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Full Length Research Paper

A dynamic model for measuring knowledge level of organizations based on Nonaka and Takeuchi Model (SECI)

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In this article, by considering Nonaka and Takeuchi model (SECI) and its dynamic simulation as a basis, a measurement model is planned which covers the necessary four dimensions of knowledge "knowledge volume", "knowledge value", "transformation speed of different types of knowledge" and "knowledge advantages and expenses" simultaneously. It is necessary to pay attention to various kinds of knowledge such as explicit, implicit and individual knowledge, organizational and group knowledge in measuring techniques, because knowledge is impressionable from diverse organizational elements and its transformation is a function of time and has a dynamic entity in an organization. This dynamic model has been designed for simulating SECI model in accordance with information delay in which its inputs are dynamically related to each other and they show the link among knowledge activities. The output of these models is the degree (amount) of explicit and implicit knowledge in an individual, group, organization and for each of them, the volume and value of knowledge, transformation speed of different type of knowledge and its expenses are acquired. This model is capable of explaining varied scenarios and policies of knowledge management in an organization with separated curves. This model was Implemented and validated in 68 Iranian organizations and has obtained favourable results.

Key words: Knowledge measuring, knowledge management, SECI model, system dynamics.

INTRODUCTION

Knowledge has long been important to organizations as they strive to gain and maintain a competitive advantage (Evans, 1997; Rayport, 1995). It is the major source of economic growth of the country and of the success of individual corporations (Cole, 1998). However, the issues of knowledge management and knowledge measurement have become even more critical in the era of knowledge economics. Many competitive advantages result from intangible assets, rather than traditional tangible assets, and a significant part of value of the commodities or services provided depends on the underlying intangible knowledge. Indeed, it is fair to say that, intangible knowledge has become the main value driver for organizations (Wu et al., 2007).

For effective knowledge management, it is very important to measure knowledge. Without valid and reliable measurement, it becomes very difficult to develop a comprehensive theory of knowledge or knowledge assets. Consequently, no clear progress can be made in the efforts to treat knowledge