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Measurement of Knowledge Potential in the ICT Service Industry: A Quantum Mechanics View

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ABSTRACT This paper investigates the measurement of the knowledge potential by u sing interactions of knowledge assets in the knowledge-based industries. In particular, the paper examined knowledge potential of Korea's ICT service industry by introducin g a quantum mechanics view. The study provides a confirmatory factor analysis, a type of structural equation modeling, to construct paths and relationships between factors b ased on knowledge potential between latent and observed factors. The latent variables are velocity, mass and position which derive from quantum mechanics concept. Also, observed factors are obtained from the surveys which conducted by the Science and Te chnology Policy Institute of Korea, in 2011 of 2,000 Korean ICT service. The relations hip among position and velocity has significant impacts than mass. By contrast, in the IT software industry, variables for velocity and mass have more meaningful relationshi ps. This implies that human capital is a more important factor than networks between s oftware industry firms. It also indicates that the variables for innovation velocity and it s enhancement power of human capital have positive effects on the growth rate in long run curve of knowledge potential across the whole ICT service industry and may be th e key drivers of firms.The main contribution of this paper is to provide the perspective on knowledge potential measurement by introducing quantum mechanics view to see t he interactions between knowledge assets in ICT service industry while traditional me asurement methods evaluate only across the intellectual capital itself.

Keywords: ICT, service industry, innovation, knowledge, quantum mechanics

Introduction

Skyrme (1998) argued that the management and measurement of knowledge asset repr esent the most important issue for knowledge-based organizations. Because knowledg e asset cannot be readily bought and sold, they should be created in-house by some org anizations (Teece, D.J., 2000). These organizations have difficulty capturing their kno wledge potential value before they obtain certain forms of explicit and tacit knowledge because knowledge is an intangible asset (del-Rey-Camorro et al., 2003). Many techni ques and new tools have been employed to capture and measure knowledge of firms and workers in different ways. For example, direct intellectual capital (DIC), market capitalization (MC), return on assets (ROA), and scorecard (SC) methods are the most frequently used measurement approaches to firm value. These methods can be classified into two groups. The first group includes traditional measurement methods, whereas the other, knowledge-based ones (Kim & Lee, 2001). Traditional measurement methods refer to those using objective financial data to calculate knowledge-based assets like intellectual capital(IC) or patent and are sufficient for comparing different organizations because they use only objective financial data. However, not being tangible like revenue or stock prices, any measurement of knowledge assets is fragmented, not comprehensive. For intangible assets like know-how and idea, there are no effective measurement tools and entities of organizations are challenging to measure intangible knowledge assets (del-Rey-Camorro et al., 2003). The other method uses subjective factors to measure knowledge assets of firms or workers and is more efficient in that different organizations have different regimes and characteristics of knowledge potential. Unfortunately, if the different measurement factors are considered for different organizations in a subjective manner for more precise measurements, then these organizations cannot be compared for meaningful implications.

From an industry perspective, there is some evidence of obstacles to the application of these methods to the ICT service industry, which has helped drive Korea's rapid economy growth. According to a study by the Korea Communications Commission in 2011, the ICT industry accounts for up to 20% of the country's GDP growth rate. Given the effect of ICT and the growth of the service industry, measuring knowledge assets and making effective decisions represent key issues in Korea's economic growth. However, SMEs account for more than 97% of Korea's ICT service industry, making it difficult to apply many techniques. Garengo et al., (2005) point out that SMEs are quite different in three aspects from large firms, namely uncertainty, innovation, and evolution. Tenhunen et al. (2001) state that measuring the performance and assets of SMEs is difficult because of a lack of time available or involvement of top management. Nevertheless, because of SMEs' pivotal role in the Korean economy, new measurement methods are required.

To address the limitations of exist methods, this study provides a new measurement tool that makes use of general and objective factors to compare different organizations and produce meaningful policy implications. This methodology is inspired by Fink's (2005) quantum mechanics approach and the KISDI's (2013) GEM/social model. Fink proposes that a quantum mechanics view in knowledge management (KM) can help measure knowledge potential because knowledge workers can be considered quanta and knowledge assets can thus be measured in terms of their velocity, mass, and position. Velocity refers to the measurement median for speed and quality of the human capital. This study translates it into a functional dimension consisting of data generation, application, and service parts. Mass refers to human capital dependent variables. This study treats mass as a personal dimension consisting of ideas, concepts, refinements, and awareness. The position is an element of network-related factors influencing organizations and can be described as a social dimension classified as stimulus-rich, organic, collaborative, intelligent, adaptable, and linked environments. These factors of each dimension are considered to measure knowledge assets of Korea's ICT service industry, and this experiment reveals the interaction of between each dimension and knowledge asset growth.

