Intellectual Capital and Innovative Capabilities of Manufacturing Enterprises in Korea

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Abstract

This study, for the first time, finds out motors of rapidly growing innovation in Korean manufacturing enterprises utilizing particular attributes of intellectual capital created from firm characteristics and management practices of enterprises. In this way, this study increases our understanding of innovative capability in Korean enterprises at various angles. This study uses 2009 and 2011 data from 360 enterprises in 22 manufacturing industries taken from the Human Capital Corporate Panel by the Korea Research Institute for Vocational Education and Training. Probit and random effects estimations along with ordinary least squares found that greater human capital radically reinforces innovative capability, and stronger social capital has significant effects on radical capability in line with the hypothesis of Subramaniam and Youndt (2005). However, unlike the hypothesis, stronger organizational capital had stronger effects on radical innovative capability than on incremental capability. Important findings for economic and enterprises' policy making are: For developing new markets, advanced research skill radically and advanced marketing skills incrementally reinforce innovative capabilities among human capital. A larger number of utility model and design registrations as organizational capital tend to enhance radical innovative capability. As social capital, cooperating human resource development between prime company and subcontractor, and employee stock ownership system radically empower innovative capability. A mentoring system incrementally reinforces innovative capability. For developing company's knowledge and technology, a larger proportion of employees with PhD tend radically to increase innovative capability. Master's degree and advanced marketing skill incrementally increase innovative capability. A highly developed IT-Infrastructure and a R&D alliance with other company seem radically to increase innovative capability.

Keywords: Korean manufacturing enterprises, Incremental and radical innovation, Intellectual capital

1. Introduction

Various types of knowledge-based capital (KBC) – innovative property, human capital, organizational know-how, computerized information, and networks that connect people and institutions – are reported as new sources that drive investment and growth in OECD economies (OECD, 2012). In recent decades, intellectual capital has also become the leading factor of economic development in Korea. Korea Institute of Intellectual Property (2013) has estimated the economic value of the KBC in Korean enterprises approximately at $496 billion USD in 2010. Its volume was comparable to the half of Korean GDP in 2010. Among several types of the KBC, the growth of patent registration and its quality improvement were most dynamic. Those economic values were 15 times and 17 times greater than those were in 1997 respectively (Lim and Ryu, 2013). What is the intellectual motor for rapidly growing innovative capabilities in Korean enterprises?

In the KBS context, innovation was considered "a process that begins with an idea, proceeds with the development of an invention, and results in the introduction of a new product, process or service to the market" (Edwards and Gordon, 1984, p. 1). In the late 1990s, researchers began to conceptualize and study knowledge and knowing capabilities and their utility in providing a competitive advantage for enterprises (Stewart, 1997; Nahapiet and Ghoshal, 1998). They sought to link firms' innovation capability to intellectual capital. The concept of intellectual capital was further refined at multidimensional levels as knowledge held by individuals and stored within organizational databases, business processes, systems, and relationships. Stewert (1997) divided intellectual capital into human capital, structural capital, and customer capital. Sveiby (1997) divided those items into individual competence, internal, and external structure. Individuals use their competence to create value by transferring and converting knowledge externally or internally to the organization to which they belong. Edvinsson and Malone (1997) deemed intellectual capital as comprised of two primary components: human capital and structural capital, which the authors then subdivided into organizational capital and customer capital. Nahapiet and Ghoshal (1998) added the remaining type of intellectual capital, which is social capital that resides at neither the individual nor the organizational level. Social capital is an intermediary form of intellectual capital that consists of knowledge in groups and networks of people. Youndt, Subramaniam and Snell (2004) pointed out the interconnectedness and coexistence of human, social, and organizational capital. Subramaniam and Youndt (2005) broke innovative capability into incremental and radical innovative capabilities in accordance with previous studies (Abernathy and Clark, 1985; Gatignon et al., 2002). In a longitudinal, multiple-informant study of 93 organizations, Subramaniam and Youndt (2005) demonstrated the selective influence of human, organizational, and social capital on incremental and radical innovative capabilities and their interaction effects.

In Korea, studies on intellectual capital and a firm's performance began in the 2000s. Kim et al. (2003) empirically studied the effect of intellectual capital on a firm's performance. They collected data from 62 knowledge-based companies in Korea and found that individual human capital was positively related to organization capital, which had again positive effect on relation capital. The results revealed that relation capital positively affected a firm's financial performance. Kang (2005) studied the effect of intellectual capital on performance in the hotel industry using questionnaires collected from 30 five-star hotels in Seoul. He found positive effects of human capital on customer and structural capital, and on financial performance in the hotel industry. Park (2007) studied the effect of intellectual capital on a company's performance using data from 1990 to 2003 on 339 manufacture companies listed on the Korean Stock Exchange (KSE). Park's study found that advertisement expenses and R&D expenses positively influenced the gross margin ratio and return on assets, whereas education and training expenses had a negative effect on these statistics. Moon (2011) studied the effect of strategic orientation – market orientation and entrepreneurial orientation – on intellectual capital and on the outcomes of business performance in government-certified innovation type SMEs (small- and medium-sized enterprises) using 287 sets of questionnaires. Market orientation and entrepreneurial orientation positively affected intellectual capital. Among intellectual capital, customer capital has a direct positive effect on performance. Kim (2012) studied the effects of intellectual capital on firm performance in Innovation type SMEs. His study found that the effect of customer capital on firm performance. Human capital and structural capital have not significant effects of on firm performance. Son and Lee (2013) studied the relationship between intellectual capital and performance in the fashion industry according to competitive strategy using 121 questionnaires from experts in the fashion industry. The 'product innovation' and the 'marketing capability' have a significant impact on financial and non financial performance. The 'customer assets' appear to have direct effects on non-financial performance.

Hereto, studies concerning the effect of intellectual capital on a firm's performance indicated that a financial performance of knowledge-based or innovative type companies was more influenced by social capital, such as relation capital or customer capital, than by R&D investment or human capital in Korea. Generally, advertisements, customer capital, or relation capital, including marketing and business relationships, had a more significant effect on a firm's financial performance in Korea.

Concerning the study of intellectual capital in relation to innovative capabilities, Choi and Sung (2008) studied the effects of human resource development (HRD) investment and learning practices on innovative performance of organizations. They used 2005 data on 232 Korean companies representing diverse industries taken from the Human Capital Corporate Panel (HCCP). Their analysis found that HRD investment promoted interpersonal learning practices that appertained to social capital. In turn, interpersonal learning practices increased the number of patents. Song (2012) studied the influence of strategic human resource management (HRM) – acquisition, developmental, egalitarian, collaborative, documentation, and information HRM – on organizational performance. Furthermore, he investigated the mediating effects of intellectual capital and innovative capability between strategic HRM systems and organizational performance. This study was the first to divide innovative capability into radical and incremental capabilities in Korea. To acquire data, he carried out a questionnaire with human resource department managers or CEOs at 273 nationwide companies. His variables for intellectual capital and innovative capabilities were translated versions of the questionnaires used by Subramaniam and Youndt (2005). By employing a correlation analysis and a structural equation model, they found the following. Acquisition and developmental HRM positively influenced the human capital. Documentation and information HRM positively influenced organizational capital. Human capital and organizational capital again positively influenced both radical and incremental innovative capabilities, which in turn positively influenced customer and financial performance. Social capital was promoted by egalitarian HRM and collaborative HRM but had no significant influence on innovative capabilities or firm performance.

A review of the studies by Subramaniam and Youndt (2005) and Song (2012) could raise suspicion regarding measurement errors for explanatory variables and sample selection. Regarding variables for intellectual capital, they requested self-evaluations from managers, CEOs, or presidents concerning their employees' skills, creativity and brightness, expertise, development of new ideas and knowledge, or concerning employee's collaboration skills, such as sharing information, learning from one another, interacting and exchanging ideas, and communicating and cooperating with customers, suppliers, alliance partners, and others in order to diagnose and solve problems. Respondents chose one from seven scalars, such as between strongly disagree and strongly agree, to describe their own enterprise. Then, respondents could reject such a survey when it seemed disadvantageous to them. This structure may have caused sample selection bias. Further, respondents did not want to reveal their weak level of intellectual capital and chose more fourth scalars posited in the middle, such as a common level of intellectual capital instead of weak levels, which caused measurement errors. Additionally, a review of Subramaniam and Youndt (2005) and Song (2012) revealed the ambiguity of the intellectual capital variables employed in their studies, although theories on human, social, and organizational capital enabled more objective indicators to be found as variables. Their variables reduced or eliminated the practical meaning of the estimation results in guiding decision making on economic issues.

This study was based on the research framework of Subramaniam and Youndt (2005). However, unlike their study, this study used data from the HCCP of the Korea Research Institute for Vocational Education and Training (KRIVET). Using this corporate panel, this study attempted to utilize and create more objective indicators as variables for human, organizational, and social capital. This could reduce sample selection and measurement error problems. Furthermore, whereas the studies by Subramaniam and Youndt (2005) and Song (2012) covered the entire industry, this study focused on 22 manufacturing industries, excludes financial and non-financial service industries. The purpose of this study was to demonstrate the selective effects of intellectual capital on innovative capabilities in the manufacturing industry in Korea. This study, for the first time, finds out motors of innovation in Korean enterprises utilizing particular attributes of intellectual capital created from firm characteristics and management practices of enterprises.

Using 2009 and 2011 data on 360 manufacturing corporations, the probit estimation and random effects estimation (RE), along with ordinary least squares (OLS), identified selective effects of human, organizational, and social capital on radical and incremental innovative capabilities. The findings supported the concept that greater human capital – more advanced researcher skills and a larger proportion of employees with PhD degrees – reinforces radical innovative capability, in line with the hypothesis of Subramaniam and Youndt (2005). Furthermore, this study demonstrated the significant effects of social capital on radical capability, such as an alliance of R&D between enterprises on radical capability. However, unlike the hypothesis, stronger organizational capital showed stronger effects on radical innovative capability rather than incremental capability.

