Types of Corporate Innovation System and Innovation Performance in Korea
- Transformation Strategy for the Better Types of CIS
in the ICT Service Sector

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Abstract

Based on the Innovation System Approach, this paper establishes a Corporate Innovation System in Korea. Using latent class analysis with the Workplace Panel Data 2005 provided by Korea Labor Institute, we induced four types of CIS in Korea: the High-involvement type CIS, the R&D type CIS, the HI+R&D type CIS, and the Low Developed CIS. A workplace belongs to the HI type CIS was establishing high-involvement institutions such as well designed work system, motivation system, vocational education and training system, and labor relations simultaneously. A workplace pertains to the R&D type CIS was engaging in R&D activities without establishing high-involvement institutions; this characteristic is directly oppose to that of the HI type CIS. A workplace belongs to the HI+R&D type CIS was establishing a virtuous circle including well designed high-involvement institutions and R&D activities; this characteristic is directly oppose to that of the Low Developed CIS.

This paper examines the relationship between types of CIS and innovation performances— product/service innovation, employees-leading innovation, patent application, and labor productivity. The result was that the innovation performance of the HI+R&D type CIS was dramatically high; the performances of the HI type CIS and the R&D type CIS following it; and the Low Developed CIS showed significantly poor performance. This pattern was always discovered in all the cases of innovation performance. In addition, the HI type CIS was superior to the R&D type CIS in case of product/service innovation and the employees-leading innovation; while the R&D type CIS had advantages of the patent application and labor productivity. Furthermore, we conclude that the main hindrance of transformation from the R&D type CIS to the HI+R&D type CIS is poorly developed corporate culture. Meanwhile, the main obstacle of systemic transformation from the HI type CIS to the HI+R&D type CIS is the dissimilar purpose of innovation; that is to say, a workplace belongs to the HI type CIS usually pursue product/service innovation but not pursue patent application.

Keywords: Corporate Innovation System, Institutional Complementarities, High-involvement Institutions, R&D activities, Latent Class Analysis

Chapter1. Research Backgrounds and Hypotheses

1. Motivations and Purposes

1.1. Exploring a Corporate Innovation System in Korea

One of the extraordinary strands of economics during the last two decades is to introduce a systemic approach in the innovation research. Lundvall (1985) introduced the concept of 'innovation system', and the adjective 'national' was added to it by Freeman (1987). After that, technological systems (Carlsson & Stankiewics, 1991), sectoral systems of innovation (Breschi & Malerba, 1995), regional systems of innovation (Cooke, 1997), corporate innovation system (Grandstrand, 2000), social systems of innovation and production (Amable, 2003), organizational innovation system (Wagner-Luptacik et al., 2006), and numerous other names of innovation systems have been coined.

Innovation system approach (IS approach) is an influential theoretical framework. This approach deals with organizations, institutions, and their relations in a single framework. From the historical and evolutionary perspectives, IS approach assumes that various organizations and institutions are co-evolving with interaction, and this co-evolution creates various types of innovation system. This view is a little complex, but it is more realistic than its alternatives. Most of all, this approach provides a consistent basis for generating hypotheses about relations among specific variables. Using this approach, we can test these hypotheses and induce policy implications. Based on the concept of national innovation system (NIS), many researchers have examined institutional complementarities, and have drawn inspiring innovation policies of nations. With the help of sectoral systems of innovation (SSI), unique characteristics of each sector have been analyzed.

However, little attention has been focused on corporate innovation system (CIS). Grandstrand (2000) defined CIS, and conducted qualitative analysis with interview/questionnaire data of 42 large corporation managers. Wagner-Luptacik et al. (2006) analyzed a firm as an organizational innovation system based on complexity theory and social system. These studies treated a firm as an innovation system, but not reached to establishing corporate innovation system. The first purpose of this paper is to establish a corporate innovation system in Korea, and empirically analyze the relationship between institutions, organizations, and their activities.

1.2. Ordering CISs on the basis of Innovation Performance

The main function of innovation system is to pursue innovation process such as developing, diffusing, and using innovation, so measuring innovation performance is crucial. This paper hypothesizes that some types of CIS are correlated with high level of innovation performances, other types of CIS are correlated with poor performances. The second purpose of this paper is to test this hypothesis.

1.3. Exploring Transformation Strategy for the Better Types of CIS in the ICT Service Sector in Korea

IS approach underlines organizational change especially organizational innovation. All the research based on IS approach has emphasized the effect of institutional complementarities in the process of organizational innovation. For example, an introduction of job rotation may function well in some workplaces, but not in other workplaces. In the former workplace, the newly introduced institution may synchronize with the existing institutions, thus these new and existing institutions may constitute a virtuous circle. In the latter workplace, however, the newly introduced institution may be conflicted with the existing institutions, thus constitute a vicious circle. Therefore, establishing an organization innovation strategy is a challenging mission.

This paper investigates organizational innovation from somewhat novel, different angle: Transformation from one CIS type to the other CIS type. If some types of CIS are correlated with high level of performance, all firms may try to transform toward that types of CIS. In reality, however, various types of CIS may exist, and some types of CIS may be correlated with poor performances. It means that there would be some factors to prevent this transformation. The third purpose of this paper is to investigate the obstacle, and explore transformation strategies for the better types of CIS, especially in the ICT service sector.

2. Research Backgrounds

2.1. Innovation System approach

This paper trails the IS approach based on the Neo-Schumpeterian tradition. IS approach has developed along the intricate paths, and various branches of research have been conducted. In this section, four branches of research, which are highly correlated with the CIS Model in Korea, are introduced: Knowledge management, competence development, learning organization, and organizational innovation.

2.1.1. Knowledge management

One of the main themes of the IS approach is to define and manage knowledge. In the IS approach, innovation or learning in a firm is considered as a process of cultivating, combining and utilizing quite different types of knowledge, thus knowledge management has become a central challenging function in the organization. OECD (2003) defines knowledge management as a function covers any intentional and systematic process of acquiring, sharing and using knowledge in order to enhance learning and performance in organizations.

The first step to understand knowledge management is to define the various types of knowledge. Lundvall and Johnson (1994) distinguished knowledge as know-what, know-why, know-how, and know-who. Know-what refers to knowledge on facts; know-why relates to causes and effects; know-how refers to competences and capabilities; and know-who refers to knowledge of who have certain competences and skills. Know-what and know-why is more explicit, tangible and easy to codify; meanwhile know-how and know-who is more implicit, intangible and difficult to codify. This difference between explicit versus tacit knowledge is of fundamental importance in understanding the challenges of knowledge management.

Lam (2000) combined this tacit/explicit knowledge with individual/collective knowledge. Embrained knowledge is individual and explicit knowledge, dependent on the person’s cognitive abilities. Encoded knowledge is explicitly and collectively shared through written rules or procedures in the organization. Embodied knowledge is tacit knowledge held by the individual. Embedded knowledge is knowledge built into routines, habits and norms of the organization.

Jensen and Lundvall (2007) defined two types of knowledge according to two modes of learning and innovation: the STI-mode (science-technology-innovation mode) and DUI-mode (learning by doing, using, interacting mode). Using survey data of 692 Danish firms in the private sector, they resulted that a firm strong in both of the STI-mode and the DUI-mode knowledge was correlated with 5.1 times of possibilities of product/service innovation (P/S innovation) than a firm strong in none of the two mode of knowledge. A firm strong in the STI-mode knowledge was 2.4 times as high, and a firm strong in the DUI-mode knowledge was 2.2 times as high.

In the context of the learning economy hypothesis, the process of knowledge management is critical. The combination of globalization, information technology and deregulation leads to more and more rapid transformation and change, in which knowledge gets obsolete with an increasing speed. Relating tacit knowledge to explicit knowledge becomes a very important management function. This function must take place on all levels in the organization and often with the middle level management as midpoint of this process (Nonaka and Takuechi, 1995). In the perspective of the learning economy, the speed of innovative capabilities, that can bring new products quickly into the market, becomes more critical. Organizational innovation may therefore be assumed to take certain directions that shorten the time lag from external change to external response.

2.1.2. Competence development

IS approach highlights on learning process and competence building. It assumes that organizations and agents have a capability to enhance their competence through learning and interacting with each other. Therefore the focus is upon how enduring patterns of interaction are established, evolve and dissolve as time goes by. New competences are built while old ones are destroyed. These patterns characterize the innovation system and change in a process of creative destruction of knowledge and relationships. A crucial normative issue is how such patterns affect the creation of new resources and to what degree they support learning among agents.

Organizational learning and competence building is crucial both for a firm and employees. Through learning activities, a firm accumulates its structural capability to innovation, and employees also improve their competence. In this reason, to assess workplaces as learning sites and to focus on competence development becomes increasingly important. There is no consent on the concept of competence development. In spite of these inconsistencies, however, three dimensions of competence development may be constructed: individual and generic competence, individual and situated competence, collective and situated competence.

Individual and generic competence denies the importance of organizational or work-related circumstances within which a given competency is used independently from the context of activities. Individual and situated competence, according to Lave and Wenger (1991), means potential possibilities to act in a specific situation or context. In this context, competence development is defined as a continuous development of experiences, skills, and responsibilities related to the job situation. With this definition, competence development becomes closely connected to the experience-based and situated part of the learning concept and related to the organizational and management context of the work situation (Nielsen, 2006). The last is collective and situated competence. If the competence is closely connected to the concrete job situation, it is a logical assumption that it can beheld by individuals as well as by the group of individuals. The main difference between individual and collective competence approaches is that the latter attributes more importance to the organizational culture of the firms and pays particular attention to the relations built up between the participants in the labor process.

These relations play an essential role in the ways employees are using and sharing their knowledge, skills and competences. Thus, it is of crucial importance what kind of organizational practices are being used in the firms in order to generate and promote these collective competences—job rotation, teamwork, multidisciplinary planning teams, and other devices to promote collective competences (Makó, Illéssy and Csizmadia 2007).

2.1.3. Learning organization

Consistent with the learning economy hypothesis, the environment of today's firm is characterized by a relatively high degree of complexity, unstableness, and unpredictability. Senge (1992) stated that these characteristics have motivated the concept of a learning organization. Learning organization is defined as an organization that has been designed, developed, and implemented to hold a capacity to adapt continuously to its environment. Daft (2001) stated that main characteristics of learning organizations are horizontal structure, empowered employees, shared information, collaborative strategy, and adaptive culture. Heery and Noon (2001) stated that the learning organization is constantly looking for new ideas and approaches.

There are some organizational traits which speed up both adaptation and innovation: A limited number of levels in the horizontal hierarchy; horizontal communication supported by teamwork or job rotation across division border; the delegation of responsibility; external interaction. An interesting analytical issue is weather each of these traits can be seen as single contributions to enhanced performance, or weather they are complementary and have a bigger impact when they appear as a combined package. Nielsen & Lundvall (2006) showed that a co-operative regime, combining direct and indirect participation, is most effective on the development of the learning organization and so innovation. Especially in case of potential conflict, the indirect methods show their importance. Arundel et al. (2007) empirically classified four types of work organizations: the discretionary learning work organization, lean production learning work organization, Taylorist work organization, and simple work organization. And they resulted that a firm organized to support high levels of discretion in solving complex problems is correlated with high level of innovation performance. And they concluded that learning and interaction within organizations are important as same as learning through interactions with external agents.

2.1.4. Organizational innovation

In most of empirical research based on IS approach, innovation normally refers to changes in technical solutions associated with process or product/service, but rarely associated with the change of organizations. Organizational change is an intentional process of breaking down regular patterns of behavior in order to create new patterns that subsequently become institutionalized. And organizational innovation is defined as the change of organizational processes and structures with the purpose of enhancing the competitiveness or performance of the organization. Thus, organizational innovation occurs in cases where: change of organizational processes leads to change of organizational structures; change of organizational structures leads to change of organizational processes; and changes of organizational processes and structures occur simultaneously.

2.2. Human Resource Management Theory and Employment Relations Theory

2.2.1. Human Resource Management and Work System Design

Storey (1995) defined human resource management is a distinctive approach to employment management which seeks to achieve competitive advantage through the strategic deployment of a highly committed and capable workforce, using an array of cultural, structural and personnel techniques. The importance of organizational design as frame of managing the human resource is critical to understand the relation between employers and employees on the basis of the HRM theory. In parallel with the concept of the learning organization, work system refers to a number of specific work practices which are seen as interrelated. Although a work system can be decomposed into a number of work practices, its outcomes are most of all determined by their integration in a coherent bundle or cluster, because there are complementarities and synergies among them.

Two approaches on how to design work system are introduced: High Performance Work System and Lean Production and Administration approach.

The main characteristic of a high performance work system (HPWS) is extensive involvement of employees. This involvement harnesses the potential of people and improves the performance of the organization. Employees in a HPWS experience greater autonomy over their job tasks or methods of work, and have higher levels of communication with other employees, functional specialists, managers, and vendors of customers. In the HPWS approach, job is firm-specific, and employees are required more skills to do their job successfully. Incentives must be provided for employees in order to obtain additional skills and to engage in activities such as problem solving. Employment security provides employees with a long-term stake in the company and a reason to invest in its future, while the payment of quality or other incentives allows them to share in the fruits of improved performance. Employment security and incentive pay motivate employees to make an extra effort in developing skills and participating in decisions.

The lean production approach has developed in many countries within both manufacturing and service. Womack and Jones (2003), who initiated the lean wave, stated the lean principles as follows: precisely specify value by specific product, identify the value stream for each product, make value flow without interruptions, let the customer pull value from the producer, and pursue perfection. The aim of lean strategies is improving performance measured by profits and new product development, and the practical use of lean strategies contains various issues such as cost reduction, employee empowerment, value chain orientation, and product innovation. Kochan et al. (1997) examined the diffusion of lean production, and so the concrete interaction between changes in production systems and employee relations at the plant level. Common trends were greater work organization flexibility, employee participation, investment in skill development, and reductions in employment security associated with downsizing. In addition, EPOC research group (1997) showed wide differences between actual employee participation and skill demands across the groups; less than two percent of workplaces matched the Scandinavian model of group delegation (high-intensity delegation + qualified workforce + high training intensity) even though it was judged to be more successful than the Toyota model (low-intensity delegation + medium or low employee skills + low training intensity).

2.2.2. Employment Relation Theory

A theoretical merge between the Human resource management and the Industrial Relation approach has taken place in the Employment Relation Theories. (Gallie et al., 1998) The role of unions and collective interests is a core aspect of the relation between employer and employee at firm level, and especially in situations of organizational change or restructuring of the employment relationship.

Employment relation theory states that the main challenges of new employment relations since the eighties are four: First, a rapid development of new information and communication technology (ICT) leads to a transformation of work toward up-skilling than deskilling; more towards increased responsibility than control. Second, industrial relations shift from sectoral level to firm level with human resource management perspective. Third, employment contract is more flexible and fragmented: growth in non-standard work contracts such as temporary work, self employment and part-time work. Fourth, job security decreases as result of downsizing, outsourcing and structural changes. Employment relation theory thus examines the employment relationship in the context of these changing external and internal environments and establishes a framework which includes the employee focused Industrial relations and the employer focused HRM analytically at firm level, incorporating the interests of the firm's stakeholders.

