market (Uyarra and Flanagan, 2010), and it is a customised IT service market whose specifications vary according to the consumers' purposes. Based on the above studies, it can be hypothesised that cumulative knowledge in the public software market will bring about gains in productivity—not only mitigating market uncertainty but also doubling the learning effects—eventually having a positive impact on growth and profitability (Lee and Jung, 2018; Syverson, 2011; Pozzi and Schivardi, 2016).

The modern theories of industry dynamics assume that firms are heterogeneous in terms of productivity and demand, which determines the firm's performance and growth (Jovanovic, 1982; Hopenhayn, Pozzi, and Schivardi, 2016). Productivity is an important construct that represents the organisational performance of firms in the same industry. According to the research framework, I added two dependent variables: labour productivity and revenue/profitability growth. The present study is focused on labour productivity. Productivity represents the efficiency of an industry or firm, that is, the relationship between the outcome as an output and the factor of production as an input. So productivity analysis shows the source of growth and the relative efficiency between industries or countries. This productivity is also divided into individual factor

productivity, that is, labour productivity, capital productivity, and total factor productivity, and total factor productivity represents the relationship between the input of all factors of production and the amount of output when the input of all factors of production changes. In the traditional software industry, most of the cost investment is devoted to R&D labour, and due to the incomplete data source, I employed labour productivity as a proxy for the productivity measure in line with the previous literatures (Datta, Guthrie, and Wright, 2005; Delmas and Pekovic, 2013; Roca-Puig et al., 2012; Sivatte et al., 2015).

According to Foster, Haltiwanger, and Syverson (2016), Lee (2017), and Ferraz, Finan, and Szerman (2015), the difference in company sizes comes from the fundamental gap in demand. Firm age and size are considered controlled variables (Bloom and Van Reenen, 2010; Pozzi and Schivardi, 2016).

3.3 Data and Analysis Method

3.3.1 Variables and Data

Table 3.3.1 presents the variables and their descriptions used in this study. For analysis, 2,665 major software companies combined transaction data from 2008 to 2017 with public software procurement service contract and financial data. The analysis data was collected through the public data released by the Korea Public Procurement Service after purchasing transaction and financial data from Korea Enterprise Data Co., Ltd., a credit rating agency.

Korea Enterprise Data Co., Ltd., is a company that collects the intercompany sales and purchase tax calculation sheets and conducts a company's credit evaluation. Using the tax invoice data, it shows how often and at what scale one company deals with other companies. This study analyses the transaction and financial data of 2,665 software companies with annual sales of 5 billion Won, which belong to computer programming services (62010), computer system consultancy and computer facilities management activities (6202), and system software and applications development/publishing (58220) from 2008 to 2017. The total number of purchase transactions was about 4 million, and the number of sales transactions was about 8 million.

The public project participation data of software companies were extracted from the contract information of the Korea Online e-Procurement System, a platform that announces bids for all public projects of 100 million or more, according to the Procurement Service Act, company information, public contract amount by year, and the number of public contracts. This data was integrated with Korea Enterprise Data, and the public sales of 2,665 software companies with annual sales of more than 5 billion won amounted to 2.245 trillion won, which is about 71.8% of the 3.126 trillion Won budget for public software construction/purchase as of 2017. The remaining 28.2% of the total business size of less than 100 million won is estimated to be carried out by small businesses, which are not included in the sample of Korean corporate data above. In fact, companies with less than 5 billion won, which are classified as small businesses, account for 76% (2013) of the number of companies, but their total sales account for 3.9 trillion

won (2016), accounting for 12.1% of all software companies' sales (Ministry of Science and ICT, 2018).

Table 3.3.1 Definition and Descriptions of Variables in the Analysis

Classification	Variable	Definition	Description
Dependent Variable	laboreff	Labour Productivity	Logarithmic value/number of employees in sales in the year
	lgprof	Logarithmic Value of Operating Profit	Logarithmic value of operating profit for the year
Independent Variable	treated	Policy Target	Treatment Group: Target firms of the policy Comparison Group: Firms outside the impact of the policy
	time	Policy Enforcement Period	Before the implementation: 2008-2012 After the implementation: 2013-2017
	did	Difference-in-difference	treated*time
Controlled Variable	age	firm age	age after the foundation
	employee	Size	Employee size in the year
Dummy Variable	startup	Start-ups	New start-up company within five years: 1 Existing company: 0
	conglomerate	Chaebol Enterprise	Chaebol enterprise group subject to limitations on mutual investment: 1 Non-chaebol enterprises: 0
	sme	Small and Medium-sized Enterprises	Small and medium-sized enterprises: 1 Non-small enterprises: 0

3.3.2 Analysis Method

3.3.2.1 Propensity Score Matching

This study mixed propensity score matching, difference in differences analysis. Before estimating difference in differences and triple differences, the treatment and comparison groups for this purpose were formulated through propensity score matching. Propensity score matching is the pairing of objects with similar attributes represented by variables, a statistical method of performing sampling close to the random selection of pure experiments (Rosenbaum and Rubin, 1983; Lee and Moon, 2014). In this study, a group of public firms (treatment group) was formed and a comparison group of private firms was collected with propensity scores close to those held by the treatment group. In order to enhance the validity of the research, this study used the clustered sampling method based on the consolidated data, and then utilised propensity score matching based on the firm size (number of employees), inter-firm cooperation hierarchy and age. A difference in differences analysis is a method of estimating the effectiveness of a policy, forming a kind of quasi-experiment state by organizing a treatment group and a non-applicable comparison group under the policy. In this study, the 'public firms' were designated as the treatment of the policy and the difference in revenue growth, labour productivity and innovation outcome of two groups was estimated from the pre-treatment period (t=0) prior to the enforcement of the legal revisions to the post-treatment period (t=1) that is after the legal revisions implemented.

Propensity score matching first used an algorithm to estimate propensity scores by taking a bivariate variable of the dummy indicating whether the policy was targeted or not and match them with the nearest neighbour method (Caliper=0.1). Next, after checking the common area of the propensity score, the quality of matching was assessed and the experimental group and comparison group were finalised.

3.3.2.2 Panel Difference-in-Differences

The general difference-in-differences method, a kind of quasi-experimental design, is adopted, focusing on the fact that the restriction system for participation of conglomerates was implemented from a specific point in time and whether or not to apply the policy is clearly classified according to the size of the firm. The average effect of the policy according to the difference-indifferences method eliminates the time effect before and after policy participation and the difference between the participating groups. Let x1i be a dummy variable indicating whether or not the policy is applied, and x2i be a dummy variable indicating the time before and after the policy. If the value of x1i is 1, the policy application is 0, the case is not. Similarly, if the value of x2i is 0, it indicates before policy enforcement, and 1, after the policy enforcement. There can be 4 cases in which x1i and x2i can have values. Given that Yi is the variable representing the financial performance of firm group i, potential performance can be expressed as α, $\alpha+\gamma$, $\alpha+\lambda$, $\alpha+\gamma+\lambda+\beta$. This expected value is shown in the graph as follows, and a general difference-in-differences model is estimated by considering beta as a policy effect based

on the parallel trends depicted in Figure 3.3.1 (Yoo, Park, Kim, and Lee, 2019).

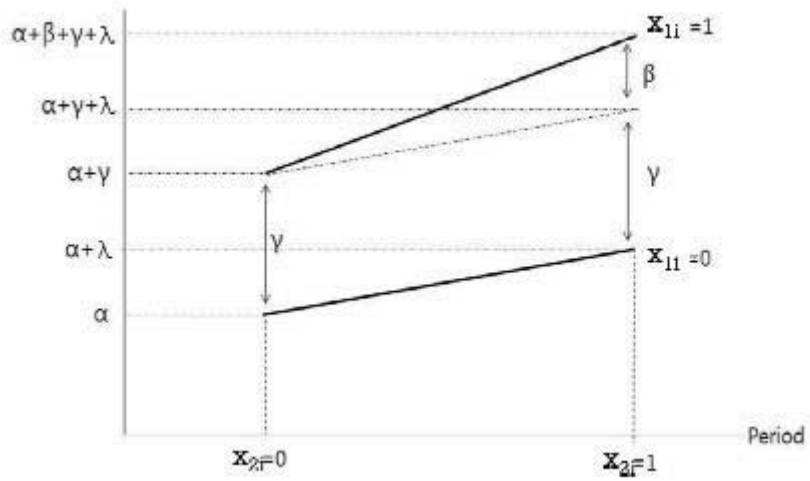

Figure 3.3.1 Concept of Difference-in-Differences Model

Source: Yoo, Park, Kim and Lee, 2019

However, the difference between the two groups estimated by the simple difference in differences analysis has some restrictions to be regarded as a net policy effect because it does not control the natural time-varying feature of the dependent variables over time. (Min and Choi, 2013). Therefore, the present study considers the panel difference-in-differences, where y(i,t) is an outcome observed for a unit i=1, …, I at period t=1,…,T, Treated(i,t) is a treatment variable, Period(i,t) is an indicator variable of period in which the treatment is in place. X(i,t) is a vector of control variables, μi is individual effects and φt is time fixed effects and, critical for the point being made, there is an interaction of an unobserved individual trend effect ωi with a time trend f(t) (Ahlfeldt, 2018).

$$Y_{(i,t)} = \alpha + \gamma\,Treated_{(i,t)} + \delta\,Period_{(i,t)} + \beta(Treated_{(i)} \cdot Period_{(t)}) + \kappa X_{(i,t)} + \mu_i + \varphi_t + \omega_j f(t) + \varepsilon_{(i,t)} \quad \text{Eq. (3.3.2.2)}$$

3.4 Result of Empirical Analysis

3.4.1 Descriptive Statistics

The first sample collected for this study is an unbalanced panel of 2,665 entities with transaction data, transaction network data, and public contract amount data from 2008 to 2017. The data consist of a total of 31,142 observations.

Table 3.4.1.1. shows the basic statistics of the variables used in the analysis.

Table 3.4.1 Descriptive Statistics of the Major Variables

Variables	Mean	S.D.	Min	Max	Observations
laboreff	1.287	1.553	0.000	15.361	31,142
lgprof	9.203	4.836	0.000	20.583	
age	8.196	5.973	0.000	65.000	
employee	46.358	265.570	1.000	14139.000	

Among them, the experimental group candidates with more than 100 million public software market contract orders obtained 13,442 observations, and the comparison group candidates had 17,700 observations.

Table 3.4.2 Descriptive Statistics for the Treatment Group and Control Group

Category	Objs	age	employee

Treatment Group	13,442	Mean	9.693	Mean	67.516
		S.D.	6.154	S.D.	389.378
Control Group	17,700	Mean	7.058	Mean	30.290
		S.D.	5.569	S.D.	91.400
Homogenous Variance (Bartlett's K-squared p-value)	-	153.77(<2.2e-16)		27319(<2.2e-16)	
Wilcoxon Rank sum	-	86761348(<2.2e-16)		87982611(<2.2e-16)	

3.4.2 Results of Analysis

3.4.2.1 Propensity Score Matching Analysis Results

Afterward, the characteristics of the experimental group and the comparison group before and after matching the propensity score were analysed through the SMD value to assess the quality of the matching. The analysis results are shown in Table 3.4.3.