The remainder of this paper is organized as follows. Section 2 defines and creates variables for intellectual capital and innovative capabilities, and an advanced research framework of this study. Section 3 describes the sample and methods employed. Section 4 presents the empirical findings, and Section 5 discusses the results of the study. Section 6 concludes the paper.

2. Definitions and Research Framework

Innovative Capabilities. Innovative capabilities are associated with identifying and using opportunities to create new products, services, or work practices (Van de Ven, 1986). Abernathy and Clark (1985) divided such innovative capability into incremental and radical innovative capabilities. Radical innovative capability is defined as capability to generate innovations that significantly transform existing products and services (Chandy and Tellis, 2000). Incremental innovative capability is capability to generate innovations that refines and reinforces existing products and services (Ettlie, 1983). This study utilized these segmentalized definitions of innovative capability and refines the comprehension of the knowledge–innovation link. Generally, innovation outcomes have been measured using the indicators of new product introductions, technology patents, and sales generated from new products. This study utilized two kinds of innovative capability. The first one is capability related to product and customer market Innovation. The second one is related to knowledge and technology innovation.

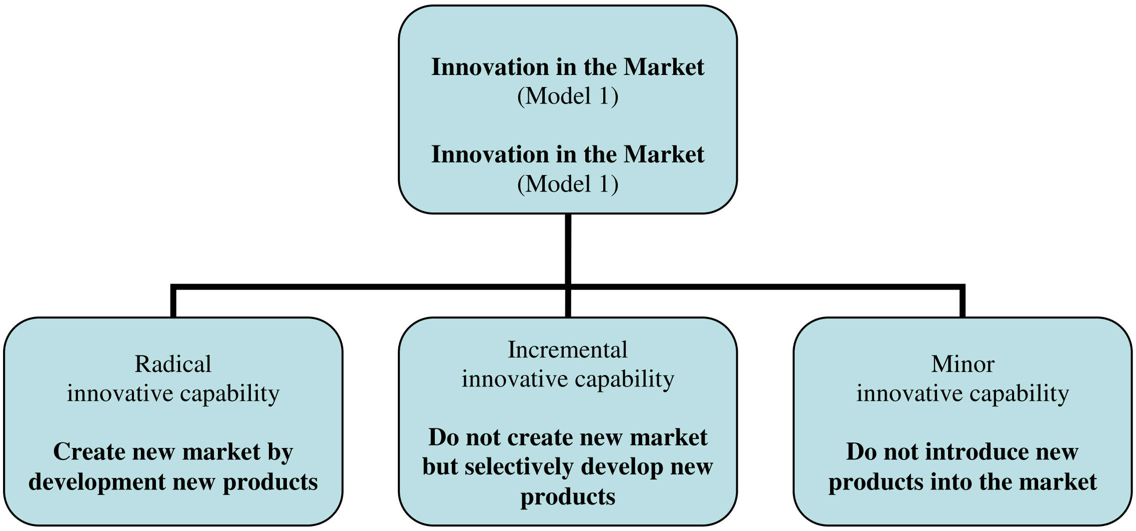

Figure1. The First Model for Innovation in the Market

To study the first model, we selected companies with radical capability that lead customers and market changes by developing new products ahead of its competitors. Companies with incremental capability do not lead to new markets and new product development, but target the market through selective development of new products taking the market performance of the leading companies into account. As a reference, this study introduced the third category of innovative capability to observe an influence of intellectual capital on a minor level of innovative capability. This group is comprised of companies that do not introduce a noteworthy new product into the market. This allows us to analyze link between innovation levels – radical, incremental and minor innovative capability – and intellectual capital (see Table1 and Figure 1).

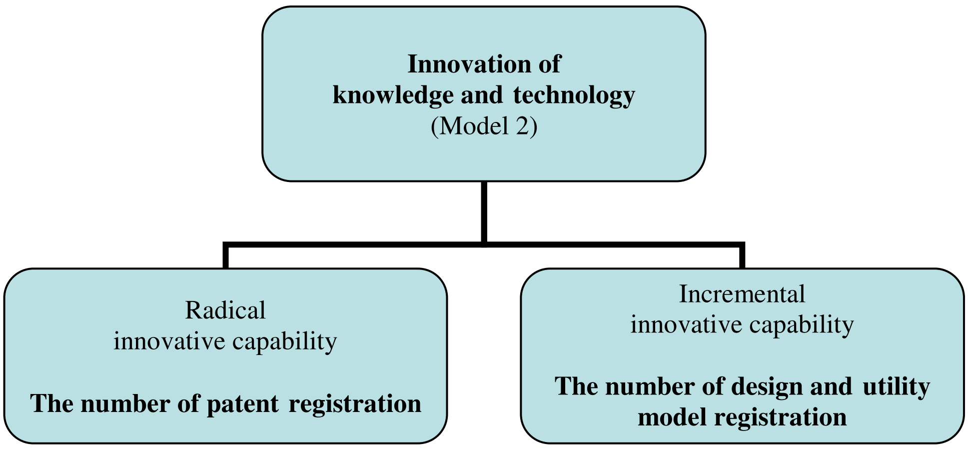

Figure 2. The Second Model for Innovation of Knowledge and Technique

The second model utilized a number of different patent registrations per employee as a measure of innovative capability. Patents were divided into utility model registration, design registration, and patent registration. Patent registration is related to the highly/completely new creation of products and technologies. Utility model registration could be acquired when improving the performance of products or processes or increasing efficiency to reduce costs. Design registration is related to the enhancement of aesthetics through form, shape, and color as attributed goods and services (Korean Intellectual Property Office, 2013). This study employed patent registration as a proxy for radical capability and other forms of patent – utility model registration and design registration – as a proxy for incremental capability. The number of patents largely varies according to the scale of companies. To establish comparability, the number of different patent registrations per employee was used instead of the number of patents per company in this study (see Table 1 and Figure 2).

Intellectual Capital. Studies (Nahapiet and Ghoshal, 1998; Youndt, Subramaniam and Snell, 2004) considered intellectual capital as the sum of all knowledge that companies utilize to acquire competitiveness. Knowledge is accumulated and distributed in individuals as human capital; in organizational structures, processes, and systems as organizational capital; or in relationships and networks in the form of social capital.

Schultz (1961) defined ***human capital*** as the knowledge, skills, and abilities residing with and utilized by individuals. Becker (1964) illustrated various human capital factors such as education and training, other knowledge and information, emotional and physical health, and ability, among others. This study used the percentage of employees with different education levels and self-evaluation of employee's skill levels in different functional areas such as research, marketing, engineer, administration, and production. To reduce measurement error related to self-evaluation of employee's skill, this study selected (much) better skill levels among five scalars. A dummy variable was created to reflect whether employees have better or much better skills than required by the company in their specialties. The number of employees differentiated by educational level was measured by the percentage of regular employees with different educational levels among all regular employees (see Table 2). Given the problem of perfect collinearity, we dropped the proportion of employees with a high school and lower education from the variable set.

Organizational capital is defined as codified knowledge – manuals, databases, and patents – that organizations use to accumulate and retain knowledge (Nelson and Winter, 1982, Garud and Nayyar, 1994). Organizational capital is further established by a firm's structures, systems, and processes to streamline innovative outcomes (Cooper, 2001). Human and organizational capital differs in the following way: whereas human capital is usually lost when individuals leave organizations, organizational capital is preserved over time in an organization in the form of codified information or systems. The present study measured the effect of organizational capital using indicators of management information systems (MIS) for human resource and using the number of different patent registrations per 100 employees. This study considered indicators of human resources MIS as a proxy for levels of IT infrastructure development: no MIS was interpreted as no systematic IT infrastructure; the introduction stage of MIS indicated the lower level of IT infrastructure; Web application of MIS was the middle level of IT infrastructure; and the application stage of the corporate portal system was the high level of IT infrastructure. The base variable for these dummy variables is no MIS (see Table 3).

Knowledge is further transferred and synthesized through communication and collaboration among individuals (Allen, 1977; Putnam, 1995). ***Social capital*** is defined as the knowledge embedded within interactions among individuals and networks (Nahapiet and Ghoshal, 1998). Thus, social capital is largely generated within organizations irrespective of changes in specific individual actors (Bourdieu, 1985), and measures the organization's overall ability to share and leverage knowledge among and between networks of employees, customers, suppliers, and alliance partners (Subramaniam and Youndt, 2005). This study used indicators of having a mentoring system or not; performance evaluation system regarding how managers foster/train their staff; team bonus system that awards team performance; employee stock ownership system; trade union or other labor representatives; HRD cooperation between a prime company and a subcontractor; and alliances with other companies in research and development, production, marketing, and capital (see Table 4).

Hypotheses. Using the research framework of Subramaniam and Youndt (2005), this study premised that attributes of human, organizational, and social capital develop knowledge to selectively influence incremental and radical innovative capabilities. According to them, this study advances following hypotheses:

Hypothesis 1. Empowering human capital strengthens enterprises' radical innovative capabilities. Knowledge transformation requires suspicion of prevailing norms and a search for fundamentally different solutions to existing problems. Creative, bright, and skilled employees with expertise in their specialty and with knowledge-acquired heterogeneous science lead to knowledge transformation, thus supporting the generation of radical innovative capability.

Hypothesis 2. Increasing organizational capital in enterprises fosters incremental innovative capability. An organization's existing knowledge tends to enhance its new knowledge. For instance, the domains of knowledge of new patent activities are closely related to the domains of knowledge of existing patents thus increase incremental innovative capability (Stuart and Podolny, 1996).