Literature Review

ICT Service Industry

Lee and Lee (2011) recently report the "service economy" trend in which the service industry itself takes into account more than half of developed countries' GDP. Given this perspective, Korea's ICT service industry has led the country's economy. Here, because of increasing competition, productivity and innovation, which reflect through knowledge assets, have become one of the most important topics at the management level, particularly in the service sector (Lee & Lee, 2011). Although many studies have focused on the importance of the ICT service industry, which has considerable influence on the economy at national and global levels, the question of how knowledge should be managed in the ICT service industry has not been covered as well as in the manufacturing sector. In the service sector, incremental innovation patterns are more important than those in the manufacturing sector because of the knowledge-intensive industry's characteristics (De Jong & Kemp, 2003). In addition, service offerings should provide a solution from direct contact with customers in certain non-reproducible situations. This provides support for the argument that there is no standard answer for the service sector because there is ad hoc innovation with extemporaneous answers (Janssen, 2003). Therefore, those who focus on the service sector cannot easily capture small improvements, which sometimes can bring about huge success. Sometimes many factors driving innovation in the ICT service industry reflect intangible assets such as know-how. Therefore, it is more difficult to capture the characteristics of knowledge and knowledge-related activities in the ICT service industry than the ICT manufacturing industry.

Similarly, the importance of R&D in the ICT service industry has been ignored because of risk and uncertainty of their result. R&D managers generally lack confidence in terms of obtaining meaningful results (Djellal, F. et al., 2003; Gault, 1997; Miles, 2007). However, some studies have investigated the ICT service industry's knowledge-related characteristics for successful R&D management. Spender and Marr (2006) explained that human resources in the ICT service industry are strategically more relevant than other organizational factors. Therefore, human resources are assumed to be a key factor in obtaining and maintaining a competitive advantage. Intellectual capital managers often invest to enhance and emphasize their organization's human capacity. However, there is an opposing view as well. If a service firm invests too much in human capital while neglecting its structural capital, the balance between tacit knowledge and explicit knowledge can collapse. Then the firm may be exposed to a high level of risk because it reduces efficiency in the context of the firm's productivity (Calabrese & Costa, 2013; Schlesinger & Heskett, 1991). Given the above discussion, it is clear that today's ICT service industry plays an important role in the global economy. Therefore, the potential achievement of its core competitiveness and productivity requires the identification of which factors are associated with knowledge and which help to increase knowledge in a relationship-oriented manner.

Knowledge Measurement Methods

For better performance and innovation, firms have to measure knowledge potential in an efficient and well-managed manner. Therefore, studies measuring the value of intangible assets or intellectual capital have suggested various methods based on innovation theory. Knowledge-measurement tools can catalyze through decision-making processe s, reduce the amount of time spent on business processes, and provide a competitive ad vantage as a result. Skyrme (1998) describes that the measurement of knowledge has b ecome more structured and widespread and thus that the need to establish it from diffe rent models and methods to have more important implication for firm actual value. Sv eiby (2005) shows various knowledge approaches to four measurement categories: DI C, MCM, ROA, and SC. The DIC method estimates the $-value of intangible assets by identifying various components. Once the components are identified, they can be eval uated directly either individually or as an aggregated coefficient. The MCM calculates the difference between a firm's market capitalization and shareholders' equity as the va lue of its intellectual capital or intangible assets. The ROA method divides average pre -tax earnings of a firm over a period of time by its average tangible assets. The result i s the ROA of the firm, and it is compared with the industry average. The difference is multiplied by the firm's average tangible assets to compute average annual earnings fr om the firm's intellectual capital. The SC method identifies different components of int ellectual capital and corresponding indicators generated in scorecards or graphs.