The upcoming of human resource management and employment relation theories means growing priority to developing work organizational frames supporting involvement, responsibilities and continuous competence development of the individual employee as well as groups of employees in the firm.

3. Hypotheses

3.1. Hypothesis 1. Various Types of CIS in Korea

3.1.1. Hypothesis 1-1 Institutional Complementarities Hypothesis

All the literature based on IS approach has emphasized institutional complementarities, but much of the research has failed to demonstrate them. Institutional complementarities have been largely assumed or stated rather than demonstrated. Establishing the CIS Model in Korea, two kinds of institutional complementarities are considered. The main institutional complementarities are between direct participation and indirect participation of employees in innovation activities; and the subordinate institutional complementarities are between direct/indirect participation and motivation/VET system.

The interdependence between indirect participation and direct participation has been investigated in some studies: In this context, indirect participation means the participation through employee representatives such as labor union; and direct participation means the participation through work system without passing by employee representatives.

Utilizing British Workplace Employment Relations Survey data, Sisson (1993) showed that individual new work practices do occur more frequently in organizations with a union presence. EPOC survey (1997), with data of 10 EU countries, concluded that workplaces which had no participative culture were significantly outperformed by workplaces which had direct or representative participation. On the basis of the EPOC survey, the OECD (1999) concluded that one of the main factors being linked to a greater application of high-involvement working practices within countries is an industrial relations system which facilitates negotiations and cooperation between managers and employees. Black and Lynch (2000) reported that employee voice and involvement has a larger positive effect on productivity when it is done in the context of unionized establishments. Bidge (2002) concluded that a specific type of works council, namely one which is frequently asked to play a strong cooperative role in organizational or technological changes, has a positive effect on the innovation performance. Nielson & Lundvall (2006) insisted that while indirect forms of participation become less frequent in Danish firm, they seem to remain important in learning organizations. However, rare empirical studies have quantitatively demonstrated the complementarities between indirect and direct participation.

Subordinate institutions such as motivation system and VET system are also important components. Well designed motivation system and VET system enforces employees to involve in innovation activities.

Motivation theory sheds light on the institutional complementarities in the IS approach. McClelland (1961) classified needs, and treated affiliation, power and achievement. Herzberg (1968) tried to build motivation in the organization design by job enrichment and job enlargement. Hackman and Oldham (1980) linked job characteristics such as skill variety, task significance, autonomy and feedback to responsibility and knowledge of results, which together gives high internal work motivation. In Vroom's expectation theory, motivation is a function of each employee's expectation that her behavior will result in outcomes of high individual value. Pinnington and Edwards (2000) insisted that work should be designed in such a way that high performance leads to outcomes desired by the employees. Monetary reward or compensation systems are an important part of motivation theory.

In the case of VET system, there is a general academic consent on the importance of vocational training. VET system is considered as an institution for improving employability and mobility as well as firms' performance, and it plays a key role in the transfer of those knowledge, skills and competencies.

We assume that high-involvement institutions such as work system, motivation system, VET system, and labor relations are considerably interacting and interdependent with each other, so we derive the institutional complementarities hypothesis as follow.

Hypothesis 1-1 (Institutional Complementarities Hypothesis) Well designed high-involvement work system makes employees to involve in innovation activities; well designed motivation system and VET system deepens and widens the involvement of employees; and well designed cooperative labor relations guarantee these systems to operate well. Meanwhile, a workplace without high-involvement work system has no well designed motivation system or VET system, and cooperative labor relations does not been established.

3.1.2. Hypothesis 1-2 Relatively Autonomous R&D Hypothesis

Vast majority of empirical research based on IS approach has focused on R&D activities, but less attention has been paid on the activities related to learning by doing, using, and interacting. Of course, R&D activities are one of the main factors in the innovation system. R&D activities are not only a learning process but also an activity of competence building. Through R&D activities, a firm accumulates its structural capability to innovation, and employees also improve their competence participating in the R&D activities. However, R&D activity is not the only factor of innovation system. A firm can create innovations without R&D activity, and can accumulate its competence without R&D activity. A well designed work system guarantees continuous interaction among employees, consumers, suppliers, and other actors related to innovation activities. This constant learning process improves the competence of a firm and employees; thus creates innovation without R&D activities. The CIS Model in Korea contains not only R&D activities but also institutions that support learning process and competence building.

But two activities have fundamentally different characteristics. The activities of learning by doing/using/interacting may be deeply correlated with high-involvement institutions such as work system, motivation system, VET system, and labor relations. Without these institutions, the activities of learning by doing/using/interacting may be realized. That is to say, these institutions are considerably interacting and interdependent each other. In contrast, R&D activities are not so deeply correlated with these institutions. Even though R&D activities may be pursued on the basis of institutional environment, but rarely limited by it. R&D activities recall Schumpeter's entrepreneurship in the sense that these are energetic activities going beyond the institutional constraints. In other words, R&D activities are relatively autonomous from institutions such as work system, motivation system, VET system, and labor relations. It means that, if we see from other angle, there exists a workplace engaging in R&D activities without establishing well designed high-involvement institutions; or a workplace establishing well designed high-involvement without engaging in R&D activities. This idea constitutes hypothesis 1-2.

Hypothesis 1-2 (Relatively Autonomous R&D Hypothesis) Even though R&D activities are influenced by institutional environment, these activity are less restricted by institutions such as work system, motivation system, VET system, and labor relations. In other words, there exists a workplace that engages in R&D investment without establishing innovation-related institutions; or a workplace that have highly developed innovation-related institution without R&D investment.

If hypothesis 1-1 and 1-2 are true, the strategy engaging in R&D activities may be relatively simple in the sense that this strategy is not limited by other institutions; but the strategy establishing well designed high-involvement institutions may be relatively complex and dependent on corporate culture.

3.1.3. Hypothesis 1-3 Learning Economy Hypothesis

Lundvall & Johnson (1994) defines learning economy as a dynamic concept: it involves the capability to learn and to expand the knowledge base, which refers not only to the importance of the science and technology systems, but also to the learning implications of the economic structure, the organizational forms and the institutional set-up. The learning economy gets firmly established through the combination of widespread ICT-technologies, flexible specialization and innovation as a crucial means of competition in the new techno-economic paradigm.

Some studies have investigated the relationship between learning economy hypothesis and forms of organization. Christensen & Lundvall (1999), with the descriptive statistics of the DISKO (Danish Innovation System) Data, insisted that increased competition drives firms toward forms of organization that are functionally flexible with the characteristics of delegation of responsibility, integration of functions, and job rotation. Laursen (2001) showed that the more knowledge-intensive is the sector, the higher is the outcome engaging in the application of new HRM practices.

This paper goes further. This paper assumes that market change or uncertainty affects to the determination of the types of CIS. A workplace establishing well designed high-involvement institutions is well adapting to market change or uncertainty. Therefore,

Hypothesis 1-3 (Learning Economy Hypothesis) A firm facing enormous market change or uncertainty has more propensity to evolve toward establishing well designed high-involvement institution, thus constitute unique types of CIS. Meanwhile, a firm facing no market change or uncertainty has less motivation to establish well designed high-involvement institutions.

If hypothesis 1-3 is true, the main strategy of a workplace facing enormous market change of uncertainty may be to establish well designed high-involvement institutions.

3.1.4. Hypothesis 1-4 Sectoral Dissimilarity Hypothesis

Service sector has fundamentally different characteristics to the manufacturing sector. The first dissimilar characteristic of service is the absence of outputs that are independent physical entities. In manufacturing there is no confusion between the process of production and the product. In services, however, the process is often indistinguishable from the product. Secondly, service involves interrelationship between producer and consumer. There is no producer without a consumer. Hill (1999) stated that a service must be provided to another economic unit. Gallouj and Weinstein (1997) emphasized the interactive aspects of services, and suggested that consumers actively participate in the provision of service, that is, service co-production.

These two characteristics of service sector are somewhat similar to the characteristic of learning by doing/using/interacting, especially with consumers. From this similarity, we assume that a workplace belonging to the service sector has different types of innovation system from a workplace belonging to the manufacturing sector, and we induce hypothesis 1-4.

Hypothesis 1-4 (Sectoral Dissimilarity Hypothesis) In the service sector, a workplace has propensity to establish well designed high-involvement institutions rather than to engage in R&D activities. Meanwhile, in the manufacturing sector, a workplace has propensity to engage in R&D activities rather than to establish high-involvement institutions.

If hypothesis 1-4 is true, the innovation strategy of a workplace belonging to the service sector should be different from that of a workplace belonging to the manufacturing sector.

3.2. Hypothesis2. Types of CIS and Innovation Performance

3.2.1. Hypothesis 2-1 Performance Ordering Hypothesis

We assume that each firm has its own unique clusters of institutions and activities, so has dissimilar competence to create innovation.

Innumerable studies have demonstrated that a workplace engaging in R&D activities yields high level of innovation performance. However, relatively less research has investigated the innovation performance of a workplace establishing well designed high-involvement institutions.

Among studies on the effect of well designed high-involvement institutions, some studies have examined the relationship between direct/indirect participation and innovation performance. The result of previous studies was that indirect participation usually affected to the innovation performance differently from countries to countries: negative in the USA or Canada, but positive or no effect in Germany or the UK. In trying to explain this difference, Schnabel and Wagner (1994) pointed to the difference in style; more cooperative labor relations in Germany may well facilitate innovation. And Friedrich-Ebert Stiftung (1998) stated that indirect participation could make the following positive contributions to innovation and change: as a communication infrastructure it simplifies and structures communication between management and personnel; co-determination leads to a higher quality of decision-making by management, because management has to justify its actions more systematically; once convinced, the employee representation can help to overcome employee resistance and to build trust, even in the case of job losses.

Meanwhile, direct participation is usually positive, from different countries and with different forms of innovation performances, and the evidence is becoming more and more convincing. From theses results we assume that the adoption of high-involvement work systems, flanked by new HRM techniques, is correlated with high level innovation performance. With regard to innovation, high levels of direct employee participation can be seen as stimulating in four different ways: forms of direct participation increase the level of decentralization, which creates a better and more spacious environment for the discovery and utilization of local, practical knowledge in the organization; team work or job rotation give workers better insights into the tasks and problems of other workers, which can lead to a better coordination of innovative activities; group forms of direct participation bring together knowledge and skills which until then existed separately within the company; direct participation and its possible effect on the quality of working life might encourage greater effort and commitment on the part of the workers to perform in ways over and above what is formally and normally expected. In addition the interaction between direct and indirect participation also showed positive relations with product/service innovation and labor productivity. From these results of previous studies we induce hypothesis 2-1.

Hypothesis 2-1 (Performance Ordering Hypothesis) A workplace, engaging in R&D activities with establishing well designed high-involvement institutions, is correlated with considerably high innovation performance; a workplace engaging in R&D activities without establishing high-involvement institutions, or a workplace establishing high-involvement institutions without engaging in R&D activities, are following it; and a workplace having neither R&D activities nor high-involvement institutions are correlated with considerably poor performance.

If hypothesis 2-1 is true, we may consider the transformation strategy for the better types of CIS: form the CIS with low level of performance to the CIS with high level of innovation performance.

3.2.2. Hypothesis 2-2 Dissimilar Innovation Target Hypothesis

Exploring the CIS Model in Korea, we consider two modes of activities: R&D activities and activities related to learning by doing, using, and interacting. These two modes of activities reflect two types of knowledge management strategies. These two activities have particular process of learning, competence building, and employee participation; thus deeply interdependent with particular organizations and institutions. R&D activities are accordant with R&D laboratory, external knowledge network, competent specialists, and amount of R&D expenditure; while learning by doing/using/interacting activities can be conducted with employee participation and well designed institutions supporting employee participation. For this reason, innovation performance must reflect these two modes of activities: innovation performance related to R&D activities; innovation performance related to learning by doing, using, and interacting activities.

From the viewpoint of HRM strategy, engaging in R&D activities is better strategy to an employer who pursues R&D related innovation; establishing high-involvement institutions is better strategy to an employer who purposes innovation related to learning bi doing, using, interacting. And from the viewpoint of firm's competence, we assume that a firm establishing R&D laboratory, competent specialists, external knowledge network, and amount of R&D expenditure, is considerably correlated with R&D-related innovations. A firm, establishing well designed high-involvement institutions, is considerable correlated with innovation related to learning by doing, using, interacting. Thus,

Hypothesis 2-2 (Dissimilar Innovation Target Hypothesis) A workplace establishing well designed high-involvement institutions is advantageous to the innovation related to the activities of learning by doing/using/interacting. Meanwhile a workplace engaging in R&D activities is strong in the science-technology innovation.

If hypothesis 2-2 is true, innovation strategy should be different following the innovation target. A workplace emphasizing employees-leading innovation or product/service innovation should pursue the strategy establishing well designed high-involvement institution. Meanwhile, a workplace emphasizing patent application should pursue the strategy engaging in R&D activities. If we consider hypothesis 2-1 and 2-2 together, the best strategy is to engage in R&D activities with establishing well designed high-involvement institutions.

Chapter2. Various Types of CIS in Korea

1. Model: A Corporate Innovation System in Korea

1.1. Innovation System based on the Neo-Schumpeterian Tradition

Before establishing a CIS in Korea, defining innovation system is required. Various definitions of innovation system have been made by many researchers. Freeman (1987) defined NIS as the network of institutions in the public and private sectors whose activities and interactions initiate, import, modify and diffuse new technologies. Nelson and Rosenberg (1993) defined system as a set of institutions whose interactions determine the innovative performance of national firms. Lundvall (1992) defined NIS as all parts and aspects of the economic structure and the institutional set-up affecting, learning as well as searching and exploring: the production system, the marketing system and the system of finance present themselves as subsystems in which learning takes place. Edquist (1997) defined innovation system as all the important economic, social, political, organizational, institutional and other factors that influence the development, diffusion and use of innovations, as well as the relations between these factors. Granstrand (2000) defined CIS as the set of actors, activities, resources and institutions and the causal interrelations that are in some sense important for the innovative performance of a corporation.

No consents are on the definition of innovation system, but vast majority of researchers approve that an innovation system, based on the Neo-Schumpeterian tradition, has its unique constituents, function, and activities. Edquist (2005) states that an innovation system consists of two kinds of constituents: components and relations among them. Main components are organizations and institutions. Organizations are formal structure that are consciously created and have an explicit purpose; they are players or actors. Institutions are sets of common habits, norms, routines, established practices, rules, or laws that regulate the relations and interactions between individuals, groups, and organizations; they are the rules of the game. The specific structure of organizations and institutions, however, varies among systems.