Table 3.4.3 PSM Result Quality Index

	Before Matching			**After Matching**		
	Treatment Mean(SD)	Control Mean(SD)	SMD (Standardised Mean Difference)	Treatment Mean	Control Mean	SMD (Standardised Mean Difference)

age	9.69(6.15)	7.06(5.57)	0.449	<0.001	9.00(5.49)	8.88(5.47)	0.021	0.092
employee	67.52(389.38)	30.29(91.40)	0.132	<0.001	49.26(264.14)	37.13(102.86)	0.061	<0.001
objs	13,442	17,700	N/A		12,482	12,482	N/A	

Note. ①*** means statistically significant at 1%, ** at 5%, and * at 10%.

② $SMD = \frac{\overline{X_{treated}} - \overline{X_{control}}}{\sqrt[2]{\frac{(S^2_{treated} + S^2_{control})}{2}}}$ X is the mean of the sample, S^2 is the variance of the sample.

3.4.2.2 Trend Analysis Results

Before the difference-in-difference analysis, this study analysed the changes in the company's labour productivity and operating profit for five years before and after 2013 when the policy for the restriction on conglomerate firms' participation was implemented. Figure 3.4.1 is the result of comparing the change in labour productivity of the analysed enterprise. It can be seen that experimental groups and comparison groups are showing a parallel trend until 2013, before the implementation of the restriction policy.

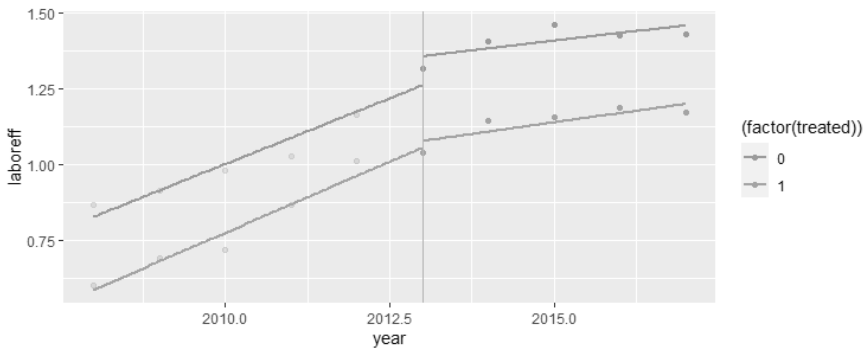

Figure 3.4.1 Labour Productivity Trends over the Period

Meanwhile, the change in operating profit did not show a parallel trend between groups before the implementation of the intergroup system. Both groups continued to fall until 2015, but have been on the rise again since 2016. Therefore, in the case of hypothesis 1, it is difficult to identify the net effect of the plan that is significant in a given way.

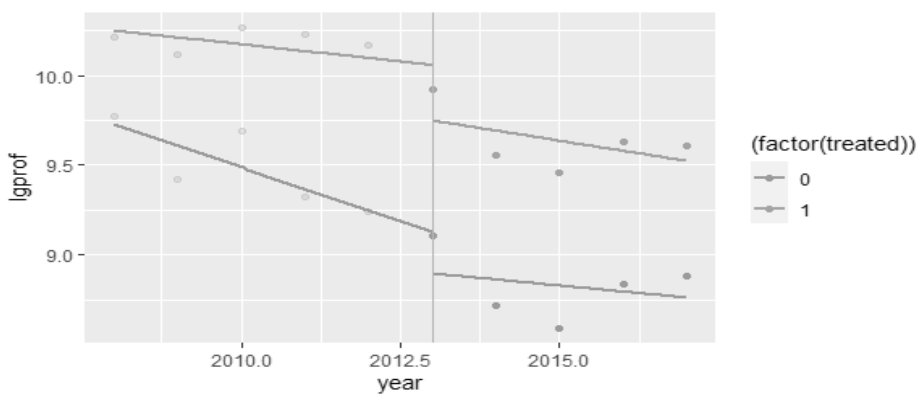

Figure 3.4.2 Profitability Trends over the Period

3.4.2.3 Difference-in-Differences Analysis Results

Table 3.4.4 shows the results of a difference-in-differences analysis of the model corresponding to hypothesis 2 for predefined independent variables and difference-in-differences variable only (Model 1), with controlled variables (Model 2), and moderating variables (Model 3). A difference-in-differences analysis showed that the restriction on conglomerate firms' participation put a crimp on labour productivity of companies (experimental groups) operating in the public market even though it controlled the effects of corporate performance and employee size.

Table 3.4.4 Results of Hierarchical Panel Difference-in-differences Regression Analysis

	y=laboreff	Model(1) : H2			Model(2) : H2			Model(3) : H2		
		Coef.	Pr(>|t|)		Coef.	Pr(>|t|)		Coef.	Pr(>|t|)	
Independent Variable	Treated Public=1, Private=0	-0.205	0.000	***	-0.198	0.000	***	-0.196	0.000	***
	Time Before=1, After=0	0	(omitted)		0	(omitted)		0	(omitted)	
DID	Treated*Time	-0.065	0.066	*	-0.067	0.044	**	-0.070	0.034	**
Controlled Variable	age				-0.072	0.000	***	-0.052	0.000	***
	employee				-0.000	0.000	***	-0.000	0.000	***
Dummy Variable	startup							0.321	0.000	***
	sme							0.165	0.024	**
	conglomerate							-0.208	0.031	**
Residual	_cons	1.259	0.000	***	1.924	0.000	***	1.488	0.000	***
Observations		24,964			24,964			24,964		
Adj R-square		0.0085			0.1079			0.1145		

AIC	85005.21	82372.53	82191.27
BIC	85029.59	82413.16	82256.27

Note. ①*** means statistically significant at 1%, ** at 5%, and * at 10%.

② The F-test indicates that all null hypotheses (H0: All estimated parameters are the same) are strongly rejected at the 1% level.

In the end, the results were slightly different from the previous hypothesis that the policy for the restriction on conglomerate firms' participation, which is the comprehensive procurement policy for small and medium enterprises, would increase the profitability of the companies and increase labour productivity. In the case of start-ups, the increase in labour productivity was somewhat high, but in the case of small and medium-sized enterprises, labour productivity decreased. Overall, the higher the performance, the lower the labour productivity.

Table 3.4.5 Hypothesis Test Results

Existing Hypotheses	H1(+)	H2(+)
Empirical Results	N/A	(-)

3.5 **Academic and Policy Implications**

The argument of existing research that the impact of public procurement on demand helps increase productivity and profitability of SMEs has a limitation that they didn't take

into account the characteristics of industry and suppliers. Also, demand for public procurement is more complicated because it is much more diverse and fragmented than the demand for private purchases (Telgen et al., 2007). The role of purchasing in a public organisation is multilayered, essentially to meet the needs of citizens' public products or services, as well as to become market participants, decision-makers, regulators, and judges while having a mutually beneficial relationship with suppliers (Georghiou et al., 2010). In particular, the public software market itself is known as technology procurement that belongs to the type of Adapted Procurement (Uyarra and Flanagan, 2010), and niche innovation based on technology capability is possible in the emerging market segment.

In the public software procurement market, due to the nature of the software industry, consumers value the awareness, the level of technology, and the experience of similar projects when selecting suppliers, and geographical proximity can also be a factor that determines the scope of the market depending on the characteristics and size of the project. In particular, the public software procurement market maintains R&D-based budgeting and execution patterns, but rather than having the characteristics of purchasing innovative products or using services to promote R&D, it consists mainly of integrated IT service projects centred on labour-intensive, single-step deployment, maintenance and operation, and thus has no continuity of business, and thus has the characteristics of diminishing returns (Yoo, Kim, and Kang, 2015).

In this paper, the system of excluding the participation of conglomerates, which aims

to protect and foster SMEs, has a negative impact on the increase in labour productivity of the treated group subject to the policy. Labour productivity was somewhat high for start-ups, but labour productivity was significantly lower for SMEs with no regulations on entering the public software procurement market. This means that public software market projects were not profitable, with only 21% of global public projects analysed between 2011 and 2015 (Standish Group, 2016) completing projects on schedule and budget (SPRi, 2016) and only 10.8% in Korea (SPRi, 2016). Moreover, even though 87.1% were not paid for the task change, 96.4% were on time for the deadline. Besides, it can be inferred that not only it is disadvantageous to start-ups that lack experience in similar businesses despite the nature of the software industry, but also that the focus of various small businesses in charge of each element technology disappeared while limiting the participation of conglomerates that had strong integration network capabilities (Hong and Jung, 2016) that are important in the IT service industry, and that the door to niche innovation has narrowed because mid-sized companies haven't had enough integration network capabilities (Kwon and Jung, 2019) to fill the vacancy.

The types and characteristics of possible innovations vary depending on the type of public procurement market. In public procurement, market focused on integrated business-supporting services where a collaborative structure such as the public software market is essential, extreme measures such as full-scale restrictions on market participants can rather halve the positive effects that demand shocks lead to increased productivity. It could have had enough effect on market participants to set the lower

bound of project value for the entry by firm size divided fourfold (small, medium, big, and conglomerates), and excessive policies to protect SMEs could harm the labour productivity growth of SMEs.

Chapter 4. Subcontracting Structure Matters: Innovation Performance in Software Industry

4.1 Literature Review

4.1.1 The Nature of Subcontracting

Subcontracting is a contract in which the prime contractor purchases parts or components of the product or process from the subcontractor when carrying out the project (Kimura, 2002). Subcontracting refers to long-term transactions between specific firm entities, and the prime contractor either entrusts production to a subcontractor or requires processing of materials, components, parts or subassemblies (Holmes, 1986). Subcontract relationships are inherently risk-sharing mechanisms based on economic grounds that they maximise mutual benefits, as demonstrated by empirical studies of manufacturing industries such as the automobile and air-conditioning industries (Yun, 1999; Okamuro, 2001; Camuffo, Furlan, and Retore, 2007). Because exchange conditions, such as asset specificity, are generally not directly related to firm performance (Markides and Wiliamson, 1994), it can be considered that performance is affected by the organisational arrangement of the inter-firm cooperation such as subcontracting relationships (Combs and Ketchen, 1999). A possible synthesis of the previous empirical studies conducted in manufacturing industries is that the prime contractor and the subcontractor can improve their competitiveness and performance through a subcontract

(Nham, 2011).

A theoretical approach to explaining the nature of subcontracting relationships between firms can be divided into three categories. They include a dualistic approach, which is a structural approach, a transaction cost approach and a network approach that explain the transactional relationship.