Hypothesis 3. Enhancing social capital in enterprises reinforces incremental innovative capability. Social capital can qualify information exchanges within and between organizations. Thus, social capital strengthens organizational capital, which promotes incremental innovation.

Hypothesis 4. Social capital in enterprises reinforces human capital and, thus, has a positive effect on radical innovative capability. An unconventional connection of heterogeneous ideas, strong ties with suppliers and distributors, and organizations engaging in networking, lobbying, and creating alliances within and between industries can influence the adoption of radical technologies and expanding the probability of creating radical innovations (Schilling, 1998).

This study tests those hypotheses by employing the sample and methods introduce in the following section.

3. Data, Descriptive Statistics and Methods

This study utilized 2009 and 2011 data on manufacturing corporations from the Human Capital Corporate Panel (HCCP) developed by the Korea Research Institute for Vocational Education and Training (KRIVET) (Korea Research Institute for Vocational Education and Training, 2012). Estimation models included the probit estimation and the random effects estimation models, along with OLS.

Data. The HCCP is a panel survey officially approved by the Korea National Statistical Office. Started in 2005, this survey is conducted every two years at corporate units. The survey collects information concerning corporate status; HR departments; human resource management (HRM); employee status; human resource development (HRD); and research and development (R&D). Questionnaires are distributed to persons in charge of business strategy, HRD, HRM, and R&D. Additionally, this survey enables an analysis of a company's financial performance and innovation using financial data provided by National Information & Credit Evaluation Inc. (NICE) and patent data from the Korean Intellectual Property Office (KIPO). The population for this panel survey was comprised of corporations in Korea that employ more than 100 workers in the following six industries: manufacturing; publishing/video/broadcast communications and information services; finance and insurance; professional/scientific and technical services; educational services; and arts/sports and leisure-related services. The samples include 450 to 500 enterprises every year (KRIVET, 2012).

The sample used in this study covered 22 manufacturing industries in 2009 and 2011(Note 1). The HCCP contains various variables to test our hypotheses, including information on company characteristics that influence innovative capabilities, in addition to the variables for intellectual capital introduced in section 2. To reduce to the greatest extent possible contamination by individual heterogeneity, this study controlled for characteristics related to a particular company, industry, and year. These control variables are as follows:

- Age and size of company, subcontractor or not, registration types divided into public registration (listed company), registration in the Korea Securities Dealers Automated Quotations System (listed on KOSDAQ), registration of Financial Supervisory Service, audited company, and general company;
- Financial competitiveness such as return on assets (ROA) and return on equity (ROE);
- A company's general abilities such as demand development for items, products and customer market competitiveness, organizational development at headquarters, process development, and technique enhancement;
- A company's investment volume in research and training, such as the proportion of research personnel among all employees and training expenditures per employee; and,
- Twenty-two industry dummies to control industry fixed effects and year dummies to control time-fixed effects.

Descriptive Statistics. The first model used binary response variables concerning product and customer market competitiveness as innovative capabilities. This model employed a single year's data from 2011. We obtained 324 enterprise observations to estimate radical innovative capabilities, 321 observations to estimate incremental capabilities and 305 observations to estimate minor capabilities. Companies with radical capabilities, which lead to customer and market changes through the development of new products and services ahead of its competitors, comprised 35 percent of observations. Companies with incremental capability that selectively develop items by taking the market performance of the leading companies into account and targets the market comprised 46 percent of observations. The remaining 23 percent of companies had no or minor innovative capability that did not introduce a (noticeable) new product into the market. This section reports the descriptive statistics for the 324 observations for the first model. Descriptive statistics for the 321 observations employed for estimation of incremental capabilities, and for the 305 observations employed for estimation of minor capabilities were not noticeably different from that.

The age of the enterprises averaged 34 years. Fifty percent of the observations comprised enterprises with 100 to 299 employees, 36 percent with 300 to 999 employees, 7.7 percent with 1,000 to 1,999 employees, and approximately 6.2 percent with more than 2,000 employees. Thirty-three percent of the observations were subcontractors.

Concerning human capital, 17 percent of the companies' employees had more advanced skills than required in research. It was 15 percent of employees in marketing, 19 percent of employees in engineering, 19 percent of employees in administration, and 12 percent of employees in production. The percentage of regular employees who were junior college graduates was 18 percent, had a bachelor's degree was 31 percent, had a master's degree was 3.4 percent, and had a PhD was 0.42 percent.

With respect to organizational capital, 45 percent of companies had no human resource MIS, 27 percent of observations recently introduced a database system of personnel information (in other words, in the introduction stage), 14 percent utilized the company's Web to support bi-directional exchange of personnel information (in other words, the Web application stage), and 15 percent used an integrated HR information system for business processes as a core technique (in other words, the application stage of a corporate portal system). On average, companies had 0.98 units of patent registration per 100 employees and 0.41 units of utility model and design registration per 100 employees.

With respect to social capital, an average of 14 percent of companies had an alliance in R&D, 8 percent in production, 9 percent in marketing, and 5 percent in capital. Seventeen percent of the observations engaged in HRD cooperation between the prime company and subcontractor, 94 percent of enterprises had an organization that represented employees (trade union or labor-management council), 43 percent had a mentoring system, 42 percent evaluated the performance of managers in fostering/training their staff, 19 percent had a bonus system that awarded team performance, and 23 percent had an employee stock ownership system.

The second model uses a number of different patent registrations per employee as independent variables. The random effects estimation used 635 observations for 380 enterprises in 2009 and 2011. On average, companies had 0.0085 units of patent registration per employee with a standard deviation of 0.0320. Companies had 0.0043 units of utility model and design registration per employees, with a standard deviation of 0.0148. Descriptive statistics for intellectual capital do not noticeably differ from the model previously described.

Tables 5 and 6 in the Appendix provide detailed descriptions of both models.

Estimation Methods. To estimate the effects of human, organizational, and social capital on radical, and incremental or additionally minor innovative capabilities, two types of explained variables were generated: a dummy variable for radical, incremental, or minor product and customer market competitiveness; and the number of radical or incremental patent registrations per employee.

The former employed probit estimation, a binary response model. With respect to the individual heterogeneity of a company, these panel data offered a relatively large set of variables related to a company's ability and properties that are correlated with intellectual capital or innovative capabilities, as were introduced through an explanation of the sample. This model revealed the probability that a company has radical, incremental or minor innovative capability attributable to human, organizational, and social capital.

The latter employed random effects estimation (RE) along with OLS. RE solves the serial correlation problem in the panel data and lessens an enterprise's unobserved heterogeneity problem to the extent that it is uncorrelated with explanatory variables. Estimates of RE reveal changes in units of radical or incremental patent registration per employee for one unit change in explanatory variables. These estimates illustrate the sizes of innovative capabilities that depend on human, organizational, and social capital. This model also included several variables for observed heterogeneity, as were introduced in the explanation of the data.

This study did not consider fixed effects estimation because industry dummies are expected time-invariant variables for an enterprise within the three-year interval from 2009 and 2011.

4. Results

The estimation results reported in this section are statistically significant approximately up to the 5 percent level, particularly when significance levels are not referenced. For test statistics, the heteroscedasticity standard errors were used.

Human Capital. The first model demonstrated that more advanced researcher skills increased the probability of having radical capabilities by approximately 26 percent, by keeping the influence of other variables fixed. This marginal effect is the probability of that a company leads customer and market changes by developing new products ahead of its competitors. A one percent increase of bachelor graduates among employees led to a 0.56 percent increase in the probability of a company having radical capabilities. However, more advanced engineering skills led to a 14 percent decrease in the probability of having radical capabilities, up to a 10 percent significance level. A one percent increase of employees with PhD degrees led to an 11 percent decrease in the probability of a company having radical capabilities. This result might reveal weaknesses in employees with PhD degrees related to market and customer competitiveness. In Korean society, a person with the highest education avoids working in sales and trade out of respect for tradition. More advanced researcher skills reduced the probability of an enterprise acquiring incremental innovative capabilities by 30 percent. This is the probability of entering a new market through selective development of products by taking the market performance of the leading companies into account. More advanced marketing skills increased this probability by 26 percent. The probability that a company does not introduce a new product in the market increased by approximately 14 percent as a result of more advanced employee administration skills. The minor innovative capability may primarily absorb advanced administration skills. More advanced marketing skills had an 8 percent negative effect on being a company with minor innovative capabilities (see Table 7, and Figures 3 and 4).

The second model, in which the explained variable was the number of different patent registrations, found more significant estimates concerning educational level. A one percent of bachelor's degrees may add 0.00019 units (OLS) and 0.00012 units (RE) of patent registrations per employee (at the 10 percent significance level). A one percent increase in PhD degrees among all employees led to a 0.017-unit increase in patent registrations per employee using OLS. A RE that more strongly reduced the unobserved effects illustrated a 0.0082-unit increase in patent registrations per employee from a one percent increase in PhDs, up to the 10 percent significance level. Higher education led to a stronger effect on radical capability. More advanced researcher skills led to a 0.003-unit increase in patent registrations per employee, up to the 10 percent significance level (RE). More advanced production skills led to a 0.011-unit (OLS) and a 0.007-unit (RE) increase in patent registrations per employee, up to the 10 percent significance level. More advanced administration skills led to a 0.004-unit decrease in patent registrations per employee. More advanced researcher and production skills supported radical capability, whereas more advanced administration skills did not. Regarding utility model and design registration, the proxy for incremental innovative capability, a one percent increase in PhDs among all employees led to a 0.0016-unit (OLS) and a 0.0014-unit (RE) decrease in utility model and design registrations per employee, whereas a one percent increase in master's degrees added 0.00028 units (OLS) and 0.00024 units (RE, 10 percent significance level) to utility model and design registration per employee. A master's degree strongly promotes incremental innovative capability whereas PhD degrees do not. More advanced skills in marketing showed a 0.004-unit (OLS, RE) increase in utility model and design registration per employee. More advanced engineering skills reduced utility model and design registration per employee by approximately 0.003 units by OLS and RE at the 10 percent significance level (see Table 8, and Figures 5 and 6).