The main function of Innovation system is to pursue innovation processes such as developing, diffusing, and using innovations; and activities in innovation system are related to that function. Edquist (2005) presents 10 crucial activities: R&D investment; competence building in the labor force such as provision of education and training, creation of human capital, production and reproduction of skills, and individual learning; articulation of quality requirements emanating from the demand side with regard to new products; creating and changing organizations needed for the development of new fields of innovation; creating and changing institutions; networking through markets and other mechanisms, including interactive learning between different organizations involved in the innovation processes; formation of new product markets; incubating activities; financing of innovation processes and other activities that facilitate commercialization of knowledge and its adoption; and provision of consultancy services for innovation processes, e.g. technological transfer, commercial information, and legal advice.

1.2. The Corporate Innovation System in Korea

This paper establishes a corporate innovation system in Korea based on Neo-Schumpeterian tradition.

Employer and employees are the basic actors in a firm, so the two main organizations are the board of director and a labor union. Employer or the board of director is the agent of R&D investment, and one of the main agents creating/changing organizations and institutions related to competence building, the involvement of employees in innovation activities, quality management, and the other management activities. Employees or Labor Union is the agent of labor relations, innovation activities such as R&D, quality management, competence building, and organizational transformation. In addition, the workplace including R&D laboratory, production plant, head office and branches functions as a crucial organization, which is also a site of learning activities.

The main institutions of this CIS are work system, motivation system, VET system, and labor relations. Two types of work system are assumed in this Model: Well designed high-involvement work system and less developed work system. Well designed work system makes employees to involve in innovation activities; well designed motivation system and VET system deepens and widens the involvement of employees; and highly developed cooperative labor relations guarantee these systems to operate well. A workplace with this virtuous circle is considerably correlated with high level of innovative performance. In contrast, a workplace with poorly designed work system, motivation system, VET system, and labor relations is considerably correlated with low level of innovative performance.

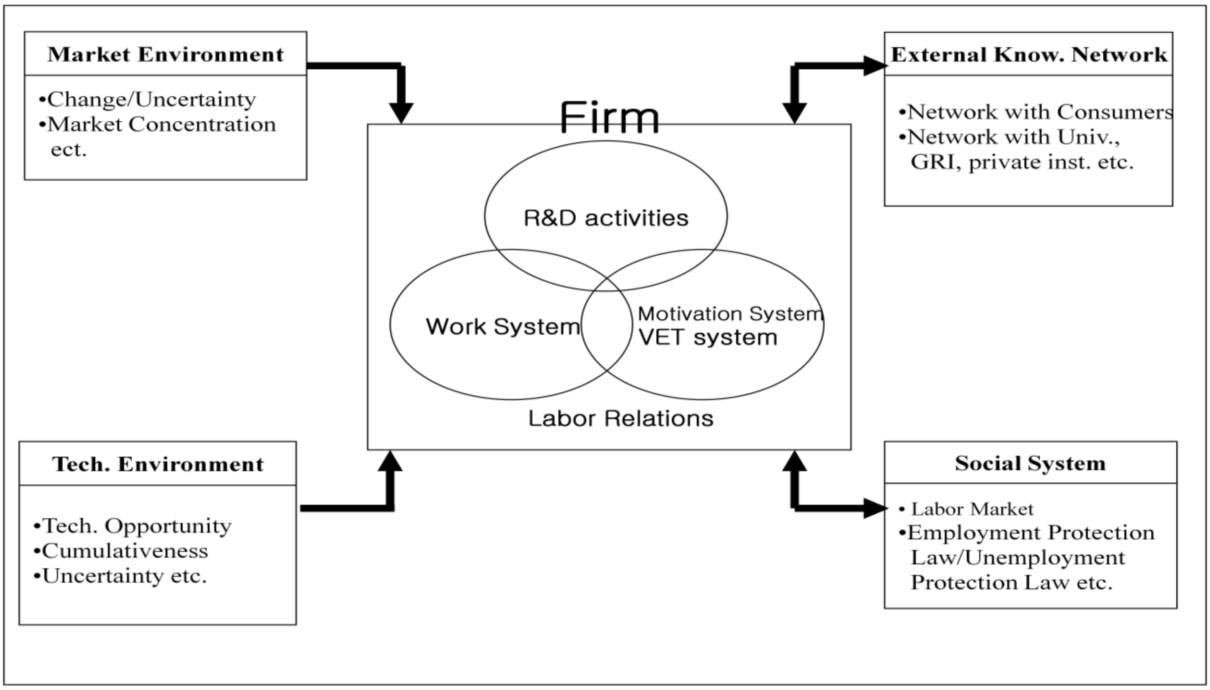
The two main activities of this CIS are R&D activities and competence building. R&D activity, which is not only a learning process but also an activity of competence building, has been a central activity in IS approach. Through R&D activity, a firm accumulates its structural capital, and employees participating in the R&D activity improve their competence. However, R&D activity is not the only activity of competence building. A firm can accumulate its competence without R&D activity. A well designed work system guarantees continuous interaction among employees, consumers, suppliers, and other actors related to innovation activities. This constant learning process improves the competence of a firm and employees. Moreover, the combination of R&D activity and the other competence building activities may yield spillover effect.

In this Model, R&D activity is treated as an innovation strategy of an employer; which means that, even though the activity of R&D investment is influenced by employees' reaction, this activity is less restricted by other institutions. Meanwhile, the other activities of competence building are assumed to be deeply correlated with other institutions such as work system, motivation system, VET system and labor relations.

Beside the two main activities, this Model includes quality management activities emanating from the demand side. This activity is a process of interaction with consumers, and the process of communication among employees to satisfy consumers' demand and to track the change of consumers' preference. The change of market demand is also explicitly included in the model to investigate the relationship between the types of CIS and market environments. Lastly, this paper explores the transformation activities for the better types of CIS.

In order to establish a better CIS, we need to consider external knowledge networks with universities, government research institutes and other agents related to knowledge transfer. For the precise analysis on competence building of a firm and employees, external social systems such as labor market, employment protection law, and unemployment protection law are also needed to be included. The characteristics of technological regime—such as technological opportunity, cumulativeness, and uncertainty—also influence on the innovation activities of a firm and employees. Nevertheless, these factors are not included in this Model.

Figure 2-1 The Corporate Innovation System in This paper



2. Data and Variables

2.1. Data

The data used in this paper is the 'Workplace Panel Survey 2005', a sample survey based on workplace units, provided by Korea Labor Institute. The population of the WPS 2005 includes workplaces with 30 or more employees, and 1905 workplaces are sampled to represent workplaces in Korea using stratified sampling. The WPS 2005 contains large amounts of information including work organization, human resource management, compensation and assessment, labor relations, and other labor-related variables. This paper uses 1350 observations, which have financial data provided by Korea Information Service.

2.2. Variables

The choice of variables is based on the IS approach, human resource management theory, work system design, and employment relations theory.

2.2.1. Indicators for Latent Class Analysis

Indicators are dependent variables that are used to define or measure the latent classes in a Latent Class Cluster Model.

Eight variables are used as indicators for corporate innovation system. Among them, six indicators are for institutions related to employee participation such as work system, motivation system, VET system, and labor relations; and the other two indicators are for innovation activities. The corporate innovation system of this paper is composed of these innovation-related institutions and R&D activities; and the configuration of those eight indicators determines the type of the corporate innovation system.

Work system is defined as an institutional device to manage working process in workplace. Three indicators are used in describing a work system: regular job rotation, enterprise-wide quality management program, and proposal system. Regular job rotation makes workers perform multiple functions and gain different types of experience and knowledge. As vitalized as a regular job rotation, more knowledge are diffused and created in firm's level. Through this process, the competence of a firm and employees are improved. Enterprise-wide quality management program, such as 6-sigma, aims to achieve quality innovation and customer satisfaction through minimizing defects in product design, manufacture and service quality. A system for receiving suggestions connects employees' ideas to innovations.

Motivation system is critical in making employees participate in innovation activities with great efforts. Whether or not the workplace enforces a performance sharing system, which is based on the management performance at the enterprise or workplace or division level, is used as an indicator. VET system is recognized as a crucial indicator determines not only worker's ability to innovate, but also the possibility of worker's promotion and employment. Manager training, professional skilled personnel training, sales and service personnel training, site supervisor training, and production worker training constitute a VET system. Labor relations are the most fundamental factors that guarantee harmonious operation of all these innovation-related institutions. Whether labor union exists or not is used as an indicator describing labor relations.

The last two indicators are for R&D activities, which contain considerably different characteristics from innovation-related institutions. R&D activities would be pursued on the basis of institutional environment, but rarely limited by it. Innovation strategies recall Schumpeter's entrepreneurship in the sense that these are energetic activities going beyond the institutional constraints. R&D expenditure is the typical indicator for innovation strategy. This paper divides R&D into two types: explicit R&D and tacit R&D. Explicit R&D is the R&D expenditure written on a balance sheet and an income statement; whereas, tacit R&D is written on a schedule of manufacturing cost. In the sense that the R&D expenditure written on a schedule of manufacturing cost cannot be separated from production activities, tacit R&D may be more correlated with work organization and the other innovation-related institutions than explicit R&D.

Table 2-1 Indicators for a Corporate Innovation System

Indicators		Explaining indicators
Work system	Regular job rotation	1=exist (#592), 0=not exist (#758)
	Quality management program	1=exist (#645), 0=not exist (#705)
	Proposal system	1=exist (#1003),0=not exist (#347)
Motivation system	Performance sharing system	1=exist (#785), 0=not exist (#565)
VET system	Vocational education training system	1=exist (#1270),0=not exist (#80)
Labor relations	Labor union	1=exist (#570), 0=not exist (#780)
Innovation strategy	Explicit R&D investment	1=exist (#704), 0=not exist (#646)
	Tacit R&D investment	1=exist (#239), 0=not exist(#1111)

2.2.2. Covariates for Latent Class Analysis

When we classify types of CIS using latent class analysis, we can control some exogenous variables, such as sector and firm size. These exogenous variables, which are called as covariates in the latent class analysis, are used to predict or describe the CIS. Controlling these exogenous variables, classification error is reduced.

Sector, firm size, and the trend in market demand are controlled in this paper. We give value 1 if the workplace belongs to the service sector, 0 if belongs to the manufacturing sector; we give value 1 if the workplace employs more than 100 workers, 0 if the workplace's employees are less than 100; we give value 1 if the market demand for the workplace's main product/service is increasing, 0 if steady or decreasing.

Table 2-2 Covariates for a Corporate Innovation System

Covariates	Explaining covariates
Sector	1=Services(#604), 0=Manufacturing(#746)
Firm size	1=over 100 employees (#922), 0=less 100 employees (#428)
Market demand trend	1=increasing, 0=steady or decreasing

3. Statistical Methodology: The Latent Class Cluster Analysis

One of the major challenges for IS approach is to develop analytical techniques studying how different factors interact in a systemic context. Hypotheses should be formulated on the basis of the IS approach, and these hypotheses should be tested by using qualitative as well as quantitative observations. The historical and evolutionary perspective of the IS approach assumes that organization, institutions, and their relations are different from system to system; and that diversity is fundamental for the dynamics of the system. In this reason, clustering method such as latent class analysis harmonizes well with the systemic approach of innovation. Latent class analysis has numerous merits as follows. First, it is based on a statistical model, so the goodness-of-fit of the model can be measured and tested. Next, latent class analysis can control some exogenous variables affecting the classification result of the latent variable, which is similar to control some exogenous variables in a regression analysis. These two merits, which are the main differences to the previous methods such as cluster analysis and factor analysis, enable to build a parsimonious model to analyze the real world. Third, latent class analysis can treat data that are measured on a nominal, ordinal, count, and continuous measurement scale in a one model. Last, it is possible to estimate the cluster membership based on the modal probabilities given a firm has implemented a particular set of practices. The last characteristic is used in the logistic regression analysis and OLS in the section 4 of this chapter.

The first step of clustering procedure is to divide populations into different sub-clusters with common characteristics. The next step is to investigate the patterns of interdependency for each cluster, and the last step is to relate these results to innovation performances.

3.1. Three kinds of Variables in the Latent Class Cluster Analysis

Three kinds of variables are in the Latent class cluster analysis: indicators, covariates, and latent variable.

Already mentioned, indicators are dependent variables that are used to define or measure the latent classes in a Latent class cluster model; and covariates are variables that can be used to describe or predict the latent classes and used to reduce classification error.

General Latent class cluster model is consists of; a single nominal latent variable x with k classes, $1 \leq x \leq K$; T indicators y_{it}, $1 \leq t \leq T$; R covariates z_{ir}^{cov} affecting x. In this model, all the eight indicators and three covariates are nominal; valued 1 or 0.

Figure 2-2 The Latent class cluster model in this paper

$$y_1, y_2, y_3, y_4, y_5, y_6, y_7, y_8$$

$$x$$

$$z_1^{cov}, z_2^{cov}, z_3^{cov}$$

Here, the indicator y_1 is the enterprise-wide quality management system, y_2 is the proposal system, y_3 is the regular job rotation, y_4 is the VET system, y_5 is the labor union, y_6 is the performance sharing system, y_7 is the tacit R&D, and y_8 is the explicit R&D. Covariates $z_1^{cov}, z_2^{cov}, z_3^{cov}$ are sector, firm size, and the trend of market demand, respectively.

3.2. Two Components of the Latent Class Cluster Analysis

Latent class cluster analysis has two components. First, the assumed probability structure, which defines the relevant set of conditional independence assumptions among the variables in the model. Second, the assumed distributional forms for the indicators and a latent variable, which will depend on the scale types of the variables concerned.

First, in this model, the assumed probability structure of each observation i, $1 \leq i \leq 1350$, is,

$$\mathbf{f(y_i|z_i^{cov}) = \sum_{x=1}^{K} P(x|z_i^{cov}) f(y_i|x, z_i^{cov}) = \sum_{x=1}^{K} P(x|z_i^{cov}) \prod_{h=1}^{H} f(y_{ih}|x, z_i^{cov})}$$

Here, $f(y_i|z_i^{cov})$ is the probability density corresponding to a particular set of y_i values given a particular set of z_i^{cov} values. $P(x|z_i^{cov})$ is the probability of belonging to a certain latent class given an individual's realized covariate values. $f(y_{ih}|x, z_i^{cov})$ is the probability density of y_{ih} given x and z_i^{cov}, y_{ih} is a set of indicators.

Here, one point is noteworthy. One of the main assumptions in the latent class cluster analysis is local independence. Appendix B-2 shows the bivariate residuals for z-y, y-y pairs. If the value of bivariate residuals is over 3.84, we interpret the local independence assumption is unfair. In this paper, eight bivariate residuals were over 3.84: performance sharing system-VET system; performance sharing system-labor union; sector-VET system; sector-performance sharing system; firm size-VET system; firm size-labor union; firm size-explicit R&D; market demand trend-labor union. Therefore we discarded the local independence assumption in these eight fairs. In other words, among eight indicators, three indicators—y_4(VET system), y_5(labor union), and y_6(performance sharing system)—constitute one h, and the other five indicators constitute the other five h.