4.1.1.1 The Dualistic Approach

The dualistic approach emphasises the qualitative and structural aspects of subcontracting relationships, rather than quantitative aspects of transactional relationship (Park and Lee, 2011). Subcontracting is an unequal power relationship between the prime contractor and the subcontractor (Berger and Piore, 1980), in which the prime contractor which tends to be large in size are deemed to benefit at the expense of the subcontractor which tends to be smaller (Taymaz and Kllıçaslan, 2005). In the presence of fluctuations and uncertainties in demand or market conditions, large firms have a tendency to utilise subcontracts strategically to increase flexibility and transfer production risks (Nishiguchi and Brookfield, 1997) to the secondary sector or market and eventually achieve cost advantage in the production process (Watanabe, 1971; Berger and Piore, 1980; Abraham and Taylor, 1996; Taymaz and Kılıçaslan, 2005; Holl, 2008; Diaz-Mora, 2008; Diaz-Mora and Triguero-Cano, 2012; Saracoglu et al., 2016). Subcontracting allows large firms to move beyond rigid regulations on production or market transactions,

taxes, labour, and etc. and operate under a more flexible and informal economic system (Beneria, 1989; Saracoglu et al., 2016). On the other hand, subcontracting is rather a good business opportunity for SMEs primarily because of their lack of marketing and other capabilities, and makes it easier to enter the industry, and eliminates obstacles to survival, subsequent development and growth (Watanabe, 1971). Subcontracting of this type is called Capacity Subcontracting (Watanabe, 1971; Holmes, 1986; Gonzalez et al., 2000); firms tend to build up this type of subcontract to meet peak-time demand generally.

4.1.1.2 The Transaction Cost Approach

The transaction-cost theory, are based on the insight (Coase, 1937) that an entity exists because the transaction costs for managing inter-firm economic exchanges are often greater than the costs for managing intra-firm economic exchanges. Transaction-cost theory focuses on the characteristics of exchanges that encourage managers to have a firm boundary (i.e., full ownership by vertical integration), share with others (i.e., collaboration, subcontracting, joint ventures, franchises, licenses), or exchange in the market (Combs and Ketchen, 1999). Given the nature of the resources, particular resources are more costly to relocate to alternative use, unlike general purpose resources (Wiliamson, 1991). Under certain conditions, resource specificity facilitates sharing or cooperation between entities (Wiliamson, 1983). If two firms in a partnership contract have to invest in a particular resource, the resource forms interdependence, reducing the

incentive for each partner to participate in opportunism, thereby reducing the cost of cooperation (Dyer, 1996). Thus, one-sided investments in specific assets should lead to full ownership, but mutual investments under specific contracts can facilitate cooperation (Combs and Ketchen, 1999). In brief, Riordan and Williamson (1985) described the nature of the transaction as a form of incentive-adjustment of economic activities appropriate to the degree of each attribute, separating it by the asset's specificity, irregularity and frequency of the transaction. Developing this, Kimura (2001) and Kawasaki and McMillan (1987) observed that long-term subcontract relationships operate as effective risk sharing mechanisms under incomplete information provided. In the same context, Mayer and Salomon (2006) stated that the lower the technical capabilities for governance, the greater the probabilities of subcontracting. The more concentrated transactions and the fewer subcontractors associated entail the cooperative relationships with the higher vertical integration characteristics (Park and Lee, 2011). Large enterprises tend to focus their technical cooperation and transfer on a small number of primary subcontractors with direct partnerships to reduce transaction costs, but generally for economic rationality, subcontract relationships are heavily stratified (Kim, 2004a; Kim, 2004b; Song, 2006).

4.1.1.3 The Network Approach

Network theory is a theory developed with cluster theory under the limitations of transaction-cost theory, which was originated by Piore and Sabel (1984) launching

flexible specialisation discussions. They emphasised networks and clusters secured by SMEs, and argued that it is important to do their best from their respective positions through horizontal cooperation and that this can be specialised. In the subcontracting relationship, there is no particular distinction between the large prime contractor and the small subcontractor, and in the same context as the specialisation subcontracting defined by Holmes (1986) as a role-sharing method, such as SMEs with superior production and technology, and large enterprises with a wide distribution network are in charge of sales. Under this approach, subcontracting allows a firm to focus on the most efficient core capabilities and the rest to subcontract (Giunta et al., 2012). Specialised subcontracting is a concept developed in Italy and France from small enterprises such as leather, clothing and agricultural distribution industries, which means complementary subcontracting relationships based on technical capabilities in horizontal relationships, and a typical example is the relationship among the independent producers and the distributors. Hong (1997) argued that, In the case of automobile industry, autonomy in transactions affects technology cooperation between large and small businesses. Even in vertical subcontracting, technology cooperation and division of roles among firms with high autonomy have developed. Comprehensively, as Taylor and Kllıçaslan (2005) argued, firms may seek economies of scale collectively through horizontal cooperation, or specialise in core competencies and use outside labour through vertical cooperation.

4.1.2 Software Industry and Multilayered Subcontracting Prohibition Policy

Software businesses are inherently required to have expertise and skills in various domains, and to reflect rapid and continuous innovation patterns upon its short-cycle fundamental technology regime. In the context of the Dualistic Approach, the short-cycle technological characteristics and the variability of demand create incentives to subcontract to avoid risk and increase business flexibility, and in the context of Network Approach, there exists an incentive to subcontract out due to the necessity of high-tech (Diaz-Mora, 2008), core technologies that do not have, or skilled personnel (Taymaz and Kllıçaslan, 2005). On the other hand, unlike manufacturing industries such as the automobile industry, subcontracting structures of the Software industries can be more liquid and flexible rather than be composed of rigid steps such as primary (parts) and secondary (intermediary products) (Korea Software Industry Association, 2011). In the software industry, a comprehensive knowledge industry where modularity and integration are emphasised at the same time, what the middle ground of intercompany inter-trade relationship means is different from manufacturing industries. In the software industry, a series of processes that formalise intangible knowledge, multi-layered subcontracting relationships result in noise and loss to knowledge inherently generated by the knowledge creation process (Nonaka and Toyama, 2003). However, due to the widespread practice of factory-style multi-level subcontracting, a phenomenon has been discovered that

negatively affects the capabilities and performance of small software companies, which are key innovators in the public software procurement market, at the end of multilevel subcontracting (Korea Software Industry Association, 2011). The multilayered subcontracting practice in software industry is only common in East Asia including South Korea and Japan, which showed very different business cases compared to the United States and Europe (Cole and Nakata, 2014).

Accordingly, in 2014 the Software Industry Promotion Act was enacted to restrict subcontracting exceeding 50% of the project amount for subcontracting in the public software procurement market and to prohibit re-subcontracting in principle, and the relevant detail regulations and policies called Software Business Subcontracting Guidelines were enacted and implemented from 31 December 2015.

As we have seen earlier, the multi-layered subcontracting prohibition policy was implemented to improve software firms' revenue structure and ensure the quality of software project outcomes by preventing excessive multi-level subcontracting practices. This is based on Article 20 of the Software Industry Promotion Act, Article 3 of the Enforcement Rules of the Act, and Article 8 of the Enforcement Rules of the Act, which is required to comply with subcontracting restrictions and preliminary approval procedures in public software procurement projects. In addition, the contractor may request that the bidder participate as a joint contractor if it intends to subcontract the project amount in excess of 10% of the project amount at the time of the project announcement, and in this case, the beneficiary who receives the request shall comply if

there are no particular reasons not to do so. This encourages joint contracts such as consortiums rather than subcontracting under the above conditions.

4.2 **Research Model and Hypothesis**

When considering the three approaches that describe the nature of subcontracting relationships and the characteristics of the software industry in a comprehensive and integrated manner, the form of subcontracting contracts can vary depending on industry-specific characteristics, and we can theoretically predict that in the software industry a flexible horizontal partnership can increase the quality of outcome and help seek economies of scale collectively. While companies can seek economies of scale collectively through horizontal cooperation, they can seek both vertical cooperation that specialises in core competencies and uses external labour, there can be a more efficient cooperative structure considering the technological and demand characteristics of the industry.

Dynamic comparative advantages are gaining more attraction in understanding the economic trends characterised by the recent escalation of competition and rapid technological advances than traditional equilibriums or static optimisation concepts (Dosi et al., 2007), which is also valid for the software industry as well. From an evolutionary economics perspective, firms determine investments based on current financial performance because they cannot accurately identify future expected returns. Firms that earn high returns through competitive advantage either by achieving cost advantages in

production or by using efficient business processes are selected, and those that do not perform well are expelled (Coad, 2009). Meanwhile, according to Nam and Kim (2019), the more outsourcing concentration, the more productive labour, but there was no significant positive impact on profitability. Based on these findings, when further considering the structure of outsourcing, including subcontracting, the prime contractor takes advantages of the economy of scale with increasing production scale and achieving cost advantage through horizontal subcontracting of lower transaction costs (Park and Lee, 2011; Saracoglu et al., 2016). The multi-layered subcontracting prohibition policy of public software projects improves the outcome of the projects and makes additional distribution of economic effects of that scale more accessible to the subcontractor. Pyo, Hong, and Kim (2013) mentioned productivity as a major factor in enhancing a company's competitiveness, while emphasizing the impact of economies of scale, information power and negotiation power. If the prime contractors benefit from the economies of scale due to lower transaction costs and this effect is distributed to the subcontractors, by achieving a collective-scale economy, through the horizontalisation of subcontracting structures, the subcontractors will experience increased productivity.

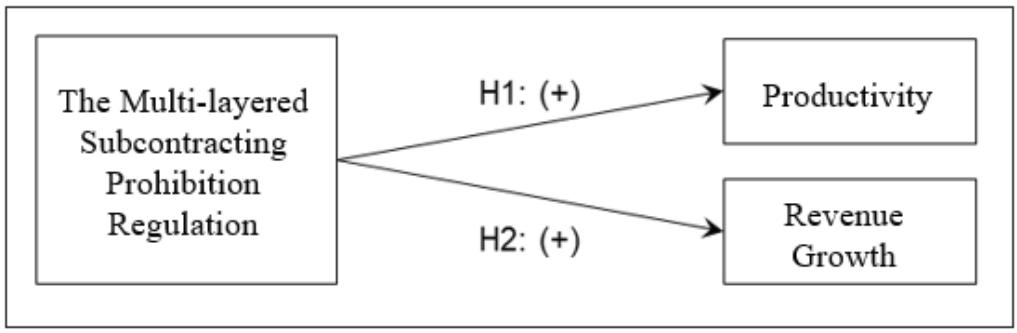

Figure 4.2.1 Research Model and Hypothesis

H1. The multilayered subcontracting prohibition policy would have a positive impact (+) on the labour productivity of the subcontractor in software industry.

H2. The multilayered subcontracting prohibition policy would have a positive impact (+) on the revenue growth of the subcontractor in software industry.

Especially, the present study focuses on the labour productivity. According to a study by Chung et al. (2018), the impact of ICT investment on productivity gains in other related industries in Korea was positive, although it changed over time. Looking at the productivity of the information and communication industry itself (Choi and Kim, 2015), as a result of an eight-year panel analysis of the information and communication industry in Korea, labour productivity, capital productivity, and total factor productivity of the information and communication industry over the entire period showed positive (+) sign. As for the change in productivity of the information and communication industry, total factor productivity declined after 2008, indicating that there was no improvement in

technology level and management level. In addition, labour productivity increased, but capital productivity decreased. In particular, the decline in capital productivity is relatively large. In the software industry, most of the cost investment is devoted to R&D labour, and since the present research deals with data from 2008 and beyond, the productivity measure in focus should be ‘labour productivity’.

In the same vein, the subcontractor will experience an increase in sales as well as achieving a collective-scale economy through the horizontalisation of the subcontracting structure as the policy effect but also because the number of gatekeepers will decrease.