Monetary valuation methods such as ROA and MCM methods are more efficient in the context of M&A situations or market valuation because they are measured by the s ame unit, namely the financial value of intangible assets. In these cases, comparing fir ms in the same industry may be possible by using these methods. One disadvantage of these methods is that, by translating intangible assets into monetary terms, they may b ecome superficial. These methods are sensitive to interest and discount rate assumptio ns and cannot be applied to nonprofit organizations, internal departments, and public s ector organizations.

On the other hand, DIS and SC methods have different advantages. They can provid e a more comprehensive result for an organization's assets than financial metrics and t hus can be widely applied at any organizational level. They measure closer to an even t, and therefore reports can be faster and more accurate than pure financial measures. Because they do not need to be measured in financial terms, they are useful for nonpro fit organizations, internal departments, and public sector organizations as well as for e nvironmental and social purposes. In terms of their disadvantages, indicators are conte xtual and have to be customized for each organization or purpose, making comparison s difficult, and these methods are new and thus not readily adopted by societies and ma nagers used to seeing everything from a purely financial perspective. Comprehensive a pproaches can generate huge amounts of data that are difficult to analyze and commun icate. To measure knowledge assets and their potential capacity in the ICT service ind ustry; this generally consists of SMEs requiring a new method that adopts and strength s while overcoming weaknesses. Stewart (1997) explains that such a new method shou ld not only measure factors influencing knowledge assets but also pay close attention t o interactions between them because intellectual capital is created not from discrete fa ctors of human, structural and customer capital but from interactions between them.

Knowledge Potential as Velocity

Fink (2004, p.167) mentions that "Knowledge velocity is the implementation speed for good solutions and the quality of the solution to the problem. Knowledge velocity sho ws the direction towards the high quality solution of customer problems. Knowledge v elocity is the set of accomplishment of problem solving objectives." Knowledge veloci ty is directly related to innovation capability because it reflects the technological functi on of an organization. Ahmed et al., (1999) also argues that a firm can get benefits fro m taking the KM strategy which reducing the cost of developing new services and inn ovation capability mostly known as a key factor of effectiveness. This dimension consi sts of a data generation layer, an application end layer, and a service median layer (KI SDI, 2013). These layers explain the key role played by the ICT service industry as a p latform and account for the function of the organization. How fast an organization resp onds and how fast it improves its services or products represent the main issue in kno wledge velocity. However, in general, quantifying service quality to measure it represe nts a difficult task. In this situation, to measure knowledge assets kind of velocity stron gly related with service quality, this study made a detour with focusing on relation bet ween knowledge potential and knowledge velocity rather than quantify and measure it directly. In this regard, the following hypotheses approach the research question from t he perspective of an organization's capability to respond to customers and improve pro cesses for service and products (Fink, 2005; Ahmed et al., 1999; KISDI, 2013):

Hypothesis 1-a *The frequency of R&D activities has a positive effect on velocity.*
Hypothesis 1-b *Improvements in an organization's capability to develop new services or processes has a positive effect on velocity.*
Hypothesis 1-c *The importance of quality improvements in products or services has a positive effect on velocity.*
Hypothesis 1-d *The importance of reducing the response time to customers has a positive effect on velocity.*

Knowledge Potential as Mass

Knowledge mass can be defined as a person-dependent variable influencing the knowledge potential of an expert (Fink, 2005). Based on this concept, this study adjusts knowledge mass to focus on an individual's capability and the environment surrounding the individual related to innovation. Nonaka (1991) introduces the socialization, externalization, combination, and internalization (SECI) model to explain the process of creating knowledge. The SECI model explains an individual's knowledge capability of knowledge acquisition. The objectives of each process in the SECI model include ideas, concepts, refinements, and awareness. Questions from the Korean Innovation Survey, which can explain these key concepts, are arranged for each place. For instance, this study assumes that improvements in environments and knowledge workers' ability are closely related to knowledge mass. Based on the resource-based view, R&D workers and environments are key factors influencing innovation performance (Souitaris, 2002). Previous empirical studies have revealed that human resource which is represented by individual's capability has a positive effect on innovation performance (Michie & Sheehan, 1999; Laursen & Mahnke, 2001; Souitaris, 2002; Laursen & Foss, 2003; Shipton et al., 2005; Pini & Santangelo, 2005; Cano, 2006). Also, Ahmed et al., (1999) asserts that if the employee leaves from an organization, it causes about the loss of intellectual capital of the organization. In this regard, knowledge mass, which covers the whole layer of the knowledge creation process of individuals and their environmental factors, is considered a major variable that can reveal interactions between knowledge assets and knowledge potential assets. In this regard, the following hypotheses are proposed (Fink, 2005; Nonaka, 1991; Michie & Sheehan, 1999; Laursen & Mahnke, 2001; Souitaris, 2002; Laursen & Foss, 2003; Shipton et al., 2005; Pini & Santangelo, 2005; Cano, 2006, Ahmed et al., 1999):