Organizational Capital. Using a probit model, this study utilized the number of different patent registrations as a variable for organizational capital, along with the levels of development of human resource MIS. Concerning radical innovative capability, a one-unit increase in utility model or design registration per 100 employees enhanced the probability of being a company with radical innovative capability in the product and customer market by approximately 2.6 percent, up to the 10 percent significance level. A one-unit increase in patent registrations per 100 employees tended to increase the probability of gaining radical capability by approximately 1.3 percent (at a 15 percent significance level). A larger number of utility model and design registrations promoted gains in radical innovative capability. In Korean enterprises, utility model and design registrations more significantly reinforce innovative capability by developing new market than patent registrations. The most sophisticated MIS also tended to have greater effects on radical capability compared with no MIS (at a 15 percent significance level). Regarding incremental capability, different types of patent registrations had no significant effect. MIS revealed the negative effects of a 16 percent reduction for the introduction stage and a 20 percent reduction for the Web application stage compared with no MIS. Introducing MIS recently or during the Web application stage reduced the probability of being a company with incremental innovative capability compared with no MIS. Concerning minor innovative capability, a larger number of patent registrations and utility model or design registrations per 100 employees reduces probability of belonging to minor innovative capability by 1.5 percent and 9 percent respectively. Unlike the hypothesis, organizational capital had a greater explanatory power with respect to more radical innovative capability.

Utilizing the number of different patent registrations as an explained variable, this study employed only MIS as a variable for organizational capital. The application of a corporate portal of MIS increased patent registrations per employees by 0.012 units (OLS) and by 0.004 units (RE, 10 percent significance level) compared with no MIS. With respect to incremental innovative capability, MIS had no significant effect on the number of utility model or design registrations. This second model also illustrated that higher organizational capital enhanced the probability that enterprises gained radical innovative capability (Tables 7 and 8, Figure 7).

Social Capital. In the first model, HRD cooperation between prime and subcontractor companies increased the probability of gaining radical capability by 33 percent. Employee stock ownership system increased the probability of gaining radical innovative capabilities by 13 percent. Trade unions or other labor representatives decreased the probability of acquiring radical capability by 27 percent. Having a mentoring system also had an approximate 10 percent negative effect on radical capability (at the 10 percent significance level). HRD cooperation between prime and subcontract companies had a 25 percent negative effect on incremental innovative capability. Having a mentoring system had a 17 percent positive effect on incremental capital. The presence of a trade union or other labor representatives increased the probability of belonging to minor innovative company by 8 percent; R&D and capital alliances increased this probability of minor innovation by 17 percent and 22 percent respectively. This phenomenon could be caused by the R&D and capital dependency on other companies in case of minor innovative company (see Table 7 and Figure 8).

In the second model, the number of patent registrations per employee increased by 0.0099 units (OLS) and 0.0055 (RE) from R&D alliances with other companies. However, production alliances reduced the number of patent registrations per employee by 0.0126 units (OLS) and by 0.006 units (RE). The number increased by 0.008 units given employee stock ownership system (OLS). The existence of a system that evaluates managers' ability to foster/train their staff reduced patent registrations per employee by 0.005 units (at the 10 percent significance level). Team bonuses reduced patent registrations per employee by 0.003 units (RE, 10 percent significance level). Production alliances also reduced utility model or design registrations by 0.004 units (OLS, RE). Other social capital has weak and insignificant and effects on incremental capability (see Table 8 and Figure 9).

5. Discussion

This study tested the hypothesis of Subramaniam and Youndt (2005). They hypothesized that greater human capital reinforces radical innovative capability and enhancing organizational capital fosters incremental innovative capability. Social capital strengthens not only increment but also radical innovative capability.

The findings related to human capital are as follows. In the first model, researchers with more advanced skills strengthened radical innovative capability (26 percent). This indicates that the probability that a company creates market and customer changes through new products and services ahead of its competitors increased by 26 percent when the company has researchers with more advanced skills than required. The second model found that the highest education level – the PhD degree – contributed strongly to increasing radical innovative capability. A one percent increase of employees with a PhD degree caused a 0.0082-unit increase in patent registration per employee (RE). Their knowledge that stems from science contributed to the transformation of knowledge and technology, as noted in the study by Ahuja and Lampert (2001). Comparing effects of educational levels between bachelor's degree, master's degree and PhD, a higher education had a stronger effect on radical capability, thus increasing the number of patent registrations. The results seem to verify this study's the hypothesis on human capital and radical capability. The findings further revealed that firm-specific human capital – more advanced skills of employees in their fields – more strongly contributed to enhancing radical innovation of the product and customer markets, whereas general human capital – educational level – more strongly contributed to enhancing radical innovation in knowledge and technology.

Regarding incremental innovative capability, employees' more advanced marketing skills illustrated positive influences in both models. The influences were 26% in the first model and 0.004 units in the second model. Incremental capability as measured by utility model and design registration was negatively influenced by the number of PhDs, but positively influenced by the number of master's degrees. A master's degree education enhances incremental capability, whereas a PhD degree promotes radical capital. Educational levels seem to be positively correlated with levels of innovative capability.

Analyzing human capital effect on minor innovative capability, more advanced administration skills had a positive influence on becoming a company with minor innovative capability. This study seems to find a new fact that different types of innovative capabilities absorb and assimilate different types of human capital: radical market innovation absorbs more advanced researcher skills, incremental market innovation absorbs more advanced marketing skills, and minor market innovation absorbs more advanced administration skills.

With respect to organizational capital, a larger number of patent registrations and utility model and design registrations seemed to increase radical innovative capability and not incremental capability in this dataset. Particularly, a one-unit increase of utility or design registration per 100 employees may increase the probability of gaining radical innovative capability in product and customer markets by 2.6 percent. Patent registration also tended to enhance radical innovative capability. However, incremental capability was not significantly influenced by more patents or more utility and design registrations, unlike as stated in the hypothesis. Incremental capability was even negatively influenced by higher forms of MIS development compared with no MIS. This dataset might reject the hypothesis concerning innovative capability and organizational capital.

In reference to social capital, the first model demonstrated that HRD cooperation between prime company and subcontractor (33 percent) and employee stock ownership (12 percent) increased the probability of comprising radical innovative capability, whereas trade unions or other labor representatives and a mentoring system had a negative effect. Incremental capability of product and customer markets was positively affected by mentoring and negatively affected by HRD cooperation between the prime company and subcontractors, unlike radical capability. HRD cooperation between prime company and subcontractor supported a more radical innovation.

Trade unions and labor representatives had a positive effect on companies with minor innovative capability, a negative effect on companies with radical capability, and were insignificant for companies with incremental capability. Following the results, trade unions and other labor representatives seem to be negatively correlated with levels of innovative capability. The second model illustrated that R&D alliances with other companies increased the number of patent registrations. However, production alliances and team bonuses decreased the number of patent registrations. Incremental innovative capability was also negatively affected by production alliances. Other types of social capital did not reveal any significant influence on incremental innovation. This study found that social capital is more closely related to the radical capability than the incremental capability. The hypothesis on social capital and innovative capability might be verified by the positive effect of social capital on radical capability, but not by the positive effect of social capital on incremental capability.

This study might have verified that human, organizational, and social capital develop the knowledge to selectively influence incremental and radical innovative capabilities. The findings of this study supported the concept that greater human capital – more advanced researcher skills or a larger proportion of employees with PhD degrees – reinforces radical innovative capability according to the hypothesis of Subramaniam and Youndt (2005). Furthermore, this study demonstrated the significant effects of social capital, such as R&D alliances among enterprises, on radical capability. However, unlike the hypothesis, stronger organizational capital had stronger effects on radical innovative capability rather than on incremental capability.

What is the intellectual motor for rapidly growing innovative capabilities in Korean enterprises? In order to develop new products and customer markets, it seems that advanced research radically and marketing skills incrementally support innovation in Korean enterprises. A larger number of utility model and design registrations might more significantly reinforce innovative capability by developing new market than patent registrations. HRD cooperation between prime company and subcontractor, and employee stock ownership may radically promote the innovative capabilities. A mentoring system may incrementally reinforce the innovative capabilities in Korean Enterprises. In innovation of company's knowledge and technology, a larger proportion of employees with master's degree might contribute to enhance the number of utility model and design registrations. A larger proportion of employees with PhD help to increase the number of patent registrations. An advanced IT-Infrastructure and a R&D alliance with other company might increase the number of patent registrations in Korean enterprises.

Connecting results from the first model with those from the second model, a larger proportion of employees with master's degree might contribute to increase the number of utility model and design registrations. Moreover, a larger number of utility model and design registrations might more significantly reinforce innovative capability for developing new market in Korean manufacturing enterprises. A larger proportion of employees with PhD help to enhance the number of patent registrations. However, the patent registration less significantly contributes to developing new market than utility model and design registrations. Employees with PhD degree might, thus, neither directly nor indirectly through enhancing the number of patent registration contribute to developing new market. It would reveal that innovative capability in the market is empowered rather by employees with bachelor's or master's degree and utility model and design registrations than employee with PhD degree and patent registration.