4.3 Data and Analysis Method

4.3.1 Variable and Data

Table 4.3.1. presents the variables and their descriptions used in this study. In the case of financial data, a logarithm is taken and applied to the three-year moving average, as it may be aggregated in the year of occurrence or the following year due to its nature.

For analysis, 2,665 major software companies combined transaction data from 2013 to 2018 with public software procurement service contract data and financial data. The analysis data was collected through public data released by the Korea Public Procurement Service after purchasing transaction and financial data from Korea Enterprise Data Co., Ltd., a credit rating agency.

Korea Enterprise Data Co., Ltd. is a company that collects the intercompany sales tax calculation sheet and purchase tax calculation sheet and conducts a company's credit

evaluation. Using the tax invoice data, it shows how often and at what scale one company deals with other companies. This study analyses the transaction and financial data of 2,665 software companies with annual sales of between 5 billion, which belong to computer programming services (62010), computer system consultancy and computer facilities management activities (6202) and system software and applications development/publishing (58220), from 2013 to 2018. The public project participation data of software companies were extracted from the contract information of the Korea Online e-Procurement System, a platform that announces bids for all public projects of 100 million or more, according to the Procurement Service Act, company information, public contract amount by year, and the number of public contracts. This data was integrated with Korea Enterprise Data, and the public sales of 2,665 software companies with annual sales of more than 5 billion won amounted to 2.245 trillion won, which is about 71.8% of the 3.126 trillion Won budget for public software construction/purchase as of 2017. The remaining 28.2% of the total business size of less than 100 million won is estimated to be carried out by small businesses, which are not included in the sample of Korean corporate data above. In fact, companies with less than 5 billion won, which are classified as small businesses, account for 76% (2013) of the number of companies, but their total sales account for 3.9 trillion won (2016), accounting for 12.1% of all software companies' sales (Ministry of Science and ICT, 2018).

Table 4.3.1 Definition and Descriptions of Variables in the Analysis

Classification	Variable	Definition	Description
Dependent Variable	laboreff	Labour Productivity	Logarithmic value/number of employees in sales in the year
	lgrev	Logarithmic Value of Revenue	Logarithmic value of revenue for the year
Independent Variable	treated	Policy Target	Treatment Group: Public Firms Comparison Group: Private Firms
	time	Policy Enforcement Period	Before the implementation: 2012-2015 After the implementation: 2016-2018
	did	Difference-in-difference	treated*time
Controlled Variable	age	Corporate History	History after the foundation
	employee	Size	Employee size in the year
Dummy Variable	SM	Service and Maintenance Sub-industry	1: 'J62022' 'J62090' 0: others
	SI	Service Integration Sub-industry	1: 'J62010' 'J62021' 0: others
	conglomerate	Chaebol Enterprise	Chaebol enterprise group subject to limitations on mutual investment: 1 Non-chaebol enterprises: 0
	sme	Small and Medium-sized Enterprises	Small and medium-sized enterprises: 1 Non-small enterprises: 0

4.3.2 **Analysis Method**

4.3.2.1 Social Network Analysis

The selection and calculation of social network indicators for analysis of inter-firm

transaction data has been taken into account the characteristics of the dyadic transaction data among software firms to be analysed. First of all, software transaction network was established by year in software transaction relationship by defining sales transaction as outgoing edge and purchase transaction as in-ward edge. The software transaction linkage analysis considered network metrics that could measure key features and change trends for each software firm in order to identify year-by-year transaction networks from a micro perspective. Accordingly, the number of normalised outgoing edges was calculated by weighting the sales transaction frequency and transaction value based on the direction of the goods and services, and the number of normalised in-ward edges was measured by taking into account the same weighting for the purchase transaction.

In addition, the key indicators used in this analysis to identify the treatment group from the control group are the average shortest path, which is defined as the average of all possible shortest path length among the connected trading entities. This average shortest path is derived by obtaining all the shortest paths between the firm nodes of interest V_i and other trading firm nodes V_j from a given directed weighted graph, using the Floyd-Warshall algorithm based on dynamic programming. The basic principle is that the distance between the node V_i and V_j is minimal, if the distance between the node V_i and the pass-through node V_k is minimal and the distance between the pass-through node V_k and the node V_j is minimal.

$$Avg(d_{ij}^{k}) = 1/n \sum_{j=1}^{n} \min_{j,k\in\{1,2,\ldots,N\}} \{d_{ij}^{k-1}, d_{ik}^{k-1} + d_{kj}^{k-1}\} (i \neq j, \text{ where } i\in\{1,2,\ldots,N\} \quad \cdots\cdots \text{ Eq. (4.3.2.1)}$$

This can be referred to an indicator of the average depth of transaction layers for the interested firm i, or as a proxy for the dyadic transaction layer, or the transaction hierarchy.

4.3.2.2 Propensity Score Matching and Difference in Differences

This study mixed propensity score matching, difference in differences. Before estimating difference in differences, the treatment and comparison groups for this purpose were formulated through propensity score matching. Propensity score matching is the pairing of objects with similar attributes represented by variables, a statistical method of performing sampling close to the random selection of pure experiments (Rosbaum and Rubin, 1983; Lee and Moon, 2014). In this study, a group of subcontractors (treatment group) was formed and a comparison group among prime contractors was collected with propensity scores close to those held by the treatment group. In order to enhance the validity of the research, this study used the clustered sampling method based on the consolidated data, and then utilised propensity score matching based on the firm size (number of employees), inter-firm cooperation hierarchy and clustering coefficients. A difference in differences analysis is a method of estimating the effectiveness of a policy, forming a kind of quasi-experiment state by organizing a treatment group and a non-applicable comparison group under the policy. In this study, the ‘subcontractors’ were designated as the treatment of the policy and the difference in performance and productivity of two groups was estimated from the pre-treatment period (t=0) prior to the

enforcement of the legal revisions to the post-treatment period (t=1) that is after the legal revisions implemented.

The difference between the two groups estimated by the simple difference in differences analysis has some restrictions to be regarded as a net policy effect because it does not control the natural time-varying feature of the dependent variables over time. (Min and Choi, 2013).

Table 4.3.2 Concept of Difference in Differences Method

	t=0 (pre-treatment period)	**t=1 (post-treatment period)**	**D (net effect of the legal revisions)**
Gt : Treatment Group	Y_{t1}	Y_{t2}	$\Delta Y_t = Y_{t2} - Y_{t1}$
Gc : Comparison Group	Y_{c1}	Y_{c2}	$\Delta Y_c = Y_{c2} - Y_{c1}$
D (net effect of the policy)			$\Delta\Delta Y = Y_t - Y_c$

Source: Blundel et al. (2009)

Therefore, this study further performed a difference in differences regression analysis to obtain the estimate β that shows the net effect of the focal legal revisions by controlling other characteristics of objects other than the law enforcement. Where y(i,t) is an outcome observed for a unit i=1, …, I at period t=1,…,T, Treated(i,t) is a treatment variable, Period(i,t) is an indicator variable of period in which the treatment is in place. X(i,t) is a vector of control variables, μi is individual effects and φt is time fixed effects and, critical for the point being made, there is an interaction of an unobserved individual

trend effect ωi with a time trend f(t) (Ahlfeldt, 2018).

$$Y_{(i,t)} = \alpha + \gamma\,Treated_{(i,t)} + \delta\,Period_{(i,t)} + \beta(Treated_{(i)} \cdot Period_{(t)}) + \kappa X_{(i,t)} + \mu_i + \varphi_t + \omega_i f(t) + \varepsilon_{(i,t)} \cdots\cdots$$

Eq. (4.3.2.2.)

4.4 **Analysis Results**

4.4.1 **Descriptive Statistics**

The following table shows the basic statistics of the 'prime contractor' group with a transaction hierarchy of 3 or more, and the 'subcontractor' group with a transaction hierarchy of less than 3. When interpreting dependent variables, it is generally known that higher revenue and labour efficiency are better.

Table 4.4.1 Descriptive Statistics of Major Variable

Variables	Mean	S.D.	Min	Max	Observations
laboreff	0.954	1.060	0	14.088	8,605
lgrev	14.879	1.430	0	22.256	
age	10.631	6.22	1	46	
employee	67.354	399.610	1	14139	

Among them, the treatment group candidates, the subcontractors obtained 7,027 observations, and the control group, the prime contractor candidates had 1,578 observations.

Table 4.4.2 Descriptive Statistics for the Treatment and Control Groups

Category	Objs	age		employee	
Treatment Group	7,027	Mean	10.400	Mean	49.293
		S.D.	5.989	S.D.	176.015
Control Group	1,578	Mean	11.662	Mean	147.779
		S.D.	7.069	S.D.	851.640
Homogenous Variance (Bartlett's K-squared p-value)	-	75.828(<2.2e-16)		9055.4(<2.2e-16)	
Wilcoxon Rank sum	-	6073770(2.767e-09)		6195917(2.698e-13)	

4.4.2 Results of Empirical Analysis

4.4.2.1 Propensity Score Matching Analysis Results

For the above basic group statistics, propensity scores were derived by a probit estimation using control variables, and 1,546 subcontractor (treatment group) measurements and 1,546 prime contractor (control group) measurements of the total sample were found within the common domain. The rest of the samples were screened and eliminated from the final sample. Finally, the quality of the match was evaluated by analysing the characteristics of the treatment group and the comparative group before and after propensity score matching. The analysis results are shown in the following table.

Table 4.4.3 PSM Result Quality Index

	Before Matching			After Matching			
	Treatment Mean (SD)	Control Mean (SD)	SMD (Standardised Mean Difference)	Treatment Mean	Control Mean	SMD (Standardised Mean Difference)	
age	10.40(5.99)	11.66(7.07)	0.193	<0.001	11.30(6.51)	10.17(7.08)	0.166	<0.001
employee	49.29(176.01)	147.78(851.64)	0.160	<0.001	76.79(216.15)	70.81(204.21)	0.028	0.429
objs	7,027	1,578	N/A		1,546	1,546	N/A	

Note. ①*** means statistically significant at 1%, ** at 5%, and * at 10%.

② $SMD = \frac{\overline{X_{treated}} - \overline{X_{control}}}{\sqrt[2]{\frac{(S^2_{treated} + S^2_{control})}{2}}}$ X is the mean of the sample, S^2 is the variance of the sample.

4.4.2.2 Trend Analysis Results

Before we analyse the effect of multilayered subcontracting prohibition policy by difference in differences, parallel trends of the dependent variable between the two groups should be tested. As below, log revenues showed similar trends between the two groups.