Second, the assumed distributional forms for each indicator y_{ih} are a (joint) binomial distribution, because the each indicator y_{ih} is a categorical variable with two categories m; 1 or 0. The (joint) binomial probability $P(y_{ih} = m|x, z_i)$ is parameterized as follows;

$$P(y_{ih} = m|x, z_i) = \pi_{m|h,x,z_i} = \frac{\exp(\eta^h_{m|x,z_i})}{\sum_{\acute{m}=1} \exp(\eta^h_{\acute{m}|x,z_i})}$$

Where, linear term with categorical indicators and local dependencies equals

$$\eta^h_{m|x,z_i} = \sum_{t \in h} \{\beta^t_{m_t 0} + \beta^t_{m_t x 0} + \sum_{r=1}^{R} \beta^t_{m_t r} \times z^{cov}_{ir}\} + \sum_{t \in h, \acute{t} \in h, t < \acute{t}} \beta^{t\acute{t}}_{m_t m_{\acute{t}}}$$

Where, $\beta^t_{m_t 0}$ is the intercept, $\beta^t_{m_t x 0}$ is the effect of clusters on y_{it}, $\beta^t_{m_t r}$ is the direct effect of covariate r on the indicator concerned, and the term $b^{t\acute{t}}_{m_t m_{\acute{t}}}$ captures the association between indicators t and $\acute{t}$ in set h. And the appropriate indentifying constraint is $\sum_{x=1}^{K} \beta^t_{x0} = 0,\ \beta^t_{10} = 0$.

In addition, the values on the latent variables given a person's covariate values are assumed to come from a multinomial distribution, because x is the single nominal latent variable with k categories. It means that x yields a standard multinomial logit model. The multinomial probability $P(x|z^{cov}_i)$ is parameterized as follows;

$$P(x|z_i) = \pi_{x|z_i} = \frac{\exp(\eta_{x|z_i})}{\sum_{\acute{x}=1}^{K} \exp(\eta_{\acute{x}|z_i})}$$

Where, linear term in the multinomial logit model for the latent classes equals

$$\eta_{x|z_i} = \gamma_{xo} + \sum_{r=1}^{R} \gamma_{xr} \times z^{cov}_{ir}$$

Where, γ_{xo} is the intercept parameters, γ_{xr} is the slope parameters, and the appropriate indentifying constraint is $\sum_{x=1}^{K} \gamma_{xr} = 0,\ \gamma_{1r} = 0$.

4. Types of Corporate innovation system: Testing Hypothesis 1

4-1. The Result of Latent Class Cluster Analysis

Before examining the relationship between types of CIS and innovation performance, we first classified corporate innovation system applying latent class analysis. As can be seen in Table 3-4, four types of CIS was induced by latent class analysis: R&D type CIS (cluster1), High-involvement + R&D type CIS (cluster2), High-involvement type CIS (cluster3), and Low Developed CIS (cluster4). The analysis for the goodness-of-fit of the model is shown in Appendix B.

Table 2-3 Four Types of Corporate innovation system based on Latent Class Analysis

Types of CIS	(Cluster 1) R&D type CIS	(Cluster 2) HI+R&D type CIS	(Cluster 3) HI type CIS	(Cluster 4) Low developed CIS	Total	
Cluster Size	#393 (29.11%)	#376 (27.85%)	#309 (22.89%)	#272 (20.15%)	#1350 (100%)	
Variables	z-value	z-value	z-value	z-value	p-val.	R^2
Indicators						
y_1	0.4509	***7.8770	0.6595	***-5.7044	4.8e-14	0.3769
y_2	***-5.0358	*1.8562	***4.0548	***-7.8481	1.5e-13	0.3470
y_3	***-3.8143	0.6198	***7.4288	***-5.3615	9.6e-16	0.1500
y_4	-0.3816	1.1301	**2.0603	***-4.1496	1.8e-4	0.1009
y_5	***-4.5030	***2.9040	***4.7947	**-2.0123	2.3e-6	0.1450
y_6	**-2.0152	***4.6932	**2.3334	***-6.1670	4.7e-15	0.1658
y_7	***3.1454	***5.1763	*-1.9030	**-2.2349	4.7e-6	0.1335
y_8	***3.0189	***5.0113	*-2.2321	***-5.9236	4.0e-15	0.1632
Covariates						
z_1^{cov}	**-2.3966	***-6.0133	***3.0830	***4.1151		
z_1^{cov}	***-4.4730	***3.1999	*1.6886	***-2.7319		
z_1^{cov}	-0.5876	0.1679	**2.4314	***-3.2449		

Note: The indicator y_1 is the enterprise-wide quality management system, y_2 is the proposal system, y_3 is the regular job rotation, y_4 is the VET system, y_5 is the labor union, y_6 is the performance sharing system, y_7 is the tacit R&D, and y_8 is the explicit R&D. Covariates $z_1^{cov}, z_2^{cov}, z_3^{cov}$ are sector(service=1), firm size(over 100 employees=1), and the trend of market demand(increasing=1)

Note: For each indicator the Wald statistic tests the restriction that each estimate in the set of beta parameter estimates associated with that indicator equals zero. A non-significant p-value associated with this Wald statistic means that the indicator does not discriminate between the clusters in a statistically significant way. Statistical significance at the level of 99%, 95%, and 90% are displayed by ***, **, and *, respectively. Standard errors and Wald statistics are robust. R^2 indicates how well an indicator is explained by the model.

Note: These log-linear parameters utilize effect coding, which means that for each indicator the estimates sum to zero over the categories of that indicator (columns). Since effect coding is also used for the clusters, the effect estimates also sum to zero across the clusters (rows).

Table 2-4 Frequency of Sector, Firm Size, Market Demand Trend, Management System, Business Group, Public sector

Covariates	Cluster 1	Cluster 2	Cluster 3	Cluster 4	N

Sector					
Manufacturing	293 (74.6%)	364 (96.8%)	29 (9.4%)	60 (22.1%)	746 (55.3%)
Services	100 (25.4%)	12 (3.2%)	280 (90.6%)	212 (77.9%)	604 (44.7%)
N. of employees					
Over 100	176 (44.8%)	328 (87.2%)	261 (84.5%)	157 (57.7%)	922 (68.3%)
Less 100	217 (55.2%)	48 (12.8%)	48 (15.5%)	115 (42.3%)	428 (31.7%)
Management Sys.					
Owner	331 (84.2%)	286 (76.1%)	152 (49.2%)	218 (80.1%)	987 (73.1%)
Professional CEO	62 (15.8%)	90 (23.9%)	157 (50.8%)	54 (19.9%)	363 (26.9%)
Business Group					
Yes	43 (10.9%)	110 (29.3%)	64 (20.7%)	20 (7.4%)	237 (17.6%)
No	350 (89.1%)	266 (70.7%)	245 (79.3%)	252 (92.6%)	1113(82.4%)
Public sector					
Public sector	10 (2.5%)	21 (5.6%)	110 (35.6%)	27 (9.9%)	168 (12.4%)
Private Firm	383 (97.5%)	355 (94.4%)	199 (64.4%)	245 (90.1%)	1182(87.6%)
Market Demand					
Increasing	187 (47.6%)	180 (47.9%)	207 (67.0%)	107 (39.3%)	681 (50.4%)
Not Increasing	206 (52.4%)	196 (52.1%)	102 (33.0%)	165 (60.7%)	669 (49.6%)

4.1.1. Cluster1: R&D type CIS

The first cluster is engaging in R&D activities without establishing innovation-related institutions. A workplace belonging to this cluster is significantly positive with both tacit R&D and explicit R&D in the 99% significance level. Meanwhile, work systems such as proposal system and regular job rotation are significantly negative in the 99% significance level; performance sharing is significantly negative, and VET system and labor union are also negative even though not significant. Considering these characteristics, we identify the first cluster as the R&D type CIS.

The R&D type CIS encompasses 393 workplaces of 1350 (29.11%). Among them, 293 workplaces (74.6%) belong to the manufacturing sector, which is significantly higher than the average of the whole sample 55.3%; and 217 workplaces (55.2%) are employing less than 100, which is significantly higher than the average of the whole sample 31.7%; 383 workplaces (97.5%) are belong to private sector, which is significantly higher than the average of the whole sample 87.6%; 43 workplaces (10.9%) are affiliated to the business group, 10 workplaces (2.5%) are public sector, which is lower than the average of the whole sample.

4.1.2. Cluster2: High-involvement + R&D type CIS

The second cluster, which we refer to as the High-involvement + R&D type CIS (hereafter, HI+R&D type CIS), is characterized by well designed high-involvement institutions and extraordinary rate of R&D investment. Quality management program, proposal system, performance sharing, and labor union are significantly positive; and tacit R&D and explicit R&D are also significantly positive. The HI + R&D type CIS may be interpreted to have a virtuous circles that the aggressive R&D investment strategy is well concordant with these highly developed institutions.

The HI+R&D type CIS encompasses 376 workplaces of 1350 (27.85%). Among the 376 workplaces, 364 workplaces (96.8%) belong to the manufacturing sectors; 328 workplaces (87.2%) are hiring more than 100 employees. Among the 237 workplaces affiliated to the business group, 110 workplaces (46.4%) belong to this type of CIS, which is higher than the average of the whole sample. Among the 168 workplaces belong to public sector, 21 workplaces (5.6%) belong to the HI+R&D type CIS.

4.1.3. Cluster3: HI type CIS

The third cluster has highly developed institutions, but the rate of R&D investment is not that high. Proposal system and regular job rotation are significantly positive in the 99% confidence level; performance sharing, VET system and labor union are also significantly positive. Meanwhile, the tacit R&D and explicit R&D are negative in the 90% confidence level. These characteristics are the direct opposite to those of the R&D type cluster. We identify the second cluster as the High-involvement type CIS (hereafter HI type CIS).

This result may be interpreted that highly developed work system makes employees to involve in innovation activities; well designed motivation system and VET system deepens and widens the involvement of employees in innovation activities; and highly developed cooperative labor relations guarantee these work system and motivation system to operate well. However, a workplace belong to the HI type CIS did not create the virtuous circle with R&D investment.

Among 309 workplaces belong to HI type CIS, 280 workplaces (90.6%) are service sectors; 261 workplaces (84.5%) are employing more than 100; the market demand trend of 207 workplaces (67.0%) is increasing; 157 workplaces (50.85) have professional management system, which is considerably higher than the average rate of 26.9%; 110 workplaces (35.6%) are public sector, which considerable higher than the average of whole sample.

4.1.4. Cluster4: Low Developed CIS

Lastly, the fourth cluster has neither highly developed institutions nor high rate of R&D investment. All the six indicators related to the innovation-related institutions are negative and statistically significant, and the two indicators related to the R&D investment are also significantly negative. These characteristics are the direct opposite to those of the HI+R&D type cluster. We refer to this cluster as the Low Developed CIS. Among 272 workplaces (20.15%) belonging to the Low Developed CIS, 212 workplaces (77.9%) are in the service sectors; 20 workplaces (7.4%) are non-business-group; the market demand of 165 workplaces in decreasing, which is lower than the average of the whole sample 50.4%.

4.2. Testing Hypothesis 1: Various Types of CIS in Korea

This classification result shows that the hypothesis 1-1 (institutional complementarities hypothesis) are true. Work system, motivation system, VET system, and labor relations are considerably correlated with each other. A workplace belonging to the HI type CIS and HI+R&D type CIS has well designed high-involvement institutions simultaneously; while, in the case of a workplace belonging to the R&D type CIS and the low developed CIS, all the high-involvement institutions are not developed. Furthermore, the other types of CIS were not discovered in Korea; for example, a workplace that work system is developed but motivation system or labor relations was not observed; a workplace that labor relations and motivation system are developed but work system was not observed.

Of course, this correlation does not directly mean the interaction or interdependence. However, the statistical methodology of this paper, i.e., latent class cluster analysis, is more inclusive of interdependence and interaction than the other statistical methodology such as regression model. Using latent class analysis, we induced four types of CIS on the basis of innovation-related indicators with controlling exogenous variables. It means that workplaces having the same characteristics of work system, motivation system, VET system, and labor relations are assumed to come from the same types of CIS. In other words, workplaces belonging to the same types of CIS have the same types of institutional clusters.

Furthermore, numerous studies of IS approach, human resource management theory, work system design theory, and employment relations theory—which are the background of this paper—are showing the interaction of the institutions and organizations both theoretically and empirically. Based on these theories, we may interpret the classification results as follows: Well designed high-involvement work system makes employees to involve in innovation activities; well designed motivation system and VET system deepens and widens the involvement of employees in innovation activities; and highly developed cooperative labor relations guarantee these systems to operate well. Meanwhile, a workplace without high-involvement work system does not have well designed motivation system and VET system; so cooperative labor relations does not been established in this type of workplace.

Table 2-3 also showed that hypothesis 1-2 (relatively autonomous R&D hypothesis) is true. All the indicators related to innovation-related institutions are always appearing simultaneously. Meanwhile, the indicators related to R&D activities and the indicators related to institutions are not always appearing simultaneously. The HI type CIS has well designed institutions, but not have high level of R&D investment. The R&D type CIS is engaging in R&D investment without establishing innovation-related institutions. Table 2-5 is the summary.

From hypothesis 1-1 and 1-2, we conclude that the strategy engaging in R&D activities may be relatively simple, but the strategy establishing well designed high-involvement institutions may be relatively complex and dependent on corporate culture.

Table 2-3 shows that hypothesis 1-3 (learning economy hypothesis) is somewhat reasonable. A workplace belonging to the HI type CIS was significantly correlated with magnificent change of market demand, but a workplace belonging to the HI+R&D type CIS showed no significant relations with market demand trend. A workplace belonging to the Low Developed CIS was significantly correlated with no change of market demand, but a workplace belonging to R&D type CIS showed no significant relations with market demand trend. From hypothesis 1-3, we conclude that the main strategy of a workplace facing enormous market change of uncertainty is to establish well designed high-involvement institutions.

Table 2-4 shows that hypothesis 1-4 (sectoral dissimilarity hypothesis) is true. Among 746 workplaces belonging to the manufacturing sector, 657 workplaces (88.1%) were pertained to the R&D type CIS or

HI+R&D type CIS. Among 604 workplaces belonging to the service sector, 492 workplaces (81.5%) were pertained to the HI type CIS or Low Developed CIS. From hypothesis 1-4, we conclude that the innovation strategy of a workplace belonging to the service sector should be different from that of a workplace belonging to the manufacturing sector.

Chapter3. Types of CIS and Innovation performance

In this chapter, we investigate the relationship between the types of CIS and innovation performance, and test four hypotheses about this relationship.