6. Conclusion

By utilizing particular attributes of human, organizational, and social capital, this study attempted to overcome the ambiguity in variables of intellectual capital to increase the utility of the estimation results for economic decision making. Additionally, we attempted to increase our understanding of innovative capability in Korean enterprises by employing concrete indicators of intellectual capital. Unlike the study by Song (2012), organizational capital, such as number of patent registrations, did not reveal a positive effect on incremental innovative capabilities but demonstrated a positive effect on radical capability through which product and customer market change ahead of their competitors. Social capital, such as R&D alliances, promoted radical innovative capability in enterprises increasing the number of patent registrations. Utilizing more specified indicators of human capital, the present study might newly find the causality between the qualitative characteristics of human capital and the level of innovative capability: radical capability was related to more advanced research skills, incremental capability was related to more advanced marketing skills, and minor innovation capability was related to more advanced administration skills. This study might also disclose a positive correlation of educational level with the level of innovative capability. General human capital might be more significantly related to knowledge innovation, while firm-specific human capital seems to be closely related to market innovation. All those could be new subjects to analyze the influence of different types of human capital on companies' innovative performance in the future. This study speculates that development utilizing bachelor's or master's degree and utility model and design registrations is more significant than research utilizing PhD degree and patent registrations in Korean enterprises for the innovation. It is also interesting to prove this speculation as the future study.

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Notes

Note 1. The population of the sample consists of the following manufacturing industries: manufactures of food and beverage, tobacco, textiles products, clothing accessories and fur products, leather bags and footwear, wood and products of wood manufacturing, pulp, paper and paper products, printing and reproduction of recorded media, coke, briquettes and refined petroleum products, chemicals and chemical products, medical materials and pharmaceuticals manufacturing, rubber products and plastic products, non-metallic mineral products, primary metal manufacturing, metal processing products, electronic components, computer, video, audio and communications equipment manufacturing, medical, precision and optical instruments, watches manufacturing, electrical equipment manufacturing, and other machinery and equipment manufacturing, car and trailer manufacturing, manufacture of other transport equipment, furniture manufacturing, and manufacture of other products.

JUNG, Mee-Kyung (PhD Economics). She was born in Seoul in South Korea on 1st of Feb. 1964. She studied in Economics in 1999-2006 and received PhD in Economics at Goethe-University in Frankfurt on Main in Germany in 2010. In 2011-2014, she worked as lecturer at University of Frankfurt or Ruhr-University Bochum.

Appendix

Table 1. Variables of radical and incremental innovative capability

<table>
<tr><th></th><th>Subramaniam and Youndt (2005); Song (2012)</th><th>The Present Study</th></tr>
<tr><td>Innovative capability</td><td>How would you rate your organization's capability to generate the following types of innovations in the products/services introduced in the last five years?
Radical Innovative Capability: Innovations that make your prevailing product/service lines obsolete. Innovations that fundamentally change your prevailing products/services. Innovations that make your existing expertise in prevailing products/services obsolete
Incremental Innovative Capability: Innovations that reinforce your prevailing product/service lines. Innovations that reinforce your existing expertise in prevailing products/services. Innovations that reinforce how you currently compete.
Answered using a seven-point Likert format (1 = weaker than competition; 4 = similar to competition; 7 = stronger than competition).</td><td>Model1. Market competitiveness of product or service
viii. Radical Innovative Capability: Company leads customer and market changes by development of new items ahead of its competitors.
ix. Incremental Innovative Capability: Entering new markets and development of new items is not leading, but company selectively develops items taking the market performance of the leading companies into account.
x. Minor innovative capability: Companies do not introduce a noteworthy new product into the market.

Model 2. Number of different patent registration per employee
xi. Radical Innovative Capability: Patent registration per employee
xii. Incremental Innovative Capability: Utility model or design registration per employee</td></tr>
</table>

Variables of innovative capability are created from the Human Capital Corporate Panel (HCCP) by applying theories concerning innovative capability. These are compared with variables of innovative capabilities used by Subramaniam and Youndt (2005) and Song (2012) in this table.

Table 2. Variables for human capital

	Subramaniam and Youndt (2005); Song (2012)	The Present Study
Human Capital	What extent do you agree with those? • Our employees are highly skilled. • Our employees are widely considered the best in our industry. • Our employees are creative and bright. • Our employees are experts in their particular jobs and functions. • Our employees develop new ideas and knowledge. Answered using a seven-point Likert format (1 = strongly disagree; 7 = strongly agree).	Are your employees' skills (much) better than required levels in their specialties? • Skill of researcher • Skill of employees in marketing • Skill of engineers • Skill of administers • Skill of employees in production Percentage of regular employees in each educational level among all regular employees. • Junior college graduates • Employees with bachelor's degree • Employees with master's degree • Employees with PhD degree

Variables for human capital are created from HCCP by applying theories of human capital. These are compared with variables of human capital used by Subramaniam and Youndt (2005) and Song (2012) in this table.

Table 3. Variables for organizational capital

	Subramaniam and Youndt (2005); Song (2012)	The Present Study
Organization Capital	What extent do you agree with those? • Our organization uses patents and licenses as a way to store knowledge. Much of our organization's knowledge is contained in manuals, databases, etc. • Our organization's culture (stories, rituals) contains valuable ideas, ways of doing business, etc. • Our organization embeds much of its knowledge and information in structures, systems, and processes. Answered using a seven-point Likert format (1 = strongly disagree; 7 = strongly agree).	Management information system (MIS) for human resource. • Do not exist. If companies have any MIS • Introducing stage: introduced data- base system of employee's personnel information. • Web application stage: using the Web to support bi-directional exchange of personnel information. • Application stage of corporate portal system: utilizing integrated HR information system in relation to business processes as core technology. Number of patent, utility model, design registration per 100 employees.

Variables for organizational capital are created from HCCP by applying theories of organizational capital. These are compared with variables of organizational capital used by Subramaniam and Youndt (2005) and Song (2012) in this table.

Table 4. Variables for social capital

	Subramaniam and Youndt (2005); Song (2012)	The present study
Social Capital	To what extent do you agree with those? • Our employees are skilled at collaborating with one another to diagnose and solve problems. • Our employees share information and learn from one another. • Our employees interact and exchange ideas with people from different areas of the company. • Our employees partner with customers, suppliers, alliance partners, and others to develop solutions. • Our employees apply knowledge from one area of the company to problems and opportunities that arise in another area. Answered using a seven-point Likert format (1 = strongly disagree; 7 = strongly agree).	Indicators for • Mentoring system. • Evaluating performance on how managers foster/train their staffs. • Team bonus system that awards team performance. • Employee stock ownership system. • Trade union or other labor representatives. • HRD cooperation between prime company and subcontractor. Indicators for Alliance with other companies in the following areas: 10. Research and development 11. Production 12. Marketing 13. Capital

Variables for social capital are created from HCCP by applying theories of social capital. These are compared with variables of social capital used by Subramaniam and Youndt (2005) and Song (2012) in this table.

Table 5. Descriptive statistics for 324 companies for probit estimation

Variable	Mean	Std. Dev.	Min	Max
Radical market competitiveness	0.3056	0.4614	0	1
Incremental market competitiveness	0.4599	0.4992	0	1
Minor innovative market competitiveness	0.2346	.4244	0	1
Higher skill of researcher	0.1698	0.3760	0	1
Higher skill in marketing	0.1512	0.3588	0	1
Higher skill of engineer	0.1914	0.3940	0	1
Higher skill in administration	0.1914	0.3940	0	1
Higher skill in production	0.1204	0.3259	0	1
Proportion of junior college for all employees	0.1843	0.1324	0	0.7294
Proportion of bachelor’s degree for all employees	0.3149	0.1566	0.0098	0.9018
Proportion of master’s degree for all employees	0.0342	0.0447	0	0.3333
Proportion of PhD for all employees	0.0042	0.0089	0	0.0769
No Management information system (MIS)	0.4475	0.4980	0	1

Introduction stage of MIS	0.2654	0.4422	0	1
Web application of MIS	0.1358	0.3431	0	1
Application of corporate portal of MIS	0.1512	0.3588	0	1
Patent registration per 100 employees	0.9829	3.4223	0	45.3846
Utility model & design registration per 100 employees	0.4144	1.4885	0	17.4208
Having mentoring system	0.4321	0.4961	0	1
Evaluating performance of manager on fostering/training of their staffs	0.4228	0.4948	0	1
Team bonus	0.1914	0.3940	0	1
Employee stock ownership system	0.2315	0.4224	0	1
HRD cooperation between prime company and subcontractor	0.1728	0.3787	0	1
Trade union or labor representatives	0.9352	0.2466	0	1
Alliance with other company in R&D	0.1389	0.3464	0	1
Alliance in production	0.0802	0.2721	0	1
Alliance in marketing	0.0864	0.2814	0	1
Alliance in capital	0.0494	0.2170	0	1
Age of enterprise	33.7222	17.0823	5	114
Return on assets (ROA)	0.0139	0.1670	-2.6010	0.2320
Return on equity (ROE)	1.3651	31.6316	-286.42	92.980
Proportion of researcher for all employees	0.0758	0.0685	0	0.3750
Training expenditure per employee	0.0113	0.0669	0	1.1880
Being subcontractor	0.3302	0.4710	0	1
Public registration/listed company	0.3457	0.4763	0	1
Registration on KOSDAQ	0.2747	0.4470	0	1
Financial Supervisory Service registration	0.3796	0.4860	0	1
Company with between 100 and 299 employees	0.5000	0.5008	0	1
300-999 employees	0.3611	0.4811	0	1
1000-1999 employees	0.0772	0.2673	0	1
more than 2000 employees	0.0617	0.2410	0	1
Demand development for items: very low	0.0432	0.2036	0	1
Demand development: low	0.1821	0.3865	0	1
Demand development: average	0.1852	0.3890	0	1
Demand development: high	0.5247	0.5002	0	1
Demand development: very high	0.0648	0.2466	0	1
Organizational development in headquarter (ODH): Almost not changed	0.0988	0.2988	0	1
OHD: few change	0.2747	0.4470	0	1
ODH: changed	0.4938	0.5007	0	1
ODH: largely changed	0.1327	0.3398	0	1
Working process development (WPD):	.1080	.3109	0	1

almost not changed				
WPD: few Change	.3210	.4676	0	1
WPD: changed	.4475	.4980	0	1
WPD: largely changed	.1235	.3295	0	1
Technique enhancement : almost not changed	0.0772	0.2673	0	1
Few technical change	0.3704	0.4837	0	1
Technique changed	0.4691	0.4998	0	1
Technique largely changed	0.0833	0.2768	0	1

Description of 22 industry dummies is omitted.