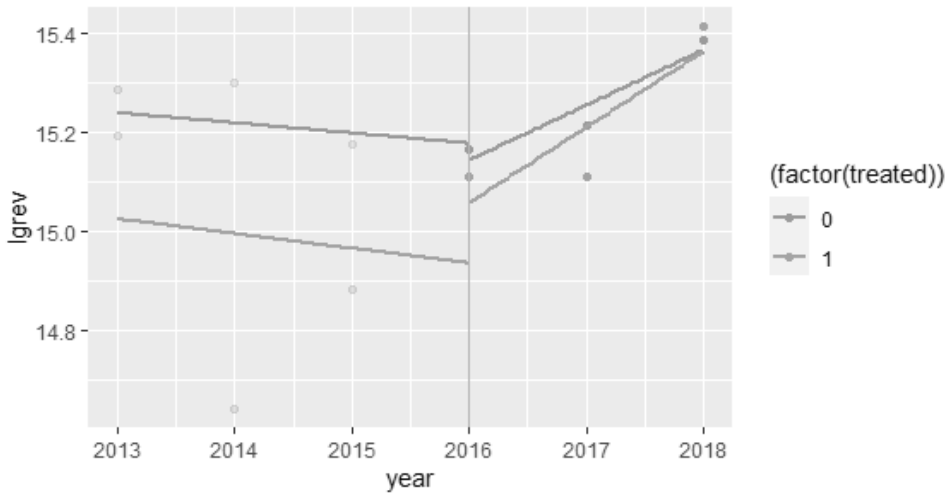

Figure 4.4.1 Parallel Trends of Log Revenues between Two Groups

However, the trends of labour efficiency of two groups showed different shapes and directions as follows.

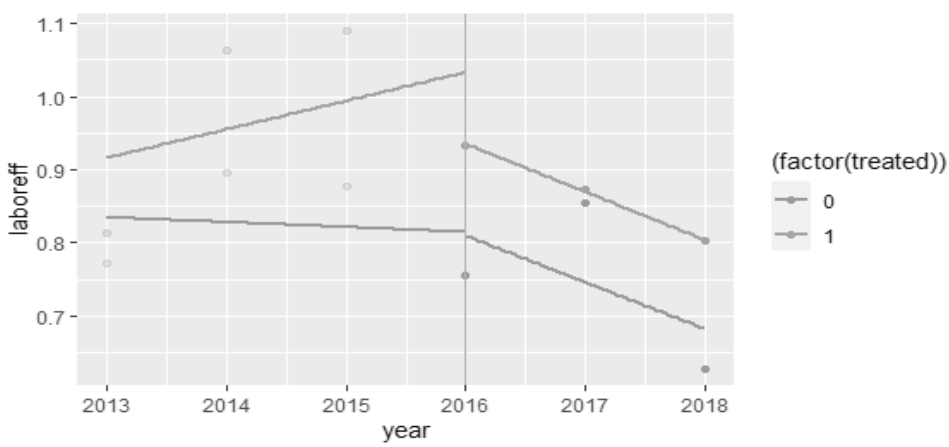

Figure 4.4.2 Trends of labour efficiency between two groups

4.4.2.3 Difference-in-Difference Analysis Results

As a result of the difference-in-differences analysis, it can be seen that the log revenue of the treatment group is getting larger than that of the comparative group. In other words, the increase in log revenue indicates that the subcontractor's annual sales have significantly improved after the policy implementation. Therefore, hypothesis 2 is supported. On the other hand, the changes of labour efficiency don't show the parallel trends, so that the model failed to meet the assumption of difference indifferences analysis. Therefore, hypothesis 1 was not tested.

Table 4.4.4 Results of Hierarchical Regression Analysis for Hypothesis 2

	y=lgrev	Model(1) : H2			Model(2) : H2			Model(3) : H2		
		Coef.	Pr(>|t|)		Coef.	Pr(>|t|)		Coef.	Pr(>|t|)	
Independent Variable	Treated	-0.291	0.001	***	-0.356	0.000	***	-0.278	0.000	***
	Time	0	Omitted		0	Omitted		0	Omitted	
DID	Treated* Time	0.244	0.038	**	0.129	0.164		0.207	0.053	*
Controlled Variable	age				0.108	0.000	***			
	employee				0.002	0.000	***			
Dummy Variable	SM							0.238	0.153	
	SI							0.222	0.001	***
	sme							-3.042	0.000	***
	conglomerate							1.195	0.000	***
Residual	_cons	15.228	0.000	***	14.002	0.000	***	18.098	0.000	***
Observations		3,092			3,092			3,092		
Adj R-square		0.0039			0.3846			0.1751		

AIC	11773.48	10288.28	11198.11
BIC	11791.59	10318.46	11240.37

Note. ①*** means statistically significant at 1%, ** at 5%, and * at 10%.

② The F-test indicates that all null hypotheses (H0: All estimated parameters are the same) are strongly rejected at the 1% level.

Table 4.4.5 Hypothesis Test Results

Existing Hypotheses	H1(+)	H2(+)
Empirical Results	N/A	(+)

4.5 **Academic and Policy Implications**

The IT service industry is defined as a professional industry that requires highly technological capabilities and provides reliable and skillful advice and development and maintenance services to customers (Lippoldt and Stryszowski, 2009). IT service is a business support service, and specifications are different depending on the goal of the consumer, so it is differentiated into a customised service that is difficult to standardise. Since it is difficult to provide a uniform service, it is difficult to have an exclusive supplier in the market, so many providers can participate in the IT service market, but it also limits international competition. Due to the nature of the industry, when choosing a supplier, the importance of brand, skill level, and similar business experience is emphasised. Geographical proximity is also a factor in determining the market coverage

depending on the nature and scale of the business. The IT service supply chain structure is a structure in which various companies in charge of each element technology cooperate. When the integrated network capability is excellent, the average consecutive transaction order among the firms is long and the size of the company tends to be large. The system development and integration sub industry, which showed high growth potential, not only has the characteristics of assembling processing to build an information system by integrating hardware and software, but also converges with domain knowledge in all fields such as manufacturing, logistics, and services to enhance corporate competitiveness and create jobs. Software is major industry in the Republic of Korea. On the other hand, in the case of the operation and maintenance sub-industry, which showed relatively low growth potential, is known that the value added is lower than the system development and integration field, and the overall domestic market size (operation and maintenance industry: 21.2%, construction, integration: 55.6%) or growth rate is also low (Ji, 2016).

On the other hand, according to Ji and Jeon (2018), the employment growth index for each sector was derived according to Birch's employment growth index method, resulting in IT service sector—1,223, package software sector 11,540, which means that overall employment in the IT service sector decreased. In the case of the IT service field, the fact that total revenue increased but employment declined implies that outsourcing or subcontracting were active during the period or labour productivity was increased. When analysing global public projects between 2011 and 2015, the success rate of completing the project according to the schedule and budget was only 21% (Standish Group, 2016),

and in Korea, the success rate was only 10.8% based on this concept (SPRi, 2016). Moreover, despite the fact that 87.1% did not receive the payment for the task change, the percentage of meeting delivery was 96.4%. Meanwhile, according to the survey on subcontracting, the proportion of subcontracting in 2016–2018 has decreased significantly. In other words, this can be seen as a statistic that supports the robustness of the results of the analysis that labour productivity has increased after the multi-level subcontracting was banned.

Table 4.5.1 Subcontracting Status Changes 2016-2018

Category	**2016**	**2017**	**2018**
Subcontracts/Total projects ratio	40.6%	30.7%	28.0%
Subcontractors per projects	3.2	3.9	4.7
Consortiums/Total projects ratio	27.8%	39.0%	29.8%

Source: NIPA (2019)

In this paper, it was analysed that the multilevel subcontracting system not only achieved legislative purpose but also had a positive effect on the financial performance of participating companies.

Therefore, based on the characteristics of the IT service industry, cluster-based specialisation can be achieved in the transaction structure between the software companies, and the opportunities for enterprise participation can be increased, and the

productivity at the project level, the enterprise level, and the industry level can increase. Vertical subcontracts should be avoided and joint contracts such as consortiums which promotes horizontal relationships between small and medium-sized enterprises and bigger firms, should be encouraged.

Chapter 5. **Conclusion**

5.1 **Summary**

The role of the government in the history of Korean economic development has been shaping and creating markets as well as solving market failures. The development of heavy and chemical industries such as shipbuilding, steel, and automobiles, as well as the ICT industry, was not possible without the government, which made an economic development plan, invested in CDMA, and quickly moved to deploy a high-speed Internet network infrastructure nationwide. The unbalanced intensive high-growth from the ’70s to the early ’90s was due to the industrial structure created by the government, centered on conglomerates that mainly export high-tech products (Lee and Malerba, 2017). However, as the problem of the conglomerate-oriented structure emerged, it began to emphasise the need to strengthen and support the complementary relationship between conglomerates and SMEs. The Small and Medium Business Administration was established in 1996, and in 2009, the Act on the Promotion of Small and Medium Business Products Purchase Promotion and Market Support was enacted, and in 2017, the administrative agency in charge of the Small and Medium Business Administration was promoted to the Ministry of SMEs, and the legal framework was reorganised. Based on this, the Korean government is actively promoting various SME-friendly policies such as R&D and marketing support for SMEs, preferential purchase of SME innovative products, and excellent product technology and quality certification system.

Korea is actively using the public procurement market as a support measure for SMEs. The size of public procurement in OECD is roughly 10%–20% of each country's GDP, and as of 2013, Korea's procurement size accounted for 12.8% of GDP and 40.3% of government expenditure. Unlike other SME support policies, support of SMEs through public procurement is characterised as an indirect method of giving actual market participation opportunities through sales.

Public procurement in the software industry is regulated by the Software Industry Promotion Act, separate from the National Contract Act or Procurement Business Act, and the high participation of conglomerates in this public software procurement market was pointed out as a problem. It is pointed out that the ratio of internal transactions of large IT service companies established by conglomerate affiliates reached 61.6% (Fair Trade Commission, 2013) from 2009 to 2012. In this market structure, even the public market has a high share of conglomerates, raising the awareness that it is difficult for SMEs to grow their own scale and accumulate technological capabilities. Accordingly, in 2013, the government kicked out the conglomerates from the public software procurement market. And from 2016, the subcontract restriction system was enacted that prohibits multi-level subcontracting.

This study focused on the structure of collaboration between participating firms is important due to the nature of the software industry, which is a comprehensive knowledge industry. Network capabilities of firms, the term used frequently in strategic management theory and organisational ecology, however have been difficult to

systematically track dynamic changes over time. Network capabilities can be operationally defined as consisting of information integration capability (closeness centrality), mediating capability (betweenness centrality), collaboration capability (clustering coefficient), and hierarchical transaction capability (average distance). In order to measure this, the financial data of 2,665 major software companies with annual sales of more than 5 billion won from 2008 to 2018 were constructed, and the above four indicators were derived through network analysis methodology based on the tax invoice transaction data to form a panel. After that, this study dynamically analyzes the effect of network capabilities on corporate growth using GMM methodology, analyzes the net effect of the policy excluding conglomerates from the public software procurement market (2013) on labor productivity and profitability of participants in the market was analyzed by panel difference-in-differences. Finally, the net effect of the multilevel subcontracting restriction system (2016) on labor productivity and profitability by panel difference-in-differences.