Hypothesis 2-a *Goal of innovation – Reductions in adverse environmental impacts have a positive effect on mass.*

Hypothesis 2-b *Goal of innovation – Improvements in the workplace environment and stability have a positive effect on mass.*
Hypothesis 2-c *Effectiveness of innovation – Improvements in the workplace environment have a positive effect on mass.*
Hypothesis 2-d *Effectiveness of innovation – Improvements in production capability has a positive effect on mass.*

Knowledge Potential as the Position

The term "knowledge position" covers all system-dependent variables influencing the creation of the knowledge potential of knowledge workers. For example, it is affected by the network status of knowledge workers and their firms with governments or rivals. Networks have generally been considered an important issue in the context of innovation. Amara and Landry (2005) reveal that the wider the firm explores information, the more likely it innovation. In addition, Laursen and Salter (2006) show that the width of exploration affects radical innovation, whereas the depth facilitates incremental innovation. Faems et al. (2005) assert that the wider the collaboration, the greater the revenue from innovative offerings. Given these findings, spatial factors may play important roles in innovation performance. In this regard, the present study's model considers how an organization collaborates with others to improve its cost efficiency, how many knowledge sources it has, and how much support from the government it receives represents its knowledge position. In this regard, the following hypotheses are proposed (Amara and Landry, 2005; Laursen and Salter, 2006; Faems et al., 2005):

Hypothesis 3-a *The government's monetary assistance has a positive effect on the position.*
Hypothesis 3-b *Participation in government R&D projects has a positive effect on the position.*
Hypothesis 3-c *The importance of information resources in conferences or exhibitions has a positive effect on the position.*
Hypothesis 3-d *The importance of cost efficiency has a positive effect on the position.*

Knowledge Potential View

As mentioned earlier, all measurement methods for firm value have strengths as well as weaknesses to measure different target groups and situations. Not all measurement approaches and models focus on the individual value of skills and experiences of knowledge workers. Fink (2005) suggests a knowledge potential view based on Heisenberg's uncertainty principle, which has characteristics distinct from those of existing methods. This view considers knowledge workers with their skills, experiences, and expert knowledge as the core of the measurement process. In this study, the key concepts of the knowledge potential view, namely knowledge mass, velocity, and potential (VMP model), are adjust to fit the context of Korea's ICT service industry. Massingham (2014) shows knowledge sharing, knowledge usage, knowledge acquisition, and knowledge preservation are closely related each other and drive learning organization capacity (LOC) by influencing knowledge workers can make better performance in service and product processing, customer satisfaction, and even in organizational culture. So knowledge can generate synergy effect on the organizations' performance under developing various dimension of interactions. The concept of knowledge potential refers to the level of interactions between factors influencing the knowledge creation process. For instance, the higher the knowledge potential of an organization, the more likely the knowledge creation is. Because measuring a combination of important factors in knowledge creation is more important than measuring discrete piles of the knowledge related factors, this study assumes knowledge potential to be affected by knowledge mass, velocity, and potential based on Fink (2005). In this regard, the following hypotheses are proposed (Fink, 2005; Massingham, 2014):

Hypothesis 4-a *In Korea's ICT service industry and segmented industry groups (IT-intensive, non-IT-intensive, and telecommunications/information industries), velocity is positively correlated with mass.*
Hypothesis 4-b *In Korea's ICT service industry and segmented Industry groups (IT-intensive, non-IT-intensive, and telecommunications/information industries), mass is positively correlated with the position.*
Hypothesis 4-c *In Korea's ICT service industry and segmented Industry groups (IT-intensive, non-IT-intensive, and telecommunications/information industries), the position is positively correlated with velocity.*