Table 6. Descriptive statistics for 635 observations of companies for OLS and random effects estimation

Variable	Mean	Std. Dev	Min	Max
Patent registration per employee	0.0085	0.0320	0	0.4600
Utility model & design registration per employee	0.0043	0.0148	0	0.1742
Higher skill of researcher	0.1732	0.3787	0	1
Higher skill in marketing	0.1591	0.3660	0	1
Higher skill of engineer	0.2110	0.4084	0	1
Higher skill in administration	0.1953	0.3967	0	1
Higher skill in production	0.1386	0.3458	0	1
Proportion of junior college for all employees	0.1832	0.1277	0	0.7294
Proportion of bachelor's degree for all employees	0.3081	0.1543	0	0.9018
Proportion of master's degree for all employees	0.0335	0.0432	0	0.3333
Proportion of PhD for all employees	0.0041	0.0089	0	0.0800
No Management information system (MIS)	0.4268	0.4950	0	1
Introduction stage of MIS	0.2772	0.4480	0	1
Web application of MIS	0.1449	0.3523	0	1
Application of corporate portal of MIS	0.1512	0.3585	0	1
Having mentoring system	0.4063	0.4915	0	1
Evaluating performance of manager on fostering/training of their staffs	0.4157	0.4932	0	1
Team bonus	0.1701	0.3760	0	1
Employee stock ownership system	0.2472	0.4317	0	1
HRD cooperation between prime company and subcontractor	0.1717	0.3774	0	1
Trade union or labor representatives	0.9260	0.2620	0	1
Alliance with other company in R&D	0.1307	0.3373	0	1
Alliance in production	0.0709	0.2568	0	1
Alliance in marketing	0.0866	0.2815	0	1
Alliance in capital	0.0520	0.2221	0	1
Age of enterprise	33.7906	17.0197	3	114
Return on assets (ROA)	0.0205	0.1485	-2.6010	0.2623

Return on equity (ROE)	3.4668	29.2260	-286.42	162.72
Proportion of researcher for all employees	0.0763	0.0720	0	0.51163
Training expenditure per employee	0.0144	0.0835	0	1.60482
Being subcontractor	0.3402	0.4741	0	1
Public registration/listed company	0.3780	0.4853	0	1
Registration on KOSDAQ	0.2803	0.4495	0	1
Financial Supervisory Service registration	0.3417	0.4747	0	1
Company with between 100 and 299 employees	0.4882	0.5003	0	1
300-999 employees	0.3717	0.4836	0	1
1000-1999 employees	0.0724	0.2594	0	1
more than 2000 employees	0.0677	0.2515	0	1
Radical innovative market competitiveness	0.3244	0.4685	0	1
Incremental innovative market competitiveness	0.4268	0.4950	0	1
Minor innovative competitiveness	0.2488	0.4327	0	1
Demand development for items: very low	0.0551	0.2284	0	1
Demand development: low	0.2094	0.4072	0	1
Demand development: average	0.2047	0.4038	0	1
Demand development: high	0.4756	0.4998	0	1
Demand development: very high	0.0551	0.2284	0	1
Year: 2009	0.4740	0.4997	0	1
Year: 2011	0.5260	0.4997	0	1

Description of 23 industry dummies is omitted.

Table 7. Marginal effects of intellectual capitals on innovative capabilities using market competitiveness as explained variables

	Radical Innovation	Incremental Innovation	Minor Innovation
Human Capital			
Higher skill of researcher	0.2575*** 2.35	-0.3041*** -2.72	0.1370* 1.82
Higher skill in marketing	-0.0772 -0.78	0.2583** 2.09	-0.0817* -1.84
Higher skill of engineer	-0.1417* -1.79	0.0302 0.26	0.0603 0.96
Higher skill in administration	-0.1031 -1.12	-0.0663 -0.54	0.1365** 1.92
Higher skill in production	0.0579 0.42	0.0640 0.44	-0.0498 -1.05
Percent of junior college	-0.001658 -0.76	0.002568 1.01	-0.000285 -0.24
Percent of bachelor’s degree	0.005556*** 2.57	0.000811 0.32	-0.002995** -2.3

Percent of master's degree	0.005858 0.48	-0.006916 -0.62	0.001258 0.3
Percent of PhD	-0.108657** -2.10	0.063742 1.28	0.033421 1.36
Organizational Capital			
Introduction stage of Management information system (MIS)	0.1104 1.52	-0.1647** -1.96	0.0433 0.93
Web application of MIS	0.0749 0.82	-0.1968** -1.94	0.1830** 2.38
Application of corporate portal of MIS	0.1681 1.55	-0.0974 -0.79	0.0103 0.16
Patent registration per 100 employees	0.01306 1.50	0.006028 0.58	-0.01514* -1.74
Utility model & design registration per 100 employees	0.02579* 1.61	-0.00209 -0.11	-0.0933*** -2.53
Social Capital			
Having mentoring system	-.0965* -1.64	0.1663** 2.31	-0.0230 -0.64
Evaluating performance of manager on fostering/training of their staffs	-0.0425 -0.70	0.0869 1.14	-0.0294 -0.83
Team bonus	-0.0562 -0.83	0.0963 1.16	0.0065 0.16
Employee stock ownership system	0.1295* 1.82	-0.0346 -0.42	-0.0495 -1.51
HRD cooperation between prime company and subcontractor	0.3318*** 3.33	-0.2453* -2.84	-0.0190 -0.43
Trade union or labor representatives	-0.2742** -2.23	0.0423 0.35	0.0819** 2.09
Alliance in R&D	-0.0693 -0.71	-0.0826 -0.78	0.1707* 2.58
Alliance in production	0.1591 1.27	-0.0019 -0.01	-0.0840 -1.51
Alliance in marketing	0.1564 1.33	0.01179 0.09	-0.0834** -2.02
Alliance in capital	-0.1372 -1.37	-0.0389 -0.26	0.2179** 1.89
Number of obs.	324	321	305
Wald chi	122.75	132.01	111.10
Pseudo R2	0.3273	0.2883	0.3754

Base variable for management information system (MIS) of Introduction stage, Web application stage, and application stage of corporate portal is no MIS. z-statistics are presented in the 2nd. line of cells in the table. For the test-statistics, the heteroskedasticity-robust standard errors are employed. Estimates of other control variables are omitted in the table. *p < .10, **p < .05, ***p < .01.

Table 8. Effects of intellectual capitals on innovative capabilities using patent registration and utility model & design registration as explained variables

	Patent registration per employee		Utility & design registration per employee	
	OLS	Random effects	OLS	Random effects
Human Capital				
Higher skill of researcher	0.00567 1.22	0.00317* 1.6	-0.00023 -0.15	-0.00057 -0.4
Higher skill in marketing	-0.00428 -0.82	0.000643 0.27	0.004067*** 2.51	0.00402*** 2.5
Higher skill of engineer	-0.00154 -0.6	-0.00028 -0.21	-0.00286* -1.69	-0.00262* -1.61
Higher skill in administration	-0.00045 -0.15	-0.00423** -1.96	-0.00151 -0.94	-0.00126 -0.9
Higher skill in production	0.010506* 1.82	0.007082* 1.75	0.001933 0.96	0.002064 1.05
Percent of junior college	-0.000118 -1.10	-0.000039 -0.57	0.000038 0.82	0.000031 0.63
Percent of bachelor’s degree	0.000185* 1.85	0.0001237* 1.65	-0.0000129 -0.3	-0.0000212 -0.46
Percent of master’s degree	-0.000792 -1.23	-0.000502 -1.57	0.000276** 1.94	0.000238* 1.74
Percent of PhD	0.016529** 2.16	0.008172* 1.76	-0.00158*** -2.44	-0.001357** -2.25
Organizational Capital				
Introduction stage of MIS	0.00033 0.15	-0.00067 -0.37	0.000757 0.55	0.001039 0.74
Web application of MIS	-0.00018 -0.05	-0.00094 -0.4	0.003362 1.33	0.002876 1.23
Application of corporate portal of MIS	0.012348** 2.06	0.004043* 1.61	0.001281 0.56	0.001647 0.71
Social Capital				
Having mentoring system	-0.00037 -0.21	0.001285 1.32	-0.00013 -0.09	0.000177 0.13
Evaluating performance of manager on fostering/training of their staffs	-0.00508* -1.79	-0.00038 -0.2	-0.00203 -1.49	-0.00178 -1.31

Team bonus	-0.00269 -1.29	-0.00346* -1.83	-0.00053 -0.39	-0.00041 -0.29
Employee stock ownership system	0.007712*** 2.59	0.001517 0.7	-0.00124 -0.74	-0.00138 -0.83
HRD cooperation between prime company and subcontractor	0.000909 0.35	0.000695 0.51	-6.6E-05 -0.04	-3.7E-05 -0.02
Trade union or labor representative	0.003505 0.6	0.00187 0.31	0.001581 0.8	0.002433 1.23
Alliance in R&D	0.009871** 2.16	0.005453** 2.2	0.001398 0.67	0.000944 0.44
Alliance in production	-0.01256*** -2.75	-0.00628*** -2.53	-0.00433** -1.99	-0.00428** -2.19
Alliance in marketing	-0.00297 -0.91	0.002329 1.08	0.001957 0.76	0.002582 1.05
Alliance in capital	-0.00311 -0.76	0.000182 0.07	0.001135 0.32	-7.2E-05 -0.02
Number of obs. (No. of enterprises)	635	635 (380)	635	635 (380)
R2 or Wald chi	0.3585	87.55	0.1524	77.95

Base variable for management information system (MIS) of Introduction stage, Web application stage, and application stage of corporate portal is no MIS. z- statistics or t-statistics are presented in the 2nd. line of cells in the table. For the test-statistics, the heteroskedasticity-robust standard errors are employed. Estimates of other control variables are omitted in the table. *$p < .10$, **$p < .05$, ***$p < .01$.