1. Variables for Regression Analysis

1.1. Dependent Variables

There has been a serious bias in measuring innovation performance. Measures related to science and technology, such as patent application and R&D expenditure, have been well designed and accumulated; meanwhile, measures related to learning by doing/using/interacting have less accumulated. When it comes to indicators of knowledge, there has been a strong bias in favor of explicit knowledge; measures for tacit knowledge are rare. In other viewpoint of competence building, the data about R&D related competence building has been much more accumulated than the data about competence building related to learning by doing, using, and interacting. This situation contributes to a bias toward promoting science-technology based activities rather than learning by doing/using/interacting activities; which is the main obstacle in innovation activities.

In this paper, the CIS contains both learning by doing/using/interacting activities and science-technology-related activities; so the measure of innovation performance must reflect these two kinds of activities.

The WPS 2005 contains variables about employees-leading innovation and P/S innovation. These variables reflect employees' activities of learning by doing/using/interacting, so we utilize those as dependent variables. We gave value 1 if the level of innovation among employees at the workplace in 2005 was higher than the average of the same industry; give 0 if not. We gave value 1 if the degree of innovation in the workplace's products/services in 2005 was higher than the average of the same industry; give 0 if not.

As an indicator for science-technology-related innovation, we utilized patent application, which can be obtained through the Korea Intellectual Property Rights Information Services. We gave value 1 if a firm applied a patent in 2005, gave 0 if not. With the support of these three indicators—employees-leading innovation, P/S innovation, and patent application—we can investigate the different effect of learning by doing/using/interacting activities and R&D activities. In addition, we utilize labor productivity as a dependent variable.

Table 3-1 Dependent Variables for Regression Analysis

Dependent variables	Explaining dependent variables

Employees-leading innovation	1=over average of that sector (#524), 0= if not (#759)
Product/service innovation	1=over average of that sector (#669), 0= if not (#636)
Patent application	1=exist (#376), 0=not exist (#974)
Labor productivity	Continuous variable

1.2. Control Variables

We utilized three control variables, which reflect the unique characteristic of Korean firms: Management system and firm ownership such as business group or not, public sector or not.

Management system is classified into two types: ownership management system and professional management system. A professional management system is completely independent from the influence of the owner, where ownership and management are completely separate. An ownership management system contains not only a system where the owner has the authority to make most decisions and directly overseas management activities, but also a system where much management authority is transferred manager but the owner still retains over major management decisions. Business group contains a business group with limits on equity investment, and a business groups with limits on mutual investment and loan guarantee of obligation. In 2005, 54 business groups exist in Korea. Lastly, public sector means that the largest shareholder is government or public sector such as public enterprises, government invested enterprises. Among 1350 samples of the WPS 2005, 168 samples (12.4%) belong to the public sector. The innovation competence of a public sector is different from that of a private firm, so whether public sector or not should be controlled. Sector, firm size, and market demand trend was utilized not only as covariates in the latent class analysis, but also as control variables in the regression analysis. The reason is that these two variables directly affect on innovative performance, and also indirectly influence through the types of CIS. In addition, capital labor ratio (lnK/L) and intermediate input labor ratio (lnM/L) are used as control variables when labor productivity and the growth rate of labor productivity are dependent variables.

Table 3-2 Control Variables for Regression Analysis

Control variables		Explaining covariates
Management system	Who manages the workplace	1=owner(#987),0=professional CEO(#363)
Firm ownership	Business group or not	1=biz group (#237), 0=not (#1113)
	Public sector or Private firm	1=public (#168), 0=private (#1182)
Sector	Manufacture-Service sectors	1=Service (#686), 0=Manufacturing (#664)
Firm size	Number of employees	1=over 100 (#922), 0=less 100 (#428)
Market environment	Market demand trend	1=increasing (#681), 0=not (#669)
Capital goods	lnK/L	Continuous variable
Intermediate goods	lnM/L	Continuous variable

2. Types of CIS and Innovation Performance: Testing Hypothesis 2-1 and 2-2

2.1. The Result of Regression Analysis

2.1.1. Types of CIS and Employees-leading Innovation

In order to analyze the relationship between types of CIS and employees-leading innovation, we applied logistic regression analysis as reported in Table 3-3.

Table 3-3 Logistic Regression Analysis: Types of CIS and Innovation among Employees

	Model 1		Model 2		Model 3	
	Odds ratio (z-value)	Coef(dy/dx) (z-value)	Odds ratio (z-value)	Coef(dy/dx) (z-value)	Odds ratio (z-value)	Coef(dy/dx) (z-value)
Cluster 1	1.9651	0.1641	2.8054	0.2495	2.6484	0.2358
(R&D type)	***(3.50)	***(3.51)	***(4.74)	***(4.86)	***(4.48)	***(4.56)
Cluster 2	5.0905	0.3854	9.1453	0.5028	7.9563	0.4765
(HI+R&D)	***(8.54)	***(9.43)	***(8.53)	***(10.47)	***(7.94)	***(9.46)
Cluster 3	5.0716	0.3848	4.6784	0.3677	4.2054	0.3444
(HI type)	***(8.14)	***(9.13)	***(7.45)	***(8.22)	***(6.74)	***(7.31)
Sector2			1.9637	0.1600	1.7832	0.1374
			***(3.57)	***(3.64)	***(3.06)	***(3.10)
Employees2			0.9715	-0.0069	0.9009	-0.0250
			(-0.20)	(-0.20)	(-0.72)	(-0.71)
Market demand			1.2367	0.0507	1.2146	0.0464
trend			*(1.74)	*(1.75)	(1.56)	(1.56)
Management					0.5601	-0.1410
System2.					***(-3.90)	***(-3.88)
Biz_Group2					1.3801	0.0783
					**(2.05)	**(2.03)
Public sector2					0.8125	-0.0487
					(-0.96)	(-0.98)
Wald χ^2	106.87 (0.0000)		119.77 (0.0000)		135.45 (0.0000)	
Pseudo R^2	0.0680		0.0771		0.0892	
number	1283		1283		1283	

Note: The cluster 1, 2, 3, and 4 means the R&D type CIS, the HI+R&D type CIS, the HI type CIS, and the Low Developed CIS, respectively. The values in the parentheses are z-value, and the statistical significance at the level of 99%, 95%, and 90% are indicated by ***, **, and *, respectively. Table 3-4, 3-5, and 3-5 are the same.

The dependent variable for this analysis is weather or not the firm's level of innovation among employees in 2005 is higher than the average of the same sector. The independent variables in the Model 1 specification are binary variables indicating whether or not the workplace belongs to a particular cluster: 1, 2, 3, or 4. In the Model 2 specification, we include control variables to account for the effect of sector, firm size, and market demand trend. Then, additional three control variables—types of management system, types of firm ownership (whether it is a business group or not, and whether it is a public sector or private firm)—are added in the Model 3.

Using the cluster4 as benchmark, the Model 1 shows that the probabilities of employees-leading innovation in the cluster 2 and the cluster 3 are more than five times as high, while the probability in the cluster 3 is slightly less than twice as high; and their odds ratios are statistically significant in the 99% confidence level.

When we add the control variables to account for the effects of sector, firm size, and market demand trend (Model 2), the probabilities of employees-leading innovation of the cluster 1 and the cluster 2 increased, while that of the cluster 3 was slightly decreased. After controlling, the gap of employees-leading innovation was manifest: the HI+R&D type CIS (Cluster2) was considerably high, the HI type CIS (Cluster3) was the second, the R&D type CIS (Cluster1) was the third.

The reason of this change is due to the effect of sector and market demand trend. As can be seen in the Model 2 specification, the odds ratios of sector and market demand trend are 1.9637 and 1.2367; that is to say, the probability of employees-leading innovation is significantly higher in the service sector and when the market demand is increasing. The cluster 3, which is almost consist of service sector (96.4%) and the market demand is increasing (67.05), was overestimated in the Model 1; meanwhile, the cluster 1 and the cluster 2, which has high percentage of manufacturing sector (66.9% and 96.0%, respectively), were underestimated.

The effect of sector and market demand trend is noteworthy. Service sector was positively correlated with employees-leading innovation. This result accords with the idea that an employee working at the service site is closely interacting with users, and these interactions encourage employees to make more innovations. In addition, as intense as the change or uncertainty of the market, more employees-leading innovation was created.

When three additional control variables was included (Model 3), the effect of CIS type on employees-leading innovation was almost indifferent to the Model 2. The odds ratio of the cluster 1, the cluster 2, and the cluster 3 was 2.6484, 7.9563, and 4.2054, respectively.

A workplace with professional ownership system showed high level of employees-leading innovation, so did a workplace affiliated to a business group. Public sector showed somewhat low performance, but not significant.

An odds ratio has a tendency to overestimate the difference between basis cluster and other clusters. Hence, we also represented coefficient (dy/dx), which is for discrete change of dummy variable from 0 to 1. In Model 3, the coefficients of the cluster1, the cluster2, and the cluster3 are 0.2358, 0.4764, and 0.3444, respectively; coefficient shows exactly equal trend to odds ratio.

2.1.2. Types of CIS and Product/Service Innovation

Table 3-4 Logistic Regression Analysis: Types of CIS and Product/Service Innovation

	Model 1		Model 2		Model 3	
	Odds ratio (z-value)	Coef(dy/dx) (z-value)	Odds ratio (z-value)	Coef(dy/dx) (z-value)	Odds ratio (z-value)	Coef(dy/dx) (z-value)
Cluster 1 (R&D type)	1.5268 **(2.58)	0.1049 **(2.61)	1.6462 **(2.57)	0.1233 **(2.61)	1.5649 **(2.29)	0.1109 **(2.32)
Cluster 2 (HI+R&D)	2.7114 ***(5.97)	0.2403 ***(6.38)	3.3248 ***(5.11)	0.2853 ***(5.61)	2.9037 ***(4.46)	0.2555 ***(4.81)
Cluster 3 (HI type)	2.4816 ***(5.17)	0.2185 ***(5.54)	2.4213 ***(4.84)	0.2130 ***(5.17)	2.2266 ***(4.20)	0.1939 ***(4.43)
Sector2			1.2182 (1.11)	0.0493 (1.11)	1.1451 (0.75)	0.0338 (0.75)
Employees2			0.8470 (-1.25)	-0.0414 (-1.25)	0.7987 *(-1.66)	-0.0560 *(-1.67)
Market demand trend			1.2479 *(1.93)	0.0553 *(1.93)	1.2398 *(1.84)	0.0537 *(1.85)
Management System2.					0.7621 *(-1.93)	-0.0676 *(-1.94)

Biz_Group2					1.5558 ***(2.85)	0.1090 ***(2.91)
Public sector2					0.8924 (-0.56)	-0.0284 (-0.56)
Wald χ^2 Pseudo R^2 number	45.28 (0.0000) 0.0258 1305		50.71 (0.0000) 0.0294 1305		62.41 (0.0000) 0.0365 1305	

Table 3-4 shows the relationship between types of CIS and P/S innovation. The dependent variable is weather or not the firm's degree of P/S innovation in 2005 was higher than the average of the same sector. Using the cluster4 as benchmark, the Model 1 shows that the probabilities of P/S innovation of the cluster1, the cluster2, and the cluster3 were 1.5 times, 2.7 times, and 2.5 times higher than that of the cluster4; and the differences of those three clusters from the benchmark cluster were statistically significant. The results of the Model 2 and the Model 3 were almost similar to that of the Model 1.

When P/S innovation was used as a dependent variable, the effect of sector disappeared. The effect of market demand trend, management system, business group, and public sector was same as the case when employees-leading innovation was used as a dependent variable. Firm size was significantly negative at the 90% confidence level.

2.1.3. Types of CIS and Patent Application

Table 3-5 Logistic Regression Analysis: Types of CIS and Patent Application

	Model 1		Model 2		Model 3	
	Odds ratio (z-value)	Coef(dy/dx) (z-value)	Odds ratio (z-value)	Coef(dy/dx) (z-value)	Odds ratio (z-value)	Coef(dy/dx) (z-value)
Cluster 1 (R&D type)	4.9461 ***(5.93)	0.3275 ***(5.89)	6.9850 ***(6.44)	0.3931 ***(6.46)	6.2372 ***(6.00)	0.3626 ***(5.86)
Cluster 2 (HI+R&D)	17.8514 ***(10.87)	0.5906 ***(13.34)	17.8347 ***(8.56)	0.5832 ***(10.03)	13.7158 ***(7.53)	0.5281 ***(8.15)
Cluster 3 (HI type)	2.4681 ***(3.10)	0.1821 ***(2.91)	1.9150 **(2.20)	0.1253 **(2.07)	1.7748 *(1.83)	0.1054 *(1.72)
Sector2			1.2790 (1.15)	0.0428 (1.16)	1.1747 (0.73)	0.0272 (0.73)
Employees2			3.2911 ***(6.66)	0.1830 ***(7.74)	2.9564 ***(5.98)	0.1634 ***(6.81)
Market demand trend			1.0114 (0.08)	0.0020 (0.08)	1.0649 (0.43)	0.0106 (0.43)
Management System2.					0.9633 (-0.21)	-0.0063 (-0.20)
Biz_Group2					4.3352 ***(8.25)	0.3042 ***(7.36)
Public sector2					0.4750 **(-2.46)	-0.1064 ***(-3.00)
Wald χ^2 Pseudo R^2 number	195.67 (0.0000) 0.1493 1350		225.37 (0.0000) 0.1815 1350		276.30 (0.0000) 0.2334 1350	

Table 3-5 provides the relationship between types of CIS and patent application, which is considered as the result of science and technological activities. The dependent variable is weather or not the firm applied a patent in 2005. Using the cluster 4 as benchmark, the Model 1 specification illustrates that the probabilities of patent application in the cluster 2 was almost 18 times as high; the cluster 1 was almost 5 times as high, the cluster 3 was about 2.5 times as high. And all the differences are statistically significant.

In the Model 2, the odds ratios of the cluster 1, the cluster 2, and the cluster 3 were 6.9850, 17.8347, and 1.9150, respectively. The odds ratio of the cluster 1 increased, while that of cluster 3 decreased after controlling the effect of firm size and sector. The bigger the workplace, the higher was the possibility of patent application. And, market demand trend showed no correlations with patent application.

After controlling the effect of business group and public sector (Model 3), each odds ratio of the cluster 1, 2, and 3 is 3, 6.2372, 13.7158, and 1.7748, respectively. Business group was significantly positive to the patent application; meanwhile, public sector was significantly negative. This result may be interpreted that large business group is usually investing in R&D activity and patent application based on long-term strategy, not based on short-term marketing strategy.