Research Framework and Hypotheses

Data

The EU and the OECD provide methods for measuring technological innovation as well as those for R&D activity. Here the Oslo Manual, published by the OECD in 1992, is an international standard for measuring technological innovation. Data from the Korean Innovation Survey, which is based on the Oslo Manual, consist of information (in a broad sense) on an organization’s innovation activity in R&D, planning, production, and marketing. The Korean Innovation Survey, biennially conducted from 2003 to 2011 by the Science and Technology Policy Institute (STEPI), considers a total of 2,000 Korean ICT service firms. The 2011 STEPI data from the service sector represent the latest data and are used in this study. The sample includes 4,044 firms based on the Korean Standard Industry Classification number from 450 to 960. Table 1 shows the variables and their definitions in terms of velocity, mass, and the position.

Hypothesis 1-a The**Table 1.** Questionnaire in the Korean Innovation Survey

Prop erty	**Vari-ables**	**Explanation**	**Scale**
Ve-locity	Vd3	Frequency of research and development activities.	1. Sometimes do 2. Always do
	Vd6	Improvements in the capability to develop new services or processes.	1.Low 2.Average 3.High
	Vd7	Importance of quality improvements in products or services	1.Low 2.Average 3.High
	Vs13	Importance of reducing the response time to customers	1.Low 2.Average 3.High
Mass	Mr2	Goal of innovation – improvements in reducing adverse environmental impacts	1.Low 2.Average 3.High
	Mr3	Goal of innovation – improvements in working environments and stability	1.Low 2.Average 3.High
	Mr4	Effectiveness of innovation – improvements in the working environment	1.Low 2.Average 3.High
	Ma6	Effectiveness of innovation – Improvements in production capability	1.Low 2.Average 3.High
Posi-tion	Pl8	Government's monetary assistance	1.Low 2.Average 3.High
	Pc13	Participation in government R&D projects	1.Low 2.Average 3.High
	Pi3	Importance of information resources in conferences or exhibitions	1.Low 2.Average 3.High
	Pa4	Importance of cost efficiency	1.Low 2.Average 3.High

Structural Equation Modelling Analysis

The data are analyzed using STATA/SE 12.1. A confirmatory factor analysis (CFA), a type of structural equation modeling (SEM), is conducted to construct paths and relationships between factors.

Table 2. Data Classification

Classification	**Obs**	**%**
IT-intensive industry	442	10.93%
Non-IT-intensive industry	2868	70.92%
Telecommunications/information industry	300	7.42%

Among those service firms responding to the STEPI survey, the sample data set does not include some data not related at all to ICT. For example, the transportation and real estate industries are excluded. In addition, the rest are divided into four groups. The first group is the "IT-intensive" industry. Classification numbers 580 to 710 are classified as the IT-intensive industry consisting of information, software, telecommunications, and broadcasting firms. There are 442 IT-intensive firms. The second group is classified as the "non-IT-intensive" industry and includes ICT service firms providing food, transportation, and sports services, among others. The last group is the "telecommunications and information" industry and comes under the "IT-intensive" industry. A comparison of IT-intensive and non-IT-intensive industries should provide the characteristics of Korea's ICT service industry. In addition, considering the telecommunications and information industry should provide concrete conclusions.

In this study, the survey questions were re-categorized into three parts. The first part (functional dimension) includes data generation, application end, and service median layers and refers to knowledge velocity. The second part (personal dimension) includes ideas, concepts, refinements, and awareness for knowledge mass. The last part (social dimension) includes stimulus-rich, organic, collaborative, intelligent, adaptive, and linked layers and explains the knowledge position. Among various variables, the following ones are used in the analysis.