As a result of the analysis, it was confirmed that, in an extension of the theoretical perspective in which the strategic management theory represented by resource-based theory and organisational ecology were integrated, network capability was also a major variable explaining the heterogeneity of a company's competitive advantage and performance. In the trading network of small and medium-sized software vendors, the integration, brokerage, and hierarchical trading network capabilities have accelerated corporate sales growth. However, the higher the collaboration capability represented by

the clustering coefficient, the lower growth in corporate sales. These results are generally contrary to the findings that high levels of collaboration in the supply chain are positive for corporate performance. A high level of collaboration has a negative impact on short term sales growth because changes in performance are dependent on clusters rather than single firm. In an extension of the perspective of the existing research that examines the network capabilities that a firm tend to use the resources of other firms in the network, when considering the collaboration network of companies longitudinally, there is a cluster ecosystem or platform centered on major companies, and this suggests that it is also necessary to re-measure the performance of the firm in a cluster unit (Kim et al., 2014). Another interpretation goes from the argument that, in the case of the existing literature, that the innovative benefits of collaboration are not realised immediately, but at a deeper lag (Schilling and Phelps, 2007; Stuart, 2000). According to rigorous empirical research, for SMEs that short-term sales growth is more important, a strategy that utilises a network structure represented by integration and brokerage capabilities is effective in achieving the target sales. Higher collaboration capabilities directly increase the sales of public contracts, but rather negatively affect the overall short-term sales growth. This means that various government efforts, such as fostering software technology companies, encouraging joint contracts through consortiums, restricting participation of conglomerates, and restricting multilayered subcontracting, should be prepared according to target periods such as short-term and long-term. Furthermore, in the software industry, a fragmentary knowledge industry composed of a series of processes of coding intangible

knowledge and multilevel subcontracting practices can intrinsically lead to loss of knowledge and inefficiency of knowledge transfer according to the theory of knowledge generation process (Nonaka and Toyama, 2003). If the requested task requires advanced core technological skills or specific skilled personnel not owned by the prime contractor (Taymaz and Kılıcaslan, 2005), the prime contractor is motivated to subcontract the task to another specialised company or freelancer. The widespread adoption of factory-style multilayered subcontracting in Korea negatively affected the performance and growth of small software companies located at the end of a hierarchical structure as well as a major player in the public software procurement market, and accordingly, the Korean government banned multi-level subcontracting. In the software industry, which is a comprehensive knowledge industry that requires modularisation and integration at the same time, the meaning of the hierarchical relationship between companies is different from that of the manufacturing industry such as the automobile industry. Enterprises can jointly pursue economies of scale through horizontal cooperation, but at the same time, they can pursue vertical cooperation that specialises in core competencies and utilises external labor. This study argues that there may be an optimal collaboration structure for each industry, and horizontal cooperation in software, especially in the IT service industry, has a more positive effect on productivity, and it is necessary to actively encourage joint contracts such as consortiums.

Finally, demand is important for SMEs to grow. In particular, procurement from the government has a positive effect on productivity, profitability, and even growth in line

with demand. The enforcement of restrictions on participation in the public procurement market of conglomerates in 2013 created a favorable environment for companies participating in the public software procurement market to directly increase public sales, but in reality, it had a negative impact on the labor productivity of the target companies and no significant influence on profitability. Demand characteristics and government intervention are also dependent on the interaction between industry innovators, and especially in the software industry, the structure of collaboration among participants is important. Extreme policy measures, such as excluding specific market participants, do not promote growth because they harm labor productivity and do not have a significant effect on profits. On the other hand, it is known that niche innovation based on technological capabilities is possible in the public software procurement market, especially in the emerging market segments (Uyarra and Flanagan, 2010). The cooperative structure in this field is essentially important, but the disadvantage for startups and conglomerates is a major obstacle to narrowing the door to niche innovation. Excessive policies to protect SMEs can be poisonous to SMEs' labour productivity improvement and further growth.

The contribution of the present study which examined impacts network capabilities of firms on their growth and the effect of two unique SME policies in South Korea can be summarised as follows. First, the study proposed the extended research framework integrates strategic management theories including IO, OR, and RBV when researchers to examine the relationships among the firm-level resources, competitive advantages, and

inter-firm interactions to firm performance. The present study suggested industry characteristics will impact not only the capabilities and competitive advantages, but also inter-firm interactions and finally firm performance. Also, institutional factor such as SME policies on inter-firm interactions should be considered. Second, the study identified four network capabilities focusing on the structural characteristics of interaction, and found that they impact the yearly revenue growth of firm differently. The previous literatures included subsets of these capabilities only, so that there found inconsistent views about the impact of network capabilities on the firm outcome or performance. Collaborations among suppliers should be carefully placed when decisions with the short-term growth strategy are necessary. Third, the study examined two unique K-SME policies and found that since collaboration structure in the software industry is more flexible, complimentary and complicated, so that policies like excluding a specific type of participants with the valid business rights in the field should be carefully designed and placed temporarily. On the other hand, with the multi-layered subcontracting practice which mismatches the industry characteristics, government intervention such as explicitly prohibiting the multi-layered subcontracting practice can affect positive impacts on firm performance.

When it comes to the inter-firm cooperation structure shaping and relevant business practices, firms and government should consider the industry characteristics and nature of value creation process of their products and services more carefully.

5.2 **Limitations and Future Research**

In Chapter 2, the present study dealt with yearly revenue growth, but it might have been more refined if it considered long-term growth and investigated various re-combinations of different network capabilities. In Chapter 3, due to the limitation of the data source and the scope of the research, the present study did not include the demand factors such as market fragmentation, demand changes and competition intensity directly. In Chapter 4, the present study didn't identify the types of subcontracts. If there is any, it would be more refined if we distinguished the difference with respect to the different characteristics of subcontracts.

In future research studies, the author will consider the context of other industries and countries and will compare them to the results of the thesis.

Bibliography

Abraham, K. G., and Taylor, S. K. (1996). Firms' use of outside contractors: Theory and evidence. *Journal of Labor Economics*, 14(3), 394-424.

Ahlfeldt, G. M. (2018). Weights to Address Non-parallel Trends in Panel Difference-in-differences Models. *CESifo Economic Studies*, 64(2), 216-240.

Ahuja, G. (2000). Collaboration networks, structural holes, and innovation: A longitudinal study. *Administrative Science Quarterly*, 45(3), 425-455.

Amit, R., and Schoemaker, P. J. (1993). Strategic assets and organizational rent. *Strategic Management Journal*, 14(1), 33-46.

Arellano, M., and Bond, S. (1991). Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations. *The Review of Economic Studies*, 58(2), 277-297.

Barney, J. (1991). Firm resources and sustained competitive advantage. *Journal of Management*, 17(1), 99-120.

Barrass, R., and Madhavan, S. (1996). *European Economic Integration: Institutions, Issues, and Policies.* London: McGraw-Hill Companies.

Baum, C. F., Schaffer, M. E., and Stillman, S. (2003). Instrumental variables and GMM: Estimation and testing. *The Stata Journal*, 3(1), 1-31.

Beneria, L. (1989). Subcontracting and employment dynamics in Mexico City. In A. Portes, M. Castells, and L.A. Benton (Eds.), *The informal economy: Studies in*

advanced and less developed countries, Baltimore and London: The Johns Hopkins University Press, 173–189.

Bennett, R. J. (2014). *Entrepreneurship, small business and public policy: Evolution and revolution*. London: Routledge.

Berger, S., Piore, M. J., and Suzanne, B. (1980). *Dualism and discontinuity in industrial societies*. Cambridge: Cambridge University Press.

Bloom, N., and Van Reenen, J. (2010). Why do management practices differ across firms and countries?. *Journal of Economic Perspectives*, 24(1), 203-24.

Blundell, R., and Dias, M. C. (2009). Alternative approaches to evaluation in empirical microeconomics. *Journal of Human Resources*, 44(3), 565-640.

Brass, D. J. (1984). Being in the right place: A structural analysis of individual influence in an organization. *Administrative Science Quarterly*, 29(4), 18-539.

Burt, R. S. (1992) *Structural Holes: The Social Structure of Competition*, Harvard University Press: Cambridge, MA.

Camuffo, A., Furlan, A., Romano, P., and Vinelli, A. (2007). Routes towards supplier and production network internationalisation. *International Journal of Operations & Production Management*, 27(4), 371-387.

Clark, K. B., and Fujimoto, T. (1990). The power of product integrity. *Harvard Business Review*, 68(6), 107.

Coad, A. (2009). *The growth of firms: A survey of theories and empirical evidence.* Northampton: Edward Elgar Publishing.

Coase, R.H. (1991): *The Nature of the Firm* (1937). In: Williamson, O.E./Winter, S.G. (eds.): The Nature of the Firm. Origins, Evolution, and Development. Oxford: New York Press, 18-33.

Cole, R. E., and Nakata, Y. (2014). The Japanese software industry: what went wrong and what can we learn from it?. *California Management Review*, 57(1), 16-43.

Coleman, J. S. (1988). Social capital in the creation of human capital. *American Journal of Sociology*, 94, S95-S120.

Combs, J. G., and Ketchen, Jr, D. J. (1999). Explaining interfirm cooperation and performance: toward a reconciliation of predictions from the resource-based view and organizational economics. *Strategic Management Journal*, 20(9), 867-888.

Coviello, N. E., and McAuley, A. (1999). Internationalisation and the smaller firm: a review of contemporary empirical research. *Management International Review*, 39(3), 223-256.

Cross, R., and Cummings, J. N. (2004). Tie and network correlates of individual performance in knowledge-intensive work. *Academy of Management Journal*, 47(6), 928-937.

Datta, D. K., Guthrie, J. P., and Wright, P. M. (2005). Human resource management and labor productivity: does industry matter?. *Academy of Management Journal*, 48(1), 135-145.

Davis, P., and Brady, O. (2015). Are government intentions for the inclusion of innovation and small and medium enterprises participation in public procurement being

delivered or ignored? An Irish case study. *Innovation: The European Journal of Social Science Research*, 28(3), 324-343.

De Sivatte, I., Gordon, J., Rojo, P. and Olmos, R. (2015), The impact of work-life culture on organizational productivity, *Personnel Review*, 44(6), 883-905.

Delmas, M. A., and Pekovic, S. (2013). Environmental standards and labor productivity: Understanding the mechanisms that sustain sustainability. *Journal of Organizational Behavior*, 34(2), 230-252.

Díaz-Mora, C. (2008). What factors determine the outsourcing intensity? A dynamic panel data approach for manufacturing industries. *Applied Economics*, 40(19), 2509-2521.

Diaz-Mora, C., and Triguero-Cano, A. (2012). Why do some firms contract out production? Evidence from firm-level panel data. *Applied Economics*, 44(13), 1631-1644.

Dosi, G., and Marengo, L. (2007). Perspective—on the evolutionary and behavioral theories of organizations: a tentative roadmap. *Organization Science*, 18(3), 491-502.

Dyer, J. H. (1996). Specialized supplier networks as a source of competitive advantage: Evidence from the auto industry. *Strategic Management Journal*, 17(4), 271-291.

Eisenhardt, K. M. (1989). Agency theory: An assessment and review. *Academy of Management Review*, 14(1), 57-74.

Fadic, M. (2020). Letting luck decide: Government procurement and the growth of small

firms. *The Journal of Development Studies*, 56(7), 1263-1276.

Fama, E. F. (1980). Agency problems and the theory of the firm. *Journal of Political Economy*, 88(2), 288-307.

Ferraz, C., Finan, F., and Szerman, D. (2015). Procuring firm growth: the effects of government purchases on firm dynamics. *National Bureau of Economic Research Working Paper*, No. 21219.