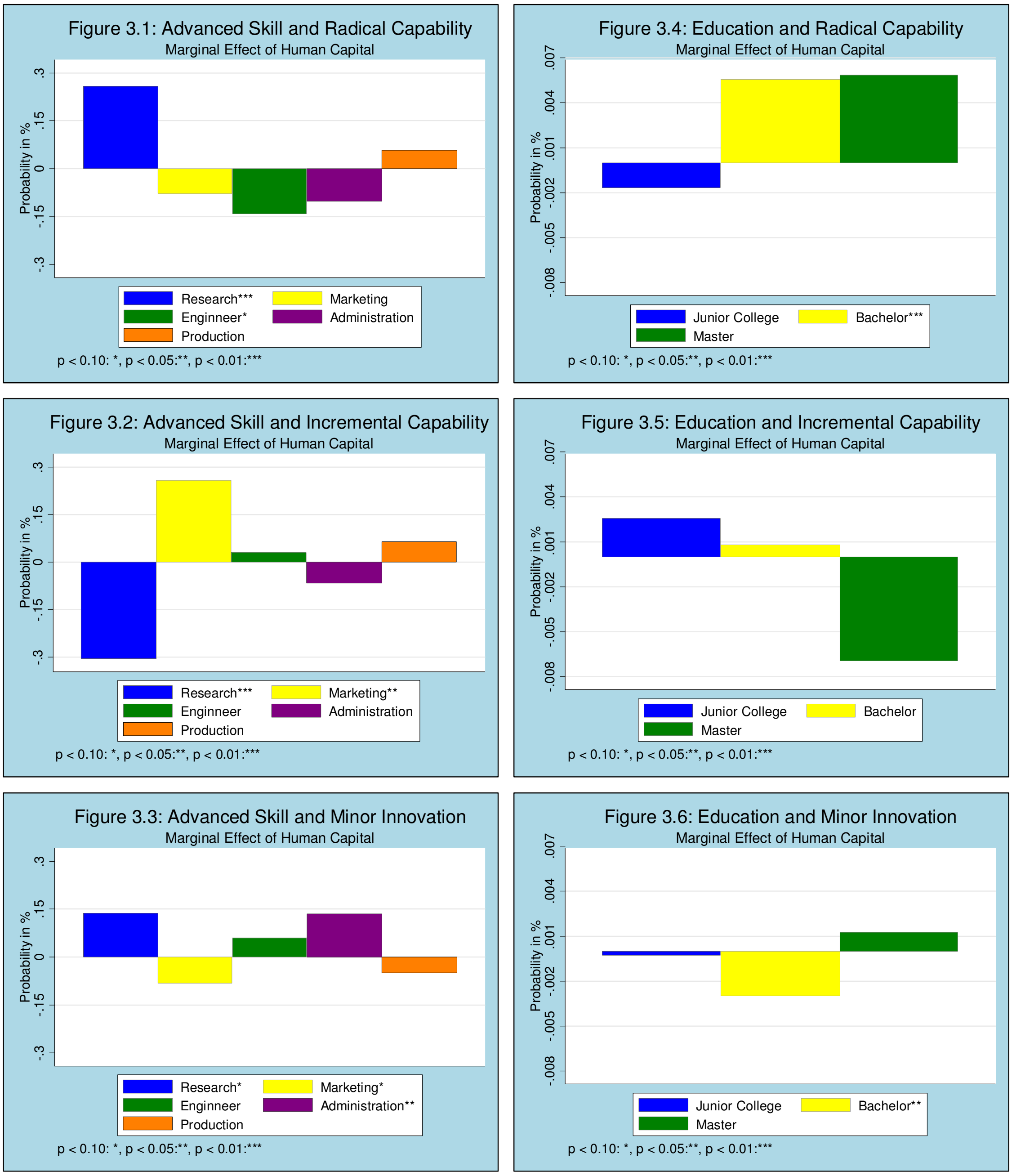


Figure 3. Effect of Human Capital on Innovative Capability measured by Market Competitiveness

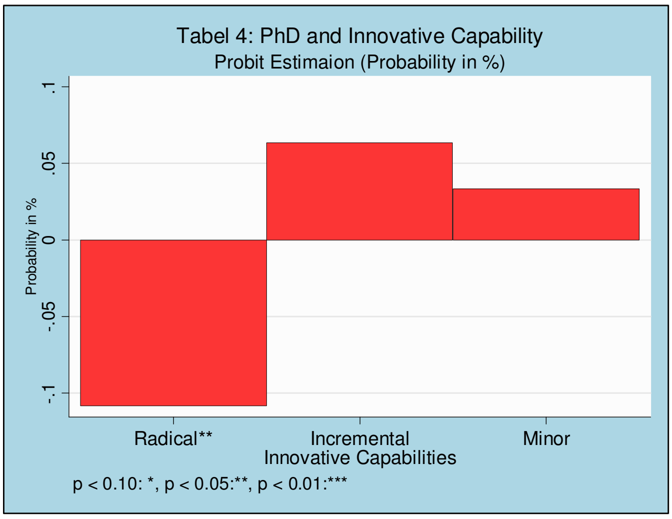


Figure 4. Effect of Proportion of PhD degree in the Company on Innovative Capability measured by Market Competitiveness

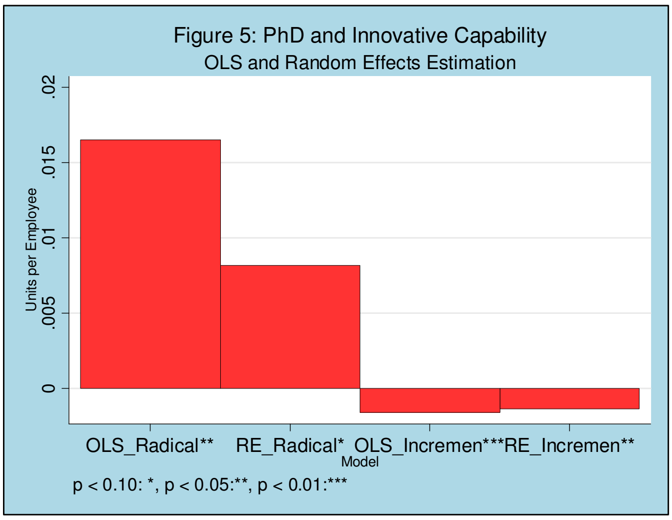


Figure 5. Effect of Proportion of PhD degree in the Company on Innovative Capability measured by Knowledge and Technology

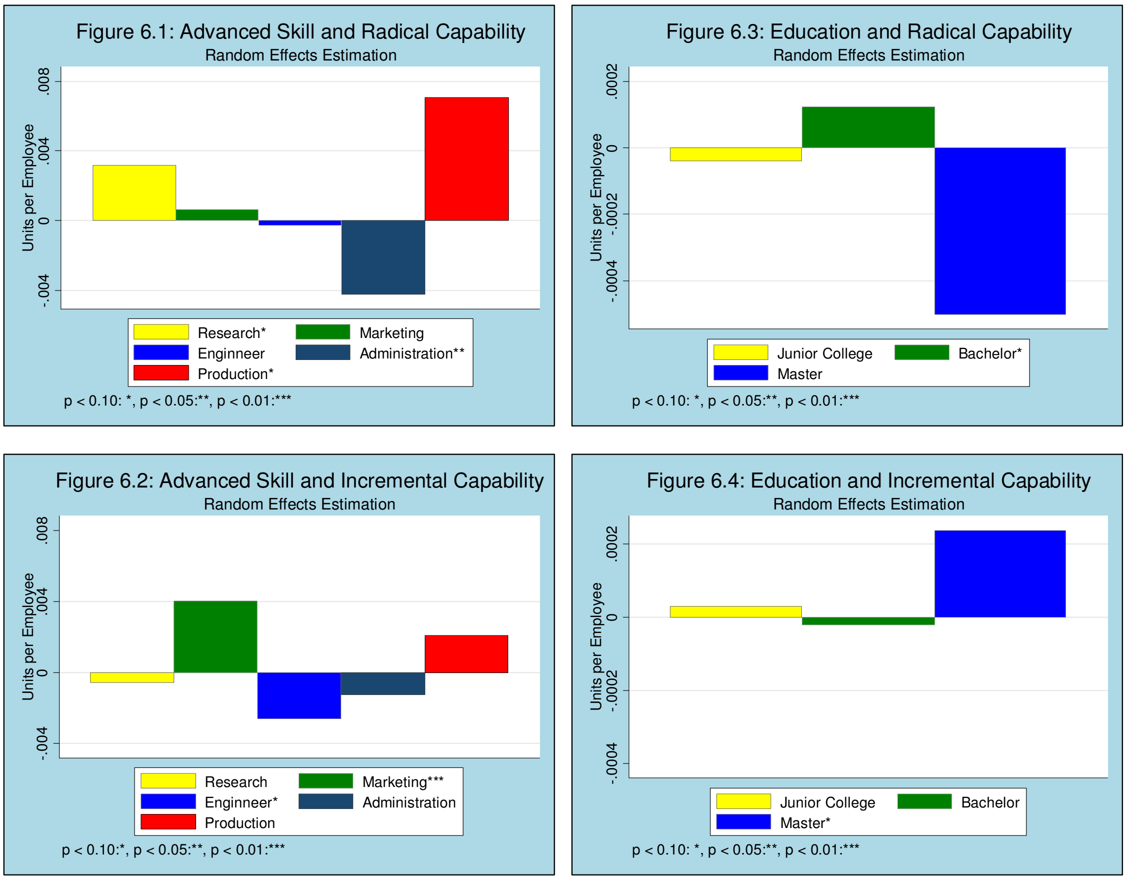
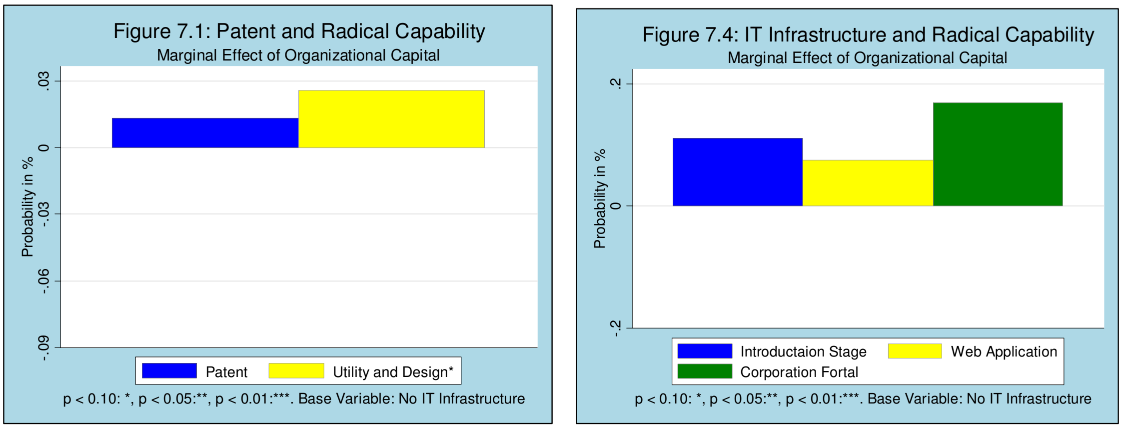