Table 3. Descriptive Statistics

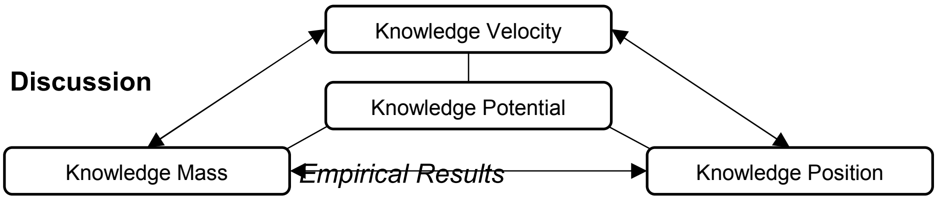
Property	Variables	Obs	Mean	Std, Dev	Min	Max	α
Velocity	Vd3	283	1.628975	.4839348	1	2	0.7344
	Vd6	658	2.261398	.6968504	1	3	
	Vd7	712	2.495787	.6184998	1	3	
	Vs13	691	2.421129	.6576765	1	3	
Mass	Mr2	359	1.969359	.7523946	1	3	0.8278
	Mr3	411	2.148418	.6983368	1	3	
	Mr4	354	1.875706	.7308094	1	3	
	Ma6	367	1.93733	.6965147	1	3	
Position	Pl8	323	1.712074	.7924781	1	3	0.6424
	Pc13	350	1.917143	.8022125	1	3	
	Pi3	315	1.815873	.7033148	1	3	
	Pa4	371	1.975741	.7511823	1	3	

Classification numbers 580 to 710 are classified by the IT-intensive industry consisting of information, IT software, telecommunications, broadcasting, and publishing firms. There are 443 IT-intensive firms. The rest are classified as non-IT-intensive firms providing food, transportation, and sports services, among others. The knowledge-based industry depending on IT, which include firms providing healthcare, financial, legal, and education services (U.S. Department of Commerce, 1996), are not selected as IT or non-IT-intensive firms.

Research Model

The main assumption of this study is that measuring knowledge potential, which refers to the how well knowledge velocity, mass, and positions interact with one another, is more important than measuring knowledge assets. In this regard, this study examines the relationship between knowledge potential and its dimensions. Figure 2 and Table 4 show the SEM results.

Figure 1. Research Model with the VMP Model



Discussion

Empirical Results

The empirical results can be summarized in three major points from the VMP model in Figure 2. First, all variables have significant positive effects on knowledge velocity, mass, and positions, providing support for Hypotheses 2, 3, and 4. In particular, vd6, mr2, and pa4 are outstanding than vd3, mr3, and pi3. This suggests that, to improve knowledge mass, velocity, and positions, activities related to targeted motives are more important than aimless ones. Comprehensive R&D activities, considered key factors in innovation and KM (Amara & Landry, 2005), are found to be significant, but this does not guarantee their efficiency. If a decision maker considers efficiency, then he or she should invest in reducing adverse environmental impacts than improving the workplace environment. Increasing cost efficiency from cooperation affects may be more efficient than expanding information sources through conferences or exhibitions. Therefore, activities with targeted motives may play a more decisive role in the knowledge creation process than ambiguous activities.

Second, knowledge potential can be expressed through correlation coefficients between velocity, mass, and positions and are examined based on equation (1). For hypothesis 4, the results verify that knowledge velocity, mass, and positions have significant positive effects on knowledge potential. In addition, knowledge potential increases with an increase in knowledge mass and positions relative to knowledge velocity based on equation (2). This study presents and empirically validates the model. The goodness of fit of this SEM model shows a good fit: CFI=1>0.8, TLI=1.054>0.8, RMSEA =0.000.

Knowledge Potential = (0.99 × Knowledge Mass, Knowledge Mass, 0.38 ×Knowledge Mass) (1)
= (Knowledge Position, 0.99× Knowledge Position, 0.34 ×Knowledge position)
= (0.34 × Knowledge Velocity, 0.38×Knowledge Velocity, Knowledge Velocity)

*| **Knowledge Potential** | = 2.1245 × | **Knowledge Mass** | (2)*
*= 2.0957 × | **Knowledge Position** |*
*= 1.26 × | **Knowledge Velocity** |*

Table 4. Coefficients of VMP Relationships for Each Group
The VMP relationship shows noteworthy results by industry group segmentation.

	M-P	M-V	V-P
Whole sample	0.99	0.38	0.34
IT-intensive industry	0.75	0.39	0.42
Non-IT-intensive industry	0.61	-0.51	-0.19
Telecommunications/information industry	0.82	0.48	0.33

The relationships with knowledge mass and positions for each industry are all positive, but the other relationships are negative in the non-IT-intensive industry. This result is consistent with the findings of previous studies suggesting that IT helps to improve performance or innovation (e.g., Brynjolfsson, 2011). Telecommunications firms generally have networks, which mean that they are not likely to consider improving cost efficiency. In addition, IT software and broadcasting firms segment are not shown in the diagram because of a lack of firm's name data. Despite the importance of mass in the telecommunications and information industry, the result shows that all IT-intensive firms are most likely to be affected by the knowledge position in Figure 3. This suggests that telecommunications and information industry are influenced by networking with respect to the knowledge position, and therefore the effectiveness of mass is canceled out. In this regard, this result explains why IT improves performance and innovation and suggests that IT facilitates can affect the interaction influencing the knowledge creation process (Table 4).