2.1.4. Types of CIS and Labor Productivity

Table 3-6 OLS: Types of CIS and Labor Productivity

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Dependent	lnTS/L (t-value)	lnTS/L (t-value)	lnTS/L (t-value)	lnVA/L (t-value)	lnVA/L (t-value)	lnVA/L (t-value)
Cluster 1 (R&D type)	0.0152 (0.36)	0.1147 ***(2.84)	0.1084 ***(2.69)	0.0152 (0.364)	0.115 ***(2.844)	0.108 ***(2.694)
Cluster 2 (HI+R&D)	0.0170 (0.41)	0.1781 ***(3.90)	0.1790 ***(3.91)	0.017 (0.414)	0.178 ***(3.901)	0.179 ***(3.913)
Cluster 3 (HI type)	-0.0604 (-1.19)	-0.0519 (-0.96)	0.0014 (0.03)	-0.060 (-1.193)	-0.0519 (-0.964)	0.0014 (0.026)
lnK/L	0.0776 ***(6.12)	0.0818 ***(6.33)	0.0831 ***(6.55)	0.0776 ***(6.121)	0.0818 ***(6.325)	0.0831 ***(6.552)
lnM/L	0.7875 ***(39.95)	0.7810 ***(38.93)	0.7726 ***(37.63)	0.787 ***(39.95)	0.781 ***(38.93)	0.773 ***(37.63)
Sector2		0.1725 ***(5.24)	0.1914 ***(5.80)		0.173 ***(5.239)	0.191 ***(5.796)
Employees2		-0.0349 (-1.11)	-0.0287 (-0.92)		-0.0349 (-1.107)	-0.0287 (-0.917)
Market demand trend		-0.0412 (-1.62)	-0.0266 (-1.08)		-0.0412 (-1.619)	-0.0266 (-1.085)
Management System2.			0.0449 (1.41)			0.0449 (1.407)
Biz_Group2			0.0604 **(2.07)			0.0604 **(2.071)
Public sector2			-0.1945 ***(-3.59)			-0.195 ***(-3.586)

Constant	2.2034 ***(12.83)	2.1208 ***(12.81)	2.2120 ***(12.14)	2.203 ***(12.83)	2.121 ***(12.81)	2.162 ***(12.14)
F-value	1440.45 (0.0000)	1206.97 (0.0000)	1036.89 (0.0000)	233.61 (0.0000)	162.45 (0.0000)	132.88 (0.0000)
$\bar{R}^2$	0.9256	0.9268	0.9287	0.5557	0.5663	0.5777
number	1266	1266	1266	1188	1188	1188

In order to analyze the relationship between types of CIS and labor productivity, we applied OLS because we have only cross-section data. Table 3-3 shows the result. The dependent variable of the first three Models, from 1 to 3, is a labor productivity measured by total sales, while the dependent variable of the last three Models, from 4 to 6, is a labor productivity estimated with value-added.

The Model 1 without control illustrates that all the three clusters was not significant to the labor productivity. When we introduce control variables of sector, firm size, and market demand trend (Model 2), the cluster 1 and the cluster 2 was significantly correlated to the labor productivity at the 99 percent confidence level; and the coefficient of the cluster 1 and the cluster 2 was 0.1147 and 0.1781, respectively. The reason is that the cluster 1 and the cluster2, which has high percentage of manufacturing sector, was underestimated in the Model 1. Those significant correlations of the cluster 1 and the cluster 2 were remained in the Model 3.

2.2. Testing Hypothesis 2-1 and 2-2

Table 3-7 shows the relationship between types of CIS and the five dependent variables—employees-leading innovation, P/S innovation, patent application, labor productivity measured by total sales, and labor productivity estimated with value-added.

Table 3-7 Results of Regression Analyses with Five Dependent Variables (Summary)

	Employees-leading Innovation	P/S Innovation	Patent Application	Labor Productivity with Sales	Labor Productivity with VA
Cluster 1					
Odds ratio	***2.6484	**1.5649	***6.2372		
Coefficient)	***0.2345	**0.1109	***0.3626	***0.1084	***0.1080
Cluster 2					
Odds ratio	***7.9563	***2.9037	***13.7158		
Coefficient	***0.4765	***0.2555	***0.5281	***0.1790	***0.1790
Cluster 3					
Odds ratio	***4.2054	***2.2266	*1.7748		
Coefficient	***0.3444	***0.1939	*0.1054	0.0014	0.0014

Note: Cluster 1, 2, and 3 are the R&D type CIS, HI+R&D type CIS, and HI type CIS, respectively.

Table 3-7 supports the hypothesis 2-1 (performance ordering hypothesis). When we utilize employees-leading innovation, P/S innovation, and patent application as dependent variables, the performances of the HI type CIS or the R&D type CIS is higher than that of the Low Developed CIS; furthermore, the HI+R&D type CIS yields considerably higher performance than the HI types CIS or the R&D type CIS.

When labor productivity was used as a dependent variable, the performance of the R&D type CIS and

HI+R&D type CIS showed the same patterns; but the performance of the HI type CIS was not significantly higher than that of the Low Developed CIS. As mentioned previous section, labor productivity has some limits as an indicator for innovation performance; so we may interpret that the hypothesis 2.a. is true.

Table 3-7 provides the manifest evidence that hypothesis 2-2 (various purpose of innovation hypothesis) is true. When employees-leading innovation or P/S quality was used as dependent variable, the performance of the HI type CIS was higher than that of the R&D type CIS; however, when patent application was used as dependent variable, the performance of the R&D type CIS was higher than that of the HI type CIS. This result is, some extent, correspond to the idea that patent application is highly correlated with explicit knowledge, and R&D investment is also correlated with explicit knowledge.

Chapter4. Transformation Strategy for the Better Types of CIS: Focus on ICT Service Sector in Korea

1. ICT-related Service and Manufacturing Sector in Korea

1.1. ICT Service Sector

In this paper, ICT service sector contains post and telecommunications (industry code 64), computer and related activities (industry code 72), research development (industry code 73), and professional, scientific and technical services (industry code 74).

This boundary is somewhat broader than the usual definition of ICT-related service. Two reasons: First, WPS 2005 contains just two-digit industry code, so we cannot exclude the postal service from two-digit code of 64; cannot exclude the research and experimental development on social sciences and humanities from two-digit code of 73; cannot exclude the legal services from two-digit code of 74. Second, one of the main purposes of this paper is to investigate the configuration of R&D activities and innovation related institutions; in other words, we cannot exclude R&D activities from our analysis, so we adopted this broad boundary. Post and telecommunications contains postal services and couriers (641) and telecommunications (642). Computer and related activities contains computer system design and consultancy (721), software consultancy and supply (722), data processing and computer facilities management services (722), database activities and on-line information provision services (724), and other computer activities (729). Research and Development contains research and experimental development on natural sciences and engineering (731) and research and experimental development on social sciences and humanities (732). Professional, scientific and technical services contains legal, accounting and tax preparation services (741), market research and management consulting services (742), architectural, engineering services (743), scientific and technical services (744), advertising (745), specialized design services (746), and other professional, scientific and technical services (749).

Table 4-1 ICT service sector

ICT-related Manufacturing/Service Sectors	R&D type CIS (C1)	HI+R&D type CIS (C2)	HI type CIS (C3)	Low Developed CIS (C4)	Total
Post and Telecommunications (64)	7	3	13	4	27
Computer and Related Activities (72)	23		17	8	48
Research and Development (73)	4	2	25	6	37
Professional, Scientific and Technical Services (74)	15	2	15	12	44
Total	49 (31.4%)	7 (4.5%)	70 (44.9%)	30 (19.2%)	156 (100%)

Note: The number in the parentheses is the two-digit industry code.

Table 4-1 shows the number of workplaces belonging to the CISs with specific ICT service sectors, which follows the 8th revision of the Korea Standard Industrial Classification in 2000. Among 604 workplaces belong to the service sectors, ICT-related workplaces are 156. A workplace belongs to the R&D type CIS, HI+R&D type CIS, the HI type CIS, and the Low Developed CIS is 49 (31.4%), 7 (4.5%), 70 (44.9%), and 30 (19.2%), respectively.

The main point to notice is that the HI type CIS and the R&D type CIS was well developed in the ICT service sector, but not well developed HI+R&D type CIS. One question is arising. The HI type CIS may transform to the HI+R&D type CIS with engaging in R&D activities, but not realized in reality. The R&D type CIS may transform to the HI+R&D type CIS with establishing well designed institutions, but not realized in reality. The main purpose of this chapter is to investigate the reason: What obstructs the transformation of CIS toward the better types of CIS?

1.2. The Other Service Sector

Table 4-2 Other Service Sector

Service Sectors	R&D type CIS (C1)	HI+R&D type CIS (C2)	HI type CIS (C3)	Low Developed CIS (C4)	Total
Wholesale and Retail Trade (50~52)	20	3	50	35	108
Hotels and Restaurants (55)	4	0	15	7	26
Transport (60~63)	7	1	31	49	88
Financial Institutions and Insurance (65~67)	3	0	49	20	72
Real Estate Activities (70)	1	0	7	5	13
Business Support Services (75)	5	1	12	26	44
Public Administration and Defense (76)	0	0	9	0	9
Education (80)	2	0	4	3	9
Health and Social Work (85~86)	1	0	12	17	30

Recreational, Cultural and Sporting Activities (87~88)	3	0	11	14	28
Other Community, Repair/Personal Service Activities (90~93)	5	0	10	6	21
Total	51 (11.4%)	5 (1.1%)	210 (46.9%)	182 (40.6%)	448 (100%)

Note: The number in the parentheses is the two-digit industry code.

Table 4-2 illustrates the number of workplaces belonging to the CISs with the other service sectors. Among 448 workplaces, a workplace belongs to the R&D type CIS, HI+R&D type CIS, the HI type CIS, and the Low Developed CIS is 51 (11.4%), 5 (1.1%), 210 (46.9%), and 182 (40.6%), respectively.

The main dissimilarity of the two sub-service sectors is the percentage of the R&D type CIS: 31.4% vs. 11.4%; and the percentage of the Low Developed CIS: 19.2% vs. 40.6%. In Korea, a workplace belongs to the ICT service sector is more engaging in R&D activities than a workplace belong to the other service sector. The percentage belongs to the HI type CIS is almost the same: 44.9% vs. 46.9%.

1.3. ICT-related Manufacturing Sector

In this paper, the boundary of the ICT-related manufacturing sector is the two-digit industry code 32: The manufacture of electronic, components, radio, television and communication equipment and apparatuses. It contains manufacture of semiconductor and other electronic components (321), manufacture of television and radio transmitters and apparatuses for line telephony and line telegraphy (322), and manufacture of television and radio receivers, sound or video recording or reproducing apparatuses, and related goods.

Among 96 workplaces pertain to the industry code 32, a workplace belongs to the R&D type CIS, HI+R&D type CIS, the HI type CIS, and the Low Developed CIS is 39 (40.6%), 54 (56.3%), 1 (1.0%), and 2 (2.1%), respectively.

2. Types of CIS and Innovation Performance in the ICT-related Sectors

2.1. The Result of Regression Analysis

2.1.1. Types of CIS and Employees-leading Innovation

Table 4-4 Logistic Regression Analysis: Types of CIS and Employees-leading Innovation

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Dependent	Employees-leading inno	Employees-leading inno	Employees-leading inno	Employees-leading inno	Employees-leading inno	Employees-leading inno
Cluster 1	0.2058	0.2232	0.2126	0.2127	0.1323	0.1315
(R&D type)	(1.48)	(1.56)	(1.45)	(1.46)	(0.84)	(0.83)
Cluster 2	0.4562	0.5146	0.5045	0.5042	0.4145	0.4151
(HI+R&D)	***(3.86)	***(4.02)	***(3.83)	***(3.80)	**(2.52)	**(2.52)
Cluster 3	0.5018	0.4444	0.4428	0.4423	0.4128	0.4140
(HI type)	***(4.53)	***(3.61)	***(3.67)	***(3.58)	***(3.24)	***(3.19)

Sector 64		0.1349	0.1161	0.1158	0.0879	0.0884
		(0.99)	(0.85)	(0.85)	(0.63)	(0.63)
Sector 72		0.1282	0.1194	0.1198	0.0744	0.0731
		(1.02)	(0.93)	(0.92)	(0.57)	(0.54)
Sector 73		0.1445	0.1542	0.1543	0.1267	0.1263
		(1.02)	(0.90)	(0.90)	(0.71)	(0.71)
Sector 74		0.0736	0.0692	0.0693	0.0386	0.0383
		(0.56)	(0.51)	(0.51)	(0.28)	(0.28)
Sector 32 (dropped)						
Employees2		0.0218	0.0114	0.0111	-0.0028	-0.0020
		(0.25)	(0.13)	(0.13)	(-0.03)	(-0.02)
Market demand trend		0.1677	0.1684	0.1684	0.1762	0.1762
		**(2.40)	**(2.41)	**(2.41)	**(2.51)	**(2.51)
Management System2.			-0.0858	-0.0857	-0.0823	-0.0824
			(-1.01)	(-1.01)	(-0.97)	(-0.98)
Biz_Group2			0.0122	0.0121	0.0021	0.0021
			(0.14)	(0.14)	(0.02)	(0.03)
Public sector2			-0.0830	-0.0838	-0.0513	-0.0489
			(-0.64)	(-0.62)	(-0.37)	(-0.33)
Labor Union				0.0023		-0.0062
				(0.03)		(-0.07)
Tacit R&D					0.0942	0.0943
					(0.88)	(0.88)
Explicit R&D					0.0933	0.0938
					(1.05)	(1.05)
Wald χ^2	15.14 (0.0000)	33.36 (0.0001)	35.18 (0.0004)	35.19 (0.0008)	35.94 (0.0011)	35.92 (0.0018)
Pseudo R^2	0.0911	0.1174	0.1213	0.1213	0.1268	0.1268
number	237	237	237	237	237	237

Note: The values in the parentheses are z-value, and the statistical significance at the level of 99%, 95%, and 90% are indicated by ***, **, and *, respectively.

Note: Sector 64 (Post and telecommunications), Sector 72 (Computer and related activities), Sector 73 (Research and development), Sector 74 (Professional, scientific, and technical services), Sector 32 (Manufacture of electronic components, radio, television and communication equipment and apparatuses)

Note: Table 4-5 and 4-6 is the same.

Table 4-4 shows the relationship between CIS type of ICT-related service/manufacturing sector and employees-leading innovation. Five points are noteworthy about the types of CIS and the direct/indirect effect of R&D activities or labor union.

First, in the Model 6 with ICT-related sample, the coefficient of the cluster 1, the cluster2, and the cluster 3 was 0.1315, 0.4141, and 0.4140, respectively. This result means that the indirect effect of labor union in the ICT-related sectors was significantly positive to employees-leading innovation. The configuration of labor union and the other institutions or R&D activities constituted the HI type CIS or HI+R&D type CIS; and these CISs was significantly correlated with high level of employees-leading innovation.

Second, the indirect effect of R&D activities on employees-leading innovation was somewhat unclear. When R&D activities configured with well designed institutions, so constituted the HI+R&D type CIS, the indirect effect was significantly positive; but not configured with well designed institutions, so constituted the R&D type CIS, the indirect effect showed no significant relations even though the coefficient was positive.

Third, the performance of the cluster 2 and the cluster 3 showed similar level. The policy implication is that, in the ICT-related sectors, well-designed institutions are significantly positive with employees-leading innovation, but the configuration with R&D activities shows no significant improvement in employees-leading innovation.