Figure 6. Effect of Human Capital on Innovative Capability measured by Knowledge and Technology



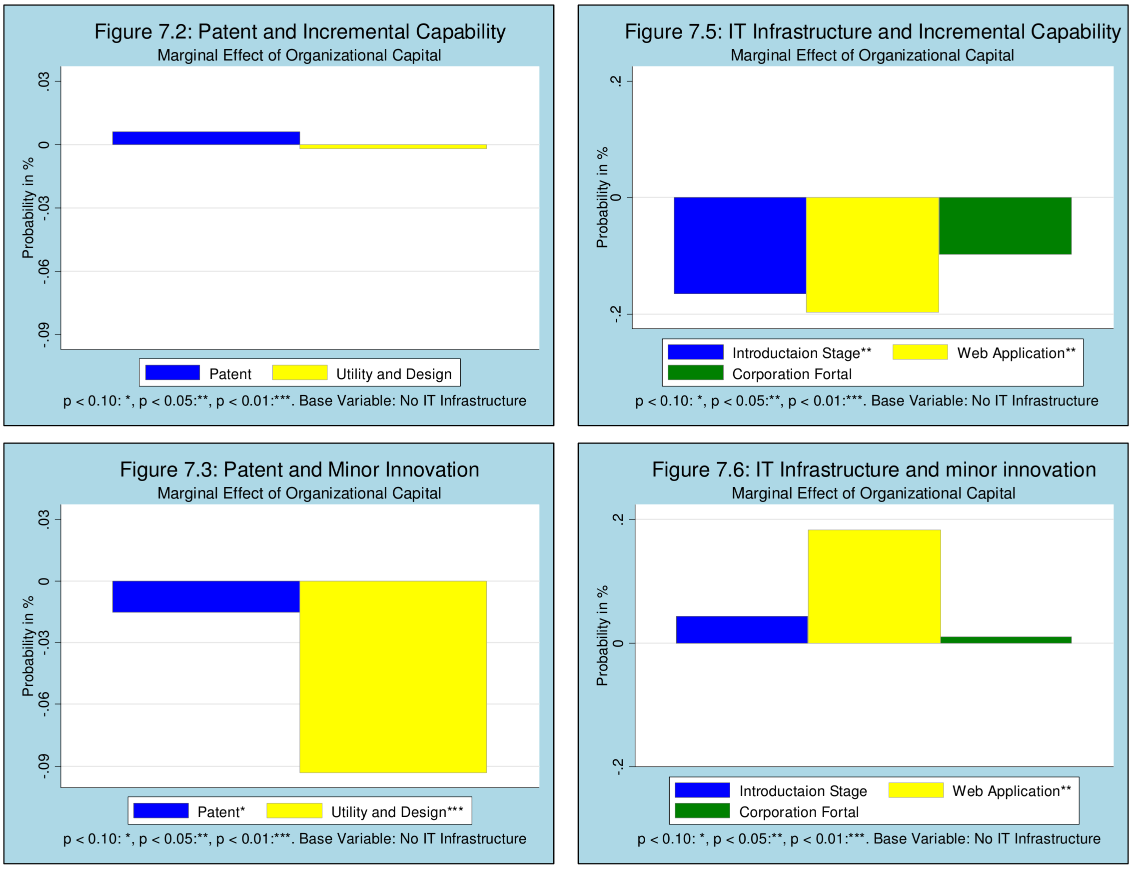
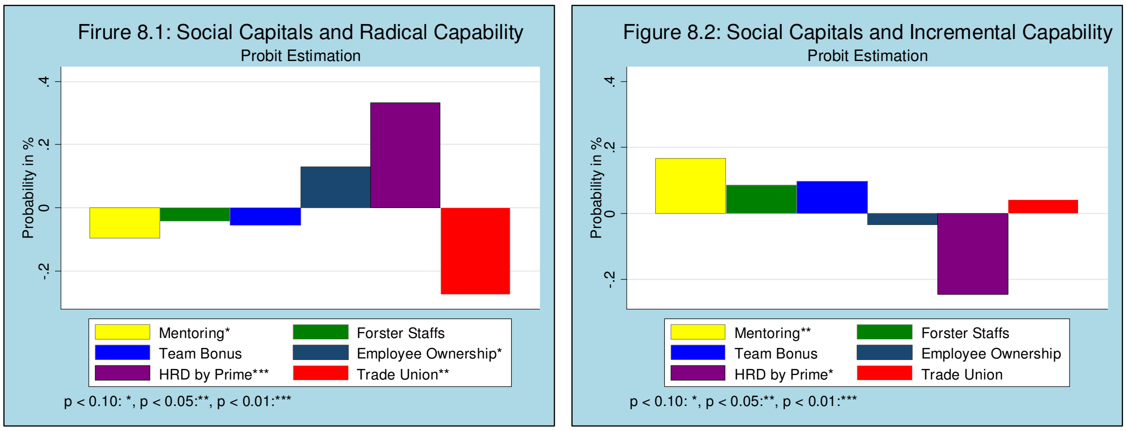


Figure 7. Effect of Organizational Capital on Innovative Capability measured by Market Competitiveness



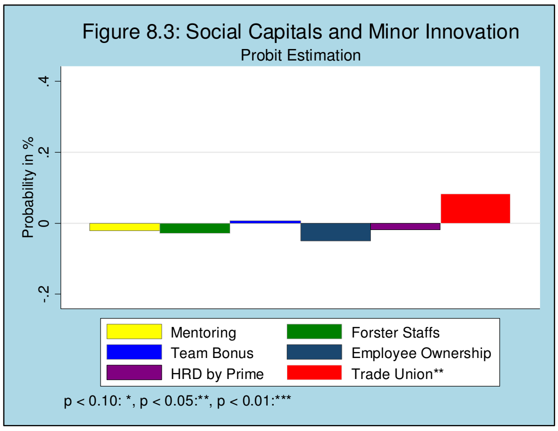


Figure 8. Effect of Social Capital on Innovative Capability measure by Market Competitiveness

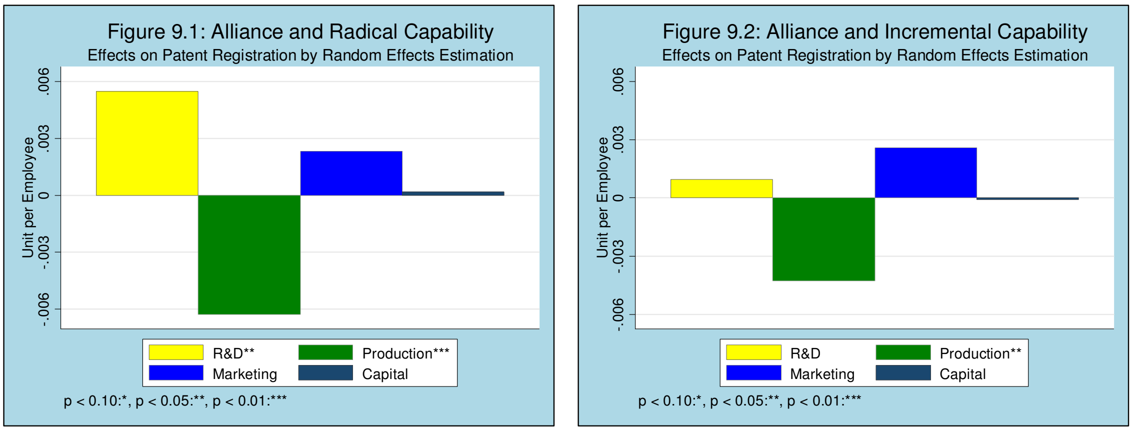


Figure 9. Effect of Social Capital on Innovative Capability measure by Knowledge and Technology