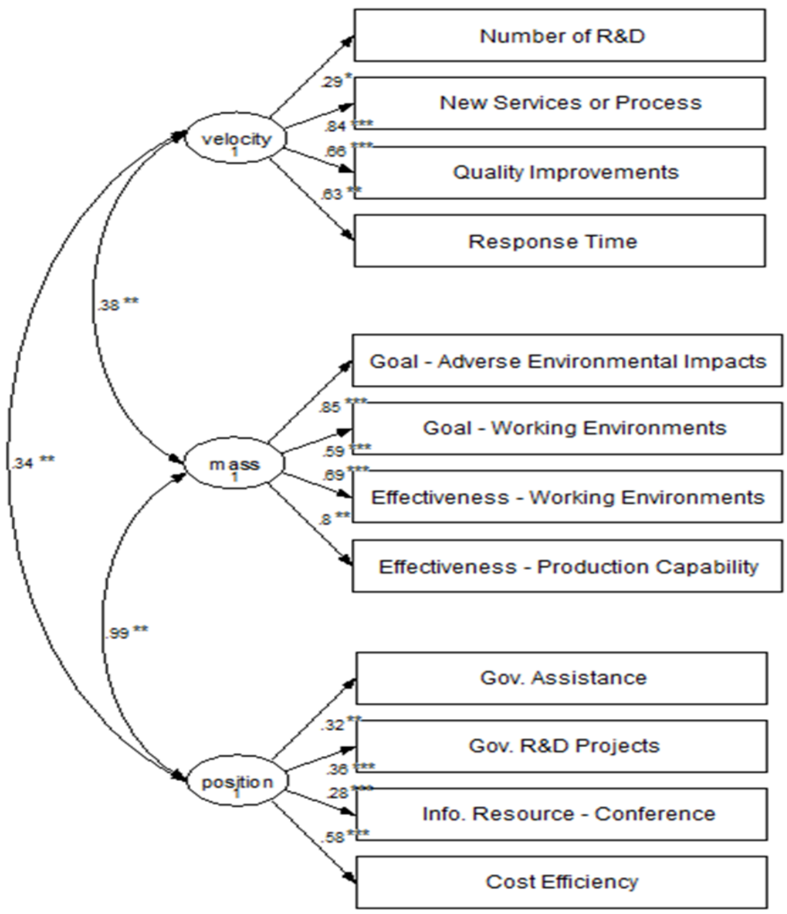


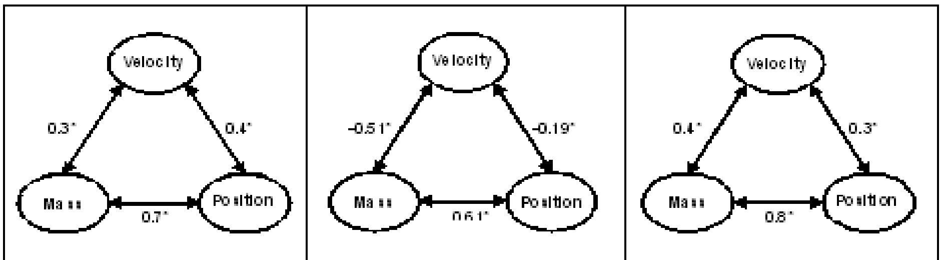
Figure 2. Empirical Results for the VPM Model