Fourth, the gap of the performance between the cluster 1 and the cluster 2 is significantly considerable. The policy implication is that, in the ICT-related sectors, a workplace belonging to the R&D type CIS shows no significant relations with employees-leading innovation; but if this workplace establishes well designed institutions, so constitutes the HI+R&D type CIS, higher level of employees-leading innovation is possible.

Fifth, the direct effect of R&D activities was positive, but not significant; and the direct effect of labor union was not observed.

Additional point to notice is that the effect of market change or uncertainty was more critical in the ICT related sectors. In the Model 6 with ICT-related sample, the coefficient of market demand trend was 0.1762 with z-value of 2.51; meanwhile, with the whole 1350 samples, the coefficient was 0.0425 with z-value of 1.40. This result is concordant with the common idea that the lifecycle of ICT-related product/service is shorter than that of the other sectors, and this market change or uncertainty encourages ICT related firms to create innovations.

2.1.2. Types of CIS and Product/Service Innovation

Table 4-5 Logistic Regression Analysis: Types of CIS and P/S Innovation

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Dependent	P/S Innovation	P/S Innovation	P/S Innovation	P/S Innovation	P/S Innovation	P/S Innovation
Cluster 1	0.1013	0.1168	0.0930	0.0919	0.0995	0.0972
(R&D type)	(0.94)	(1.01)	(0.78)	(0.77)	(0.74)	(0.72)
Cluster 2	0.1114	0.2001	0.1866	0.1891	0.2097	0.2111
(HI+R&D)	(0.99)	(1.47)	(1.34)	(1.35)	(1.35)	(1.35)
Cluster 3	0.2286	0.1782	0.1930	0.1975	0.1917	0.1957
(HI type)	**(2.16)	(1.50)	(1.59)	(1.60)	(1.53)	(1.54)
Sector 64		0.1682	0.1618	0.1629	0.1628	0.1636
		(1.34)	(1.29)	(1.30)	(1.30)	(1.30)
Sector 72		0.0926	0.1169	0.1137	0.1251	0.1213
		(0.84)	(1.05)	(1.01)	(1.09)	(1.04)
Sector 73		0.1162	0.1677	0.1678	0.1775	0.1773
		(0.85)	(1.07)	(1.07)	(1.16)	(1.15)
Sector 74		0.0919	0.1077	0.1071	0.1151	0.1142
		(0.79)	(0.92)	(0.91)	(0.98)	(0.97)
Sector 32 (dropped)						
Employees2		-0.1072	-0.1063	-0.1042	-0.1083	-0.1063
		(-1.37)	(-1.34)	(-1.30)	(-1.35)	(-1.32)
Market demand		0.1729	0.1734	0.1729	0.1697	0.1692
trend		**(2.44)	**(2.44)	**(2.43)	**(2.36)	**(2.35)
Management			-0.0744	-0.0751	-0.0759	-0.0765
System2.			(-0.89)	(-0.89)	(-0.90)	(-0.19)
Biz_Group2			-0.0775	-0.0771	-0.0758	-0.0754
			(-0.89)	(-0.88)	(-0.86)	(-0.86)

Public sector2			-0.1558 (-1.15)	-0.1511 (-1.09)	-0.1548 (-1.13)	-0.1494 (-1.05)
Labor Union				-0.0167 (-0.18)		-0.0172 (-0.19)
Tacit R&D					-0.0590 (-0.58)	-0.0587 (-0.57)
Explicit R&D					0.0085 (0.09)	0.0102 (0.11)
Wald χ^2	4.82 (0.1857)	14.61 (0.1022)	17.21 (0.1420)	17.39 (0.1820)	18.02 (0.2057)	18.20 (0.2523)
Pseudo R^2	0.0150	0.0450	0.0514	0.0515	0.0524	0.0526
number	239	239	239	239	239	239

Table 4-5 shows the relationship between CIS type of ICT-related sector and P/S innovation. The first point to notice is that goodness-of-fit of the Model did not been guaranteed as can be interpreted from the value of Wald χ^2 value. All the six Models with ICT related sample, we could not reject the null hypothesis that all the coefficients in the Model is zero.

Second, All the coefficients of CISs were not significant. In the model 6 with ICT related sample, the coefficient of the cluster 1, the cluster 2, and the cluster 3 was 0.0972, 0.2111, and 0.1957, respectively. When we analyzed with whole 1350 samples, the coefficient of the cluster 1, the cluster 2, and the cluster 3 was 0.0912, 0.2467, and 0.1982, respective. The value of coefficients was almost similar. It means that the decrease of z-value originated from the reduction of sample size.

Third, nevertheless of this limit, we prudently interpret the indirect effect of R&D activities and labor union. The performance of the cluster 2 and the cluster 3 showed similar level. The policy implication is that, in the ICT-related sectors, well-designed institutions are positively correlated with employees-leading innovation even though not significant; however, the configuration with R&D activities shows no significant improvement in employees-leading innovation. In addition, the gap of the performance between the cluster 1 and the cluster 2 is somewhat large. The policy implication is that, in the ICT-related sectors, a workplace belonging to the R&D type CIS shows no significant relations with employees-leading innovation; but if this workplace establishes well designed institutions, so constitutes the HI+R&D type CIS, higher level of employees-leading innovation is possible.

Fourth, the direct effect of R&D activities and labor union was not observed.

Last, the effect of market change or uncertainty was more critical in the ICT related sectors. In the Model 6 with ICT-related sample, the coefficient of market demand trend was 0.1692 with z-value of 2.35; meanwhile, with the whole 1350 samples, the coefficient was 0.0469 with z-value of 1.58.

2.1.3. Types of CIS and Patent Application

Table 4-6 Logistic Regression Analysis: Types of CIS and Patent Application

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Dependent	Patent Application	Patent Application	Patent Application	Patent Application	Patent Application	Patent Application

Cluster 1	0.0774	0.0895	0.1077	0.0912	-0.1958	-0.1990
(R&D type)	(0.72)	(0.81)	(0.91)	(0.77)	*(-1.83)	*(-1.86)
Cluster 2	0.3589	0.2759	0.2594	0.2658	-0.0480	-0.0567
(HI+R&D)	***(3.39)	*(1.89)	*(1.69)	*(1.78)	(-0.35)	(-0.40)
Cluster 3	-0.0676	-0.1094	-0.0761	-0.0554	-0.1938	-0.1945
(HI type)	(-0.62)	(-1.06)	(-0.59)	(-0.42)	*(-1.93)	*(-1.93)
Sector 64		0.2241	0.1643	0.1652	0.0601	0.0592
		(1.49)	(1.03)	(1.05)	(0.38)	(0.38)
Sector 72		0.0575	-0.0144	-0.0415	-0.1584	-0.1603
		(0.47)	(-0.12)	(-0.36)	*(-1.72)	*(-1.74)
Sector 73		-0.2469	-0.1988	-0.2070	-0.2239	-0.2259
		***(-2.91)	*(-1.80)	*(-1.88)	**(-2.36)	**(-2.41)
Sector 74		0.0615	0.0066	-0.0064	-0.0592	-0.0612
		(0.53)	(0.06)	(-0.06)	(-0.59)	(-0.61)
Sector 32 (dropped)						
Employees2		0.3751	0.3676	0.3750	0.3507	0.3508
		***(6.95)	***(6.72)	***(6.98)	***(6.58)	***(6.58)
Market demand trend		0.0333	0.0370	0.0335	0.0249	0.0259
		(0.48)	(0.52)	(0.47)	(0.35)	(0.36)
Management System2.			0.0304	0.0238	0.0585	0.0582
			(0.39)	(0.30)	(0.76)	(0.76)
Biz_Group2			0.3075	0.3117	0.3123	0.3113
			***(3.13)	***(3.11)	***(3.15)	***(3.13)
Public sector2			-0.1274	-0.1012	0.0692	0.0683
			(-0.99)	(-0.72)	(0.36)	(0.35)
Labor Union				-0.1004		-0.1685
				(-1.33)		**(-2.45)
Tacit R&D					-0.1691	0.0184
					**(-2.48)	(0.21)
Explicit R&D					0.3795	0.3798
					***(6.10)	***(6.11)
Wald χ^2	24.24 (0.0000)	40.28 (0.0000)	53.00 (0.0000)	52.24 (0.0000)	65.69 (0.0000)	65.68 (0.0000)
Pseudo R^2	0.0784	0.2061	0.2464	0.2510	0.3233	0.3234
number	252	252	252	252	252	252

Table 4-6 shows the relationship between CIS type of ICT-related sector and patent application. The most conspicuous result is that the coefficient of the cluster 1, the cluster2, and the cluster 3 was -0.1990 with z-value of -1.86, -0.0567 with z-value of -0.41, and -0.1945 with z-value of -1.93. This result is remarkably dissimilar to the case when we utilized employees-leading innovation or P/S innovation. This means that the indirect effect of R&D activities or labor union is significantly negative.

The second point to notice is that the direct effect of tacit R&D and explicit R&D was adverse. Explicit R&D was significantly positive at the 99% confidence level, but tacit R&D was significantly negative at the 95% confidence level. Labor union was also negative, even though not significant.

The implication of this result is that, in the ICT-related sectors, well designed institutions do not helpful to patent application; In addition, explicit R&D is critical to patent application, but not is tacit R&D.

The third point to notice is that firm size was significantly positive to the patent application. As large as a firm, more attach importance to patent application. Meanwhile, market change or uncertainty was not significant.

Business group was significantly positive. This result may be interpreted that large business group is usually investing in R&D activity and patent application based on long-term strategy, not based on short-term marketing strategy.

2.1.4. Types of CIS and Labor Productivity Measured by Total Sales

Table 4-7 OLS: Types of CIS and Labor Productivity measure by Total Sales

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Dependent	lnTS/L	lnTS/L	lnTS/L	lnTS/L	lnTS/L	lnTS/L
Cluster 1	0.1523	0.1808	0.1594	0.1404	0.1071	0.0830
(R&D type)	*(1.67)	*(1.87)	(1.62)	(1.40)	(0.93)	(0.72)
Cluster 2	0.1526	0.1884	0.1796	0.1858	0.0616	0.0627
(HI+R&D)	(1.42)	(1.53)	(1.43)	(1.50)	(0.43)	(0.44)
Cluster 3	0.0363	0.0723	0.1141	0.1469	0.1063	0.1378
(HI type)	(0.37)	(0.75)	(1.14)	(1.44)	(1.04)	(1.32)
Sector 64		0.1631	0.1552	0.1571	0.1468	0.1476
		(1.57)	(1.55)	(1.56)	(1.50)	(1.50)
Sector 72		-0.0340	-0.0032	-0.0213	-0.0414	-0.0622
		(-0.40)	(-0.04)	(-0.23)	(-0.45)	(-0.66)
Sector 73		-0.1518	-0.0303	-0.0411	-0.0680	-0.0790
		(-1.33)	(-0.24)	(-0.33)	(-0.55)	(-0.65)
Sector 74		0.2570	0.2713	0.2714	0.2298	0.2282
		***(2.68)	***(2.67)	***(2.70)	**(2.37)	**(2.37)
Sector 32 (dropped)						
Employees2		0.0098	0.0218	0.0365	0.0204	0.0344
		(0.14)	(0.31)	(0.49)	(0.28)	(0.46)
Market demand		0.2270	0.0237	0.0187	0.0373	0.0320
trend		(0.43)	(0.38)	(0.31)	(0.58)	(0.52)
Management			-0.0230	-0.0280	-0.0239	-0.0289
System2.			(-0.34)	(-0.41)	(-0.36)	(-0.42)
Biz_Group2			-0.0486	-0.0563	-0.0558	-0.0638
			(-0.61)	(-0.70)	(-0.72)	(-0.83)
Public sector2			-0.2243	-0.1785	-0.2210	-0.1728
			**(-2.11)	(-1.63)	**(-2.12)	(-1.62)
Labor Union				-0.1422		-0.1448
				(-1.49)		(-1.54)
Tacit R&D					0.2305	0.2330
					***(3.21)	***(3.31)
Explicit R&D					0.0048	0.0113
					(0.06)	(0.15)
F-value	188.34	104.77	85.39	86.34	82.32	85.28
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
R^2	0.9022	0.9097	0.9114	0.9127	0.9140	0.9154
number	235	235	235	235	235	235

Note: The values in the parentheses are z-value, and the statistical significance at the level of 99%, 95%, and 90% are indicated by ***, **, and *, respectively.

Note: Sector 64 (Post and telecommunications), Sector 72 (Computer and related activities), Sector 73 (Research and development), Sector 74 (Professional, scientific, and technical services), Sector 32 (Manufacture of electronic components, radio, television and communication equipment and apparatuses)

Note: lnK/L, lnM/L, constant were not reported.

Table 4-7 shows the relationship between CIS type of ICT-related sector and labor productivity measured by total sales. The first point to notice is that the coefficient of the cluster 1, the cluster2, and the cluster 3 was 0.0830, 0.0627, and 0.1378, respectively. This result means that the indirect effect of labor union in the ICT-related sectors was positive even though not significant; and indirect effect of R&D activities was also positive but not significant. What has to be noticed is that the coefficient of the HI+R&D type CIS is smaller than that of the HI type CIS or R&D type CIS. It means that there is no motivations to transform from the HI type CIS to the HI+R&D type CIS, and from the R&D type CIS to the HI+R&D type CIS if we do not consider the direct effect of R&D activities.

Second, tacit R&D was significantly positive to the labor productivity at the 99% confidence level, but the direct effect of explicit R&S was not observed. This is the adverse result comparing to the case of patent application. When we used patent application as a dependent variable, explicit R&D activities were significantly positive, and tacit R&D activities were significantly negative. Meanwhile, if labor productivity was used as a dependent variable, tacit R&D activities were more important than explicit R&D activities. Labor union was negative even though not significant.

The implication of this result is that, considering direct effect and the indirect effect simultaneously, the R&D type CIS has no motivation to transform to the HI+R&D type CIS because both direct effect and indirect effect of labor union are negative. HI type CIS has some motivation to transform to the HI+R&D CIS with engaging in tacit R&D because the direct effect of tacit R&D is significantly positive even though the indirect effect is negative.

2.1.5. Types of CIS and Labor Productivity Measured by Value-added

Table 4-8 OLS: Types of CIS and Labor Productivity measure by Value-added

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Dependent	lnVA/L	lnVA/L	lnVA/L	lnVA/L	lnVA/L	lnVA/L
Cluster 1	-0.0151	0.2494	0.1710	0.1482	-0.2581	-0.2953
(R&D type)	(-0.05)	(0.87)	(0.60)	(0.51)	(-0.82)	(-0.92)
Cluster 2	-0.0042	0.5403	0.4973	0.5316	-0.1916	-0.1680
(HI+R&D)	(-0.01)	(1.52)	(1.39)	(1.47)	(-0.48)	(-0.42)
Cluster 3	-0.4101	-0.2004	-0.0471	0.0398	-0.1924	-0.0924
(HI type)	(-1.26)	(-0.64)	(-0.14)	(0.12)	(-0.56)	(-0.27)
Sector 64		0.9215	0.8674	0.8883	0.7710	0.7935
		***(3.33)	***(3.19)	***(3.26)	***(2.85)	***(2.93)
Sector 72		0.3406	0.3287	0.3132	0.0643	0.0395
		(1.42)	(1.32)	(1.28)	(0.25)	(0.16)
Sector 73		-0.3174	0.1370	0.1066	-0.0132	-0.0532
		(-0.92)	(0.35)	(0.28)	(-0.04)	(-0.15)
Sector 74		1.0269	0.9720	0.9939	0.7479	0.7684
		***(3.94)	***(3.53)	***(3.62)	***(2.98)	***(3.07)
Sector 32 (dropped)						

Employees2		-0.2421 (-1.33)	-0.2224 (-1.28)	-0.2074 (-1.19)	-0.2742 (-1.59)	-0.2576 (-1.47)
Market demand trend		0.0807 (0.50)	0.0718 (0.44)	0.0814 (0.50)	0.1146 (0.71)	0.1272 (0.79)
Management System2.			-0.0390 (-0.19)	-0.0579 (-0.28)	-0.0464 (-0.23)	-0.0691 (-0.34)
Biz_Group2			0.1613 (0.77)	0.1399 (0.67)	0.1411 (0.71)	0.1149 (0.58)
Public sector2			-0.7807 **(-2.05)	-0.6908 *(-1.70)	-0.6836 *(-1.83)	-0.5749 (-1.47)
Labor Union				-0.2980 (-1.13)		-0.3539 (-1.41)
Tacit R&D					0.8638 ***(4.79)	0.8865 ***(4.94)
Explicit R&D					0.3583 *(1.80)	0.3660 *(1.85)
F-value	22.57 (0.0000)					
R^2						
number						

Note: The values in the parentheses are z-value, and the statistical significance at the level of 99%, 95%, and 90% are indicated by ***, **, and *, respectively.

Note: Sector 64 (Post and telecommunications), Sector 72 (Computer and related activities), Sector 73 (Research and development), Sector 74 (Professional, scientific, and technical services), Sector 32 (Manufacture of electronic components, radio, television and communication equipment and apparatuses)

Note: lnK/L, lnM/L, constant were not reported.

Table 4-8 shows the relationship between CIS type of ICT-related sector and labor productivity measured by value-added. The first point to notice is that the coefficient of the cluster 1, the cluster2, and the cluster 3 was -0.2953, -0.1680, and -0.0924. This result means that the indirect effect of labor union or R&D activities in the ICT-related sectors was negative even though not significant. What has to be noticed is that the coefficient of the HI+R&D type CIS is smaller than that of the HI type CIS. It means that there is no motivations to transform from the HI type CIS to the HI+R&D type CIS.

Second, tacit R&D was significantly positive to the labor productivity at the 99% confidence level, and the direct effect of explicit R&S was significantly positive at the 90% confidence level. The value of coefficient is noteworthy. The coefficient of tacit R&D activities and explicit R&D activities is 0.8865 and 0.3660, respectively. We may conclude that tacit R&D activities are more important than explicit R&D activities for labor productivity.

The implication of this result is that, considering direct effect and the indirect effect simultaneously, the HI type CIS has incentive in transforming to the HI+R&D CIS with engaging in tacit R&D because the direct effect of tacit R&D and explicit R&D is significantly positive, even though the transformation effect is somewhat negative.

2.2. Result and Implications

2.2.1. Transformation Strategy from the HI type CIS to the HI+R&D type CIS

Table 4-9 indicates the introduction effect of R&D activities in the case of transforming from the HI type CIS to the HI+R&D type CIS.

Table 4-9 Transformation from the HI type CIS to the HI+R&D type CIS through Engaging in R&D activities

		Indirect R&D effect	Direct tacit R&D effect	Direct explicit R&D effect
Employees-leading inno.	Coefficient (z-value)	From 0.4140 (3.19) To 0.4151 (2.52)	0.0943 (0.88)	0.0938 (1.05)
P/S Innovation	Coefficient (z-value)	From 0.1957 (1.53) To 0.2111 (1.35)	-0.0587 (-0.57)	0.0102 (0.11)
Patent Application	Coefficient (z-value)	From -0.1945 (-1.93) To -0.0567 (-0.40)	0.0184 (0.21)	0.3798 (6.11)
lnTS/L	Coefficient (t-value)	From 0.1378 (1.32) To 0.0627 (0.44)	0.2330 (3.31)	0.0113 (0.15)
lnVA/L	Coefficient (t-value)	From -0.0924 (-0.27) To -0.1680 (-0.42)	0.8865 (4.94)	0.3660 (1.85)

Note: The value of coefficient, z-value, t-value are based on the Model 6 including direct effect of labor union and R&D activities. lnTS/L means natural logged total sales per employee, and lnVA/L means natural logged value-added per employee.

A workplace attaching importance to employees-leading innovation may hesitate transforming from the HI type CIS to the HI+R&D type CIS by engaging in tacit R&D and explicit R&D. The direct effect of tacit R&D and explicit R&D was positive, but not significant. Furthermore, there was no transformation effect from the HI type CIS to the HI+R&D type CIS: the coefficient of the HI type CIS was 0.4140, and the coefficient of the HI+R&D type CIS was 0.4151.

A workplace laying emphasis on P/S innovation may have no motivation to engage in R&D activities. The direct effect of tacit R&D and explicit R&D was not observed, and the transformation effect from the HI type CIS to the HI+R&D type CIS showed no improvement in P/S innovation.

A workplace laying weight on patent application may improve its performance with engaging in R&D activities. The direct effect of explicit R&D was significantly positive, and the indirect effect was also positive: from -0.1945 to -0.0567. In addition, Engaging in explicit R&D activities is better than engaging in tacit activities. The direct effect of explicit R&D activities was significantly positive with coefficient of 0.3798.

A workplace attaching importance to labor productivity measured by total sales, may consider the trade-off between the direct effect and the indirect effect. The direct effect of tacit R&D activities was significantly positive with coefficient of 0.2330, but the transformation effect is somewhat negative.

A workplace laying emphasis on labor productivity measured by value-added, may consider transforming from the HI type CIS to the HI+R&D type CIS by engaging in tacit and explicit R&D activities. The direct effect of tacit R&D activities and explicit R&D was conspicuously positive with coefficient of 0.8865 and 0.3660. The implication of this result is that, considering direct effect and the indirect effect simultaneously, the HI type CIS has incentive in transforming to the HI+R&D CIS through engaging in tacit R&D. Even though the transformation effect is somewhat negative, from -0.0924 to -0.1680, the direct positive effect exceeds this negative effect.

Among ICT-related 156 workplaces, 70 workplaces (44.9%) are remaining in the HI type CIS. Only seven workplaces (4.5%) are belonging to the HI+R&D type CIS. Most of workplaces belonging to the HI type CIS is hesitating over transformation toward HI+R&D type.

It is plausible to assume that most of workplaces belonging to the HI type CIS may lay emphasis on employees-leading innovation and P/S innovation. Four reasons of this assumption may be derived. First, these workplaces have already well designed institutions suitable for employees-leading innovation and P/S innovation. Based on evolutionary approach, an existing firm may be establishing institutions harmonious with its own purposes. Second, among 301 workplaces belong to HI type CIS, 280 workplaces (90.6%) were service sectors; in these sectors, interaction with consumers and among employees is critical. Next, 207 workplaces (67.0%) were facing increasing market demand; this market change or uncertainty encourages workplaces to create employees-leading innovation and P/S innovation. Lastly, the HI type CIS has already established well designed cooperative labor relations. If a workplace really pursue transforming, it would be possible.

From this analysis, we conclude that the unique purpose of each workplace is the main obstacle of transformation from the HI type CIS to the HI+R&D type CIS.

But if the purpose of a workplace belonging to the HI type CIS is patent application or labor productivity measured by value-added, transforming to the HI+R&D type CIS with engaging in R&D activities is a good strategy.

2.2.2. Transformation Strategy from the R&D type CIS to the HI+R&D type CIS

Table 4-10 illustrates the effect of establishing labor union in the case of transforming from the R&D type CIS to the HI+R&D type CIS.

Table 4-10 Transformation from the R&D type CIS to the HI+R&D type CIS through Establishing Labor Union

		Indirect Labor Union effect	Direct Labor Union effect
Employees-leading inno.	Coefficient (z-value)	From 0.1315 (0.83) To 0.4151 (2.52)	-0.0062 (-0.07)
P/S Innovation	Coefficient (z-value)	From 0.0972 (0.72) To 0.2111 (1.35)	-0.0172 (-0.19)
Patent Application	Coefficient (z-value)	From -0.1990 (-1.86) To -0.0567 (-0.40)	-0.1685 (-2.45)
lnTS/L	Coefficient (t-value)	From 0.0830 (0.72) To 0.0627 (0.44)	-0.1448 (-1.54)
lnVA/L	Coefficient (t-value)	From -0.2953 (-0.92) To 0.1680 (-0.42)	-0.3539 (-1.41)

Note: The value of coefficient, z-value, t-value are based on the Model 6 including direct effect of labor union and R&D activities. lnTS/L means natural logged total sales per employee, and lnVA/L means natural logged value-added per employee.

A workplace attaching importance to employees-leading innovation may improve its performance by transforming from the R&D type CIS to the HI+R&D type CIS through establishing high-involvement institution, especially labor union. We may induce the effect of transformation from coefficient of CISs; the coefficient of the R&D type CIS was 0.1315, while that of the HI+R&D type CIS was 0.4151. The direct effect of labor union was not observed. The same result was inducted when we used P/S innovation as a dependent variable.

A workplace laying weight on patent application may reduce the negative effect of CIS type by establishing well designed institutions: from -0.1990 to -0.0567. The direct effect of labor union, however, was significantly negative. This trade-off should be considered when a workplace establishes a transformation strategy.

A workplace attaching importance to labor productivity may have no motivation to establish an institution enhancing employees' involvement. No transformation effect was observed, and the direct effect of labor union was also negative even though not significant.

Among ICT-related 156 workplaces, 49 workplaces (31.4%) are remaining in the R&D type CIS. Only seven workplaces (4.5%) are belonging to the HI+R&D type CIS. Most of workplaces belonging to the R&D type CIS is hesitating over transformation toward the HI+R&D type.

It is plausible to assume that a workplace belonging to the ICT related service sector has motivation to improve its competence for P/S innovation and employees-leading innovation. The reason may come from the unique characteristics of service sectors: interacting with consumers is critical.

As can be seen in the Table 4-9, a workplace belonging in the R&D type CIS can improve its competence through establishing well designed institutions, but this transformation was not realized. The main hindrance of transformation may be the difficulty of establishing well designed institutions. A workplace belonging to the R&D type CIS has no well designed high-involvement work system, well designed motivation system or VET system. Most of all, it has no highly developed cooperative labor relations, which guarantee these systems to operate well. Further research is required on creating virtuous circle including both R&D activities and well designed institutions.

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Appendix A. The Questionnaire Used in the Survey

Table A The Questionnaire Used in the Survey

In 2005, how did the level of innovation among employees at your workplace compare with the average for companies in the same industry? Very low/Low/Similar/High/Very High
In 2005, how did the degree of innovation in your workplace's goods and services compare with the average for companies in the same industry? Very low/Low/Similar/High/Very High
Is your workplace implementing an enterprise-wide quality management program such as six-sigma program? Yes/No
Does your workplace have a system for receiving suggestions for work improvement from employees?
In your workplace do employees implement regular job rotation to enable workers to perform multiple functions and gain different types of experiences? Yes/No
In 2005, did your workplace implement or support training for the development of workers' job capabilities? Yes/No
Does your workplace implement a performance sharing (variable bonus) system based on the management performance at the enterprise, workplace or division level? Yes/No
Is there a union in your workplace? Yes/no/Yes, but it is currently inactive
What is the trend in market demand for your workplace's main product/service? Rapidly increasing/Increasing/steady/declining/rapidly declining

Appendix B. Analysis for the goodness-of-fit of the model

Table B-1 Summary Statistics from the Latent Class Analysis

Number of Latent Class	BIC(LL)	Degree of Freedom	p-value	Classification Error
Cluster 2	11850.269	1322	**0.40**	0.1035
Cluster 3	11731.343	1310	**1.00**	0.1449
Cluster 4	**11709.694**	1298	**1.00**	0.2002
Cluster 5	11759.204	1286	**1.00**	0.2166
Cluster 6	11831.335	1274	**1.00**	0.2274

In order to determine the cluster numbers of the latent variable, we conducted the two-step procedure. The first step was the standard chi-squared test with the null hypothesis that the specified model holds true in the population. A p-value associated with a log likelihood (LL) is a formal assessment of the extent to which the model fits the data; P<0.05 indicates a poor fit. The p-value of the model with two clusters is 0.15, and the p-values of the model with three clusters, four clusters and five clusters are all 1.00. This result means that all the models with two clusters, three clusters, four clusters, and five clusters are fit the data. The second step is to examine the parsimony of the model with Bayesian Information Criteria (BIC). When comparing models, the lower the value of the BIC, the better the model. The model with four clusters is the lowest value, 11709.694. Table 3-4 in Chapter 3 is the result of the model with four clusters.

Table B-2 Bivariate Residuals

Variables	1	2	3	4	5	6	7	8
1.Quality management program	.							
2. Proposal system	1.953							
3. Regular job rotation	0.022	0.028						
4. VET system	0.074	0.031	0.988					
5. Performance sharing system	0.403	0.337	1.481	0.000				
6. Labor union	0.251	0.354	0.376	0.008	0.000			
7. Tacit R&D	0.628	0.880	0.344	0.214	1.202	0.263		
8. Explicit R&D	1.551	0.086	2.456	0.005	0.005	0.199	1.294	
Sector (Indus2)	0.331	0.012	0.542	0.000	0.000	0.013	0.233	1.248
# of employees (emp2)	0.532	0.020	0.767	0.000	0.128	0.000	1.618	0.000

Market Demand Trend	0.735	0.693	0.359	0.016	0.010	0.000	1.055	3.767

Another indication, which provides a good fit to the data, is to examine whether there are significant residuals or not. In general, bivariate residuals larger than 3.84 identify correlations between the associated variable pairs that have not been adequately explained by the model. When bivariate residuals larger than 3.84 are observed, we can treat it by including direct relationships between indicators and direct effects of covariates on indicators in a model. We guaranteed the goodness-of-fit of the model by including direct relationships and direct effects in eight variable pairs: small group activity and explicit R&D, job rotation and explicit R&D, performance sharing system and VET system, labor union and performance sharing system, sector and VET system, number of employees and explicit R&D, number of employees and VET system, number of employees and labor union.