Foster, L., Haltiwanger, J., and Syverson, C. (2008). Reallocation, firm turnover, and efficiency: Selection on productivity or profitability?. *American Economic Review*, 98(1), 394-425.

Foster, L., Haltiwanger, J., and Syverson, C. (2016). The slow growth of new plants: Learning about demand?. *Economica*, 83(329), 91-129.

Garvin, D. A. (1988). *Managing quality: The strategic and competitive edge*. New York: London: Free Press.

Georghiou, L., Li, Y., Uyarra, E., and Edler, J. (2010). Public procurement for innovation in small European countries. *A Report from the ERA-PRISM:(Policies for Research and Innovation in Small Member States to Advance the European Research Area) OMC-Net Project*, Brussels.

Geroski, P. A. (2002). The growth of firms in theory and in practice. *Competence, Governance, and Entrepreneurship-Advances in Economic Strategy Research*, 168-176.

Geroski, P., and Gugler, K. (2004). Corporate growth convergence in Europe. *Oxford*

Economic Papers, 56(4), 597-620.

Giunta, A., Nifo, A., and Scalera, D. (2012). Subcontracting in Italian industry: labour division, firm growth and the north–south divide. *Regional Studies*, 46(8), 1067-1083.

González-Díaz, M., Arruñada, B., and Fernández, A. (2000). Causes of subcontracting: evidence from panel data on construction firms. *Journal of Economic Behavior and Organization*, 42(2), 167-187.

Harrison, A., and Rodríguez-Clare, A. (2010). Trade, foreign investment, and industrial policy for developing countries. *Handbook of Development Economics*, 5(63), 4039-4214.

Hayes, R. H., and Clark, K. B. (1986). Why some factories are more productive than others. *Harvard Business Review*, 64(5), 66-73.

Holl, A. (2008). Production subcontracting and location. *Regional Science and Urban Economics*, 38(3), 299-309.

Holmes, J. (1986). The organization and locational structure of production subcontracting. Scott A J, Storper M eds. *Production, Work, Territory: The Geographical Anatomy of Industrial Capitalism.* London: Allen and Unwin.

Hopenhayn, H. A. (1992). Entry, exit, and firm dynamics in long run equilibrium. *Econometrica: Journal of the Econometric Society*, 60(5), 1127-1150.

Hoskisson, R. E., Wan, W. P., Yiu, D., and Hitt, M. A. (1999). Theory and research in

strategic management: Swings of a pendulum. *Journal of Management*, 25(3), 417-456.

Iansiti, M., 1998. *Technology Integration*. Boston: Harvard Business School Press.

Jovanovic, B. (1982). Selection and the Evolution of Industry. *Econometrica: Journal of the Econometric Society*, 50(3), 649-670.

Katz, M. L., and Shapiro, C. (1994). Systems competition and network effects. *Journal of Economic Perspectives*, 8(2), 93-115.

Kawasaki, S., and McMillan, J. (1987). The design of contracts: evidence from Japanese subcontracting. *Journal of the Japanese and International Economies*, 1(3), 327-349.

Kim, H. D., Lee, D. H., Choe, H., and Seo, I. W. (2014). The evolution of cluster network structure and firm growth: a study of industrial software clusters. *Scientometrics*, 99(1), 77-95.

Kim, J. Y., Park, T. Y., and Lee, K. (2013). Catch-up by Indigenous Firms in the Software Industry and the Role of the Government in China: A Sectoral System of Innovation (SSI) Perspective. *Eurasian Business Review*, 3(1), 100-120.

Kimura, F. (2002). Subcontracting and the performance of small and medium firms in Japan. In *Small Firm Dynamism in East Asia*. Boston: Springer, 163-175.

Koka, B. R., and Prescott, J. E. (2002). Strategic alliances as social capital: A multidimensional view. *Strategic Management Journal*, 23(9), 795-816.

Korea Procurement Service. (2017). Contract Information Data.

https://data.go.kr/data/15058815/openapi.do

Korea Public Procurement Service. (2020). Introduction. http://www.pps.go.kr/kor/jsp/introduce/vision.pps

Kuhn, T. S. (1962). *The structure of scientific revolutions*. Chicago: University of Chicago press.

Lee, K., and Malerba, F. (2017). Catch-up cycles and changes in industrial leadership: Windows of opportunity and responses of firms and countries in the evolution of sectoral systems. *Research Policy*, 46(2), 338-351.

Lee, M. (2017). Government purchases, firm growth and industry dynamics (Technical report). University of California San Diego. https://drive.google.com/file/d/0B7usas1Ib32gdF84QklCeGhkaG8/view

Lippman, S. A., and Rumelt, R. P. (1982). Uncertain imitability: An analysis of interfirm differences in efficiency under competition. *The Bell Journal of Economics*, 13(2), 418-438.

Lippoldt, D., and Stryszowski, P. (2009). *Innovation in the software sector*. OECD innovation strategy series. Paris: OECD.

Markides, C. C., and Williamson, P. J. (1994). Related diversification, core competences and corporate performance. *Strategic Management Journal*, 15(S2), 149-165.

Mayer, K. J., and Salomon, R. M. (2006). Capabilities, contractual hazards, and governance: Integrating resource-based and transaction cost perspectives. *Academy of Management Journal*, 49(5), 942-959.

McDougall, P. P., Shane, S., and Oviatt, B. M. (1994). Explaining the formation of international new ventures: The limits of theories from international business research. *Journal of Business Venturing*, 9(6), 469-487.

Mehra, A., Kilduff, M., and Brass, D. J. (2001). The social networks of high and low self-monitors: Implications for workplace performance. *Administrative Science Quarterly*, 46(1), 121-146.

Ministry of Science and ICT. (2018). Korea Software Industry Survey 2018. https://kosis.kr/statisticsList/statisticsListIndex.do?menuId=M_01_01&vwcd=MT_ZTITLE&parmTabId=M_01_01&statId=1996008&themaId=N#SelectStatsBoxDiv

Montgomery, C. A., and Wernerfelt, B. (1988). Diversification, Ricardian rents, and Tobin's q. *The Rand Journal of Economics*, 19(4), 623-632.

National IT Industry Promotion Agency. (2019). Software Development Market Demand in Public Sector. https://www.swit.or.kr/

National Statistical Office. (2020). Statistics of the Procurement. https://kosis.kr/statHtml/statHtml.do?orgId=131&tblId=DT_13103_C001&vw_cd=MT_ZTITLE&list_id=131_13103_02_001&scrId=&seqNo=&lang_mode=ko&obj_var_id=&itm_id=&conn_path=K1&path=%25EC%25A0%2595%25EB%25B6%2580%25E3%2586%258D%25EC%259E%25AC%25EC%25A0%2595%2520%253E%2520%25EC%25A1%25B0%25EB%258B%25AC%25ED%2586%25B5%25EA%25B3%2584%2520%253E%2520%25EA%25B3%25B5%25E

A%25B3%25B5%25EC%25A1%25B0%25EB%258B%25AC%25ED%2586%25B5%25EA%25B3%2584%2520%253E%2520%25EC%25A3%25BC%25EC%259A%2594%25ED%2586%25B5%25EA%25B3%2584%25EC%25A0%2584%25EC%25B2%25B4%2520%25EA%25B3%25B5%25EA%25B3%25B5%25EC%25A1%25B0%25EB%258B%25AC%2520%25ED%2598%2584%25ED%2599%25A9

Nham, P. T., and Hoang, V. H. (2011). Building an integrated framework of strategic management theories to explain performance of firm in one industry. *Journal of Global Management Research*, 29-41.

Nishiguchi, T., and Brookfield, J. (1997). The evolution of Japanese subcontracting. *MIT Sloan Management Review*, 39(1), 89.

Nonaka, I., and Toyama, R. (2005). The theory of the knowledge-creating firm: subjectivity, objectivity and synthesis. *Industrial and Corporate Change*, 14(3), 419-436.

Okamuro, H. (2001). Risk sharing in the supplier relationship: new evidence from the Japanese automotive industry. *Journal of Economic Behavior and Organization*, 45(4), 361-381.

Organisation for Economic Co-operation and Development. (2018). *SMEs in Public Procurement: Practices and Strategies for Shared Benefits*, OECD Public Governance Reviews, Paris: OECD Publishing.

Organisation for Economic Co-operation and Development. (2019). Public Procurement.

http://www.oecd.org/gov/public-procurement/

Phan, P. H., and Hill, C. W. (1995). Organizational restructuring and economic performance in leveraged buyouts: An ex post study. *Academy of Management Journal*, 38(3), 704-739.

Piore, M. and Sabel, C. (1984). *The Second Industrial Divide*. New York: Basic books, 354.

Pisano, G. P. (1996). Learning-before-doing in the development of new process technology. *Research Policy*, 25(7), 1097-1119.

Pisano, G. P. (2017). Toward a prescriptive theory of dynamic capabilities: connecting strategic choice, learning, and competition. *Industrial and Corporate Change*, 26(5), 747-762.

Porter, M. E. (1980). Industry structure and competitive strategy: Keys to profitability. *Financial Analysts Journal*, 36(4), 30-41.

Powell, W. and Grodal, S., 2005. *Networks of Innovators*, in J. Fagerberg, D. Mowery and R. Nelson (Eds.), The Oxford Handbook of Innovation. Oxford: Oxford University Press, 56-85.

Pozzi, A., and Schivardi, F. (2016). Demand or productivity: What determines firm growth?. *The Rand Journal of Economics*, 47(3), 608-630.

Riordan, M. H., and Williamson, O. E. (1985). Asset specificity and economic organization. *International Journal of Industrial Organization*, 3(4), 365-378.

Roca-Puig, V., Beltrán-Martín, I., and Cipres, M. S. (2012). Combined effect of human

capital, temporary employment and organizational size on firm performance. *Personnel Review*, 41(1), 4-22.

Rosenbaum, P. R., and Rubin, D. B. (1983). The central role of the propensity score in observational studies for causal effects. *Biometrika*, 70(1), 41-55.

Rumelt, R. P. (1991). How much does industry matter?. *Strategic Management Journal*, 12(3), 167-185.

Saracoglu, D. S., and Kizilirmak, B. (2016). Subcontracting and firm characteristics: Evidence from two new local industrial districts in Turkey. *METU Studies in Development*, 43(2), 635.

Schilling, M. A., and Phelps, C. C. (2007). Interfirm collaboration networks: The impact of large-scale network structure on firm innovation. *Management Science*, 53(7), 1113-1126.

Storey, D. J. (2003). *Entrepreneurship, small and medium sized enterprises and public policies*. In Handbook of entrepreneurship research. Boston: Springer, 473-511.

Storey, D. J., and Greene, F. (2010). *Small business and entrepreneurship*. London: Pearson Books.

Stuart, T. E. (2000). Interorganizational alliances and the performance of firms: a study of growth and innovation rates in a high-technology industry. *Strategic Management Journal*, 21(8), 791-811.

Syverson, C. (2011). What determines productivity*?*. *Journal of Economic Literature*, 49(2), 326-65.

Taymaz, E., and Kiliçaslan, Y. (2005). Determinants of subcontracting and regional development: An empirical study on Turkish textile and engineering industries. *Regional Studies*, 39(5), 633-645.

Teece, D. J. (1982). Towards an economic theory of the multiproduct firm. *Journal of Economic Behavior and Organization*, 3(1), 39-63.