Standardized	Coef.	OIM Std. Err.	z	P>|z|	[95% Conf.	Interval]
Measurement						
vd3 <-						
velocity	0.283339	0.128231	2.25	**0.025***	0.037011	0.539666
vd6 <-						
velocity	0.841491	0.009433	69.21	**0.000*****	0.823004	0.859979
vd7 <-						
velocity	0.661633	0.153965	4.3	**0.000*****	0.359871	0.963401
vs13 <-						
velocity	0.627125	0.180806	3.47	**0.001****	0.272751	0.981498
mr2 <-						
mass	0.849391	0.030743	27.63	**0.000*****	0.789135	0.909646
mr3 <-						
mass	0.585459	0.062271	9.4	**0.000*****	0.46341	0.707508
mr4 <-						
mass	0.683821	0.061384	11.19	**0.000*****	0.566511	0.807131
ma6 <-						
mass	0.801823	0.076298	10.51	**0.000*****	0.652287	0.951368
pl8 <-						
position	0.323238	0.096529	3.35	**0.001****	0.134045	0.512431
pc13 <-						
position	0.36472	0.087945	4.15	**0.000*****	0.192351	0.537089
pi3 <-						
position	0.284399	0.064756	4.39	**0.000*****	0.157479	0.411319
pa4 <-						
position	0.581301	0.091506	6.35	**0.000*****	0.401952	0.76065
velocity						
mass	0.37536	0.076169	4.93	**0.000*****	0.226363	0.524938
position	0.339405	0.12481	2.72	**0.007****	0.094587	0.584223
mass						
position	0.990743	0.152817	6.48	**0.000*****	0.691232	1.290264

* Level of Significance at 10%, ** Level of Significance at 5%, *** Level of Significance at 1%

Comparison by Industry Segmentation

Table 6 Correlation Coefficients for Each Industry



a. IT-intensive industry | b. Non-IT-intensive industry | c. Telecommunications/information industry

Figure 3 shows leverages for knowledge potential calculated from the sum of coefficients related to each factor. The results indicate that relatively small investments in knowledge positions and mass have effects similar to those of relatively large investments in knowledge velocity based on the role of IT in Korea's service sector. IT makes the Korean industry more efficient for knowledge creation. In addition, the proposed model makes it possible to compare the characteristics of knowledge creation in different industries. Tables 5 and 6 validate the model.

Implications and Future Research

The measurement of KM emphasizes the ability of human capital or the level of R&D activity itself. However, this study assumes that innovative business environments in the IT service industry should be reassigned and modified for interactions between factors influencing KM activity. The study applies a quantum mechanics view in KM theory to the analysis of the importance of relationships between knowledge velocity, mass, and positions to measure the potential value of knowledge assets. According to the results, knowledge velocity, mass, and positions help create a firm's knowledge assets. The results based on data from the Korean Innovation Survey of the ICT service industry suggest that relationships are more important than individuals' activities. Because of the increasing complexity of business environments in the ICT service industry, confirmatory paths in the SEM analysis are adopted to capture this path-oriented relationship. That is, interactions between innovation activities can be more important than individual processes and product innovation itself.

IT service Industry has been through fast growing technological development and the rapid response of customer requirement in terms of the industry characteristics. This result implies that what is needed to be promoted and sustained their strategic competitiveness in the sense of velocity, mass and position in knowledge management. To implement its network position by the competitiveness, the firms need to focus the direction of KM. Recently many firms participate in project sharing and knowledge sharing beyond their own KM. In sum, the innovation mass and velocity should have a linkage with position level like collaboration. Instead of being a keystone player, the IT service firms do more finding partners with M&A or strategic alliance. Nokia is acquired by Microsoft for collaboration in the IT service industry make the value chain of their service more accurate and more enables for business entity. To have a solution and standardization for current problems for both firms, collaborating agency should be varies in the form of information sharing. Therefore, the rise issue of openness is more important than the amount of innovation and frequency of innovation itself. For example, in consideration of new technology Internet of Thing, the firm tries to have a new value chain in the new tech-industry. The enabler is that the driver to connect new innovative market. They have to innovate not between themselves, but have others which already have the technology based knowledge and information which have a target in short time framing.

This study still has some limitations to define the intellectual capital in the VMP model which offer some interesting venues for future research to have suggestion for the direction of knowledge potential measurement. The proposed model for measuring knowledge potential can characterize outcomes of KM in the service industry. In this regard, this study sheds some light on ways to enhance potential outcomes concerning the existing BSC method. In addition, future research should address strategic corporate management based on the type of quantum view in order to find which is the better-off option among the mass-position, position-velocity, velocity-mass way for promoting of knowledge potential value of firms in the knowledge-based ICT service industry.

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