Teece, D. J., Pisano, G., and Shuen, A. (1997). Dynamic capabilities and strategic management. *Strategic Management Journal*, 18(7), 509-533.

Telgen, J., C. Harland, L. Knight, and K.V. Thai. 2007. *Public Procurement: International Cases and Commentary*. London: Routledge.

The Standish Group International, Inc. (2016). CHAOS Report 2016. https://www.standishgroup.com/store

Utterback, J. M. (1994). Radical innovation and corporate regeneration. *Research Technology Management*, 37(4), 10.

Uyarra, E., and Flanagan, K. (2010). Understanding the innovation impacts of public procurement. *European Planning Studies*, 18(1), 123-143.

Wapshott, R., and Mallett, O. (2018). Small and medium-sized enterprise policy: Designed to fail?. *Environment and Planning C: Politics and Space*, 36(4), 750-772.

Watanabe, S. (1971). Subcontracting, industrialisation and employment creation. *International Labour Review*, 104, 51-76

Wernerfelt, B. (1984). A resource-based view of the firm. *Strategic Management*

Journal, 5(2), 171-180.

Williamson, O. (1983). Organization Form, Residual Claimants, and Corporate Control, *Journal of Law and Economics*, 26(2), 351-366.

Williamson, O. (1991). Comparative Economic Organization: The Analysis of Discrete Structural Alternatives. *Administrative Science Quarterly*, 36(2), 269-296.

Williamson, O. 1975. *Markets and hierarchies*. New York: Free Press.

Yun, M. (1999). Subcontracting relations in the Korean automotive industry: risk sharing and technological capability. *International Journal of Industrial Organization*, 17(1), 81-108.

Zaheer, A., & Bell, G. G. (2005). Benefiting from network position: firm capabilities, structural holes, and performance. *Strategic Management Journal*, 26(9), 809-825.

공정거래위원회. (2013). 기업집단포털. 대규모기업집단 정보공개. https://www.egroup.go.kr/egps/wi/stat/kap/appnSttusList.do

권순원, 정동일. (2018). 시스템 통합(SI) 사업 하도급 문제 개선의 고용효과. *한국노동연구원 고용영향평가 연구보고서*.

권영철. (2004). 중소벤처기업의 국제화이론으로서 네트워크우위론의 정립과 검증. *기업가정신과 벤처연구*(구 벤처경영연구), 7(2), 77-104.

김계숙, 민인식. (2010). 직접경제가 지역-산업 고용성장에 미친 영향: System GMM 추정방법의 활용. *국토계획*, 45(2), 227-246.

김승일. (2009). 중소기업 하도급의 문제점과 개선 방안. *경영법률*, 19(2), 151-174.

김승일. (2011). 대・중소기업 생산성 분석과 동반성장 방안. *한국국제경영관리*

학회 학술발표대회 논문집, 301-307.

남종석, 김종호. (2019). 아웃소싱이 기업 경영성과에 미치는 영향: 생산성과 수익성을 중심으로. *산업혁신연구*, 35(2), 91-114.

라정주, 신원규. (2015). 금융이 중소기업에서 중견기업으로의 성장에 미치는 영향: 한국사례를 중심으로. *국제지역연구*. 24(4), 141-159.

박문수, 이호형. (2011). 한국 대중소기업간 기술협력 성과의 영향요인 분석-하도급 특성을 중심으로. *정보화연구* (구 정보기술아키텍처연구), 8(3), 229-244.

박은경, 강태구. (2014). 기업가 지향성과 네트워크 역량이 한국 중소기업의 국제화 성과에 미치는 영향. *국제경영연구*, 25(3), 97-131.

송장준. (2006). 중소유통 조직화 · 협업화 촉진방안 연구. *중소기업중앙회 · 중소기업연구원 보고서*.

위평량. (2018). 한국 500대기업의 동태적 변화 분석과 시사점(1998~2017). *경제개혁연구소 경제개혁리포트 2018-08호*.

유재흥, 김준연, 강송희. (2015). 공공 SW 의 新패러다임. *한국 IT 서비스학회 학술대회 논문집*, 541-545.

유호석, 강송희. (2020). SW산업 생태계 내 공공SW의 역할과 한계. *소프트웨어정책연구소 월간SW중심사회 2020(2).* https://spri.kr/posts/view/22900?code=industry_trend

유호석, 강송희, 유재흥. (2016). 공공SW 생태계 선진화 연구. *소프트웨어정책연구소 연구보고서 2016-02*.

유호석, 박강민, 김준연, 이삼열. (2019). 기업 규제의 다층적 효과 연구 : 공공 소프트웨어 사업 대기업참여제한제도를 중심으로. *한국IT서비스학회지*, 18(4): 29-53

은석. (2015). 교육 및 사회정책의 출산율 고양효과에 대한 비교 연구: System-GMM 을 활용한 26 개국 18 년간의 패널 자료 분석 결과를 중심으로. *보건사회연구*, 35(2), 5-31.

이민철, 정태현. (2018). 공공조달 성과가 중소기업의 성장에 미치는 영향. *중소기업연구*, 40(4).

이정화, 문상호. (2014). 기초연금이 고령자의 소득에 미치는 영향-성향점수매칭 (PSM) 이중차이 (DID) 를 활용한 분석. *한국정책학회보*, 23(3), 411-442.

전승훈. (2014). 한국경제분석: 복지지출 국제 비교 및 경제적 효과 분석. *한국경제의 분석*, 20(1), 165-219.

정우진, 김현석, 조신. (2019). ICT 산업의 R&D 투자가 타 산업에 미치는 파급효과 측정. *지식경영연구*, 20(1), 27-43.

정재헌, 홍장표. (2015). 중소기업/중견기업: 대기업과 중소기업간 거래네트워크 구조와 특성. *중소기업연구*, 37(4), 77-103.

조덕희, 양현봉, 홍지승, 한창용. (2016). 2016년 중소기업의 경영환경 및 경쟁력 실태조사. *산업연구원 정책자료 2016-288*.

조병선, 조상섭. (2014). 소프트웨어산업의 특징 및 구조변화에 대한 분석. 전자통신동향분석, 29(2), 69-78.

지은희, 전이슬. (2018). 2018 소프트웨어 산업 실태조사. *소프트웨어정책연구소*

연구보고서 2018-021.

지은희. (2016). 국내 소프트웨어 산업 실태조사. *소프트웨어정책연구소 연구보고서 2016-023*.

최봉호, 김상춘. (2015). 한국 정보통신산업의 생산성 변화에 대한 패널추정. *한국콘텐츠학회논문지*, 15(3), 388-395.

최필선, 민인식. (2013). 수능성적이 초기 노동시장 성과에 미치는 효과. *노동정책연구*, 13(1), 139-162.

통계청. (2019). *통계로 본 광복 70년 한국사회의 변화(해설편)*. 세종: 통계청.

표한형, 홍성철, 김지수. (2013). 수익성과 기업 성장 간의 관계에 관한 연구. *한국경제연구*, 31(2), 43-71.

하봉찬, 홍장표, 김종호. (2016). *산업생태계 연구를 위한 거래네트워크 DB구축과 활용사례*. 서울: 형설출판사.

한국소프트웨어산업협회. (2011). 『SI분야에서의 소프트웨어거래실태 및 경쟁제한 관행 조사』 연구 보고서. https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwjJktuQ4p7uAhWsyYsBHQyfA-sQFjAFegQIDBAC&url=http%3A%2F%2Fwww.prism.go.kr%2Fhomepage%2FresearchCommon%2FdownloadResearchAttachFile.do%3Bjsessionid%3D648D22B2B011A238D13E0AA871443CA3.node02%3Fwork_key%3D001%26file_type%3DCPR%26seq_no%3D001%26pdf_conv_yn%3DN%26research_id%3D1130000-201200001&usg=AOvVaw0qrrkEM4LunwXVDEVxaOkJ

홍장표, 정재헌. (2016). 기업의 연결망 특성이 생산성에 미치는 영향. *산업혁신연구*, 32(1), 1-29.

홍장표. (1997). 제품개발에서 대기업과 중소기업의 기술협력과 인센티브제도-자동차산업 승인도 방식을 중심으로. *중소기업연구*, 19(2), 111-133.

Abstract (Korean)

한국의 집약적인 1970~1990년대 고도 성장은 정부가 조성하고 지원한 하이테크 제품을 주로 수출하는 대기업 중심의 산업구조 덕택이었다. 하지만 재벌에 편중된 산업 구조에 대한 문제점이 더 부각되면서 정부는 중소기업 친화적인 공공 조달 정책과 같은 중소기업 지원 정책을 강화해 왔다. 소프트웨어 분야 공공 조달 시장은 국가계약법, 조달사업법, 소프트웨어진흥법 등의 규율 하에 있는데, 그간 대기업의 독점적 참여가 중대한 이슈였다. 그에 따라 정부는 2013년부터 재벌 기업의 공공 소프트웨어 조달 시장 참여를 금지하고, 2016년부터 다단계 하도급을 금지하는 재 하도급 제한 제도를 실시했다. 소프트웨어 산업에서는 중소기업 뿐 아니라 모든 참여기업들의 협업 구조가 중요하기 때문에, 네트워크 역량을 나타내는 구조적 특성의 동태적인 변화를 면밀히 분석할 필요가 있다. 이를 위해, 이 연구는 2008~2018년까지 연 매출 50억 원 이상인 2,665개의 주요 소프트웨어기업의 재무 데이터를 구성했다. 또한 네트워크 역량을 구성하는 네 가지 지표를 조작적으로 정의하고 세금계산서 거래 데이터에 기초하여 분석한 후 통합 패널을 구축하였다. 그리하여 네 가지 서로 다른 네트워크 역량이 기업 성장에 미치는 영향을 동적으로 분석하고, 대기업 참여 제한 제도(2013)가 노동생산성과 수익성에 미치는 순 효과와 다단계 하도급 제한 제도(2016)가 노동 생산성 변화와 매출 성장에 미치는 순 효과를 분석하였다. 분석 결과, 통합 · 매개 · 계층적 거래 네트워크 역량은 연 매출 성

장에 긍정적인 영향을 미치지만, 중장기적 협업 역량은 오히려 부정적인 영향을 미쳤다. 기업의 성장에 수요는 중요하지만, 해당 분야에 유효한 사업 권리를 갖고 있는 특정 기업군의 참여를 전면 제한하는 과도한 조치는 오히려 중소기업의 노동생산성 향상에 부정적인 영향을 미칠 수도 있다. 또한 소프트웨어 산업에서는 자동차 산업과 같은 제조업과 달리 수직적, 혹은 다층적 협력 구조 보다 수평적 협력 구조가 매출 성장에 보다 긍정적인 영향을 미친다. 산업과 기업 육성에 마중 물이 되는 공공 조달 시장 환경을 조성할 때, 우리는 산업 고유의 특성뿐 아니라, 기업 규모별로 역할 및 역량이 이질적이라는 점을 고려하여 사업의 기간 및 규모, 참여 기업 조건 등을 조화롭게 계획할 필요가 있다.

주요어 : 정부, 대기업, 중소기업, 소프트웨어, 네트워크 역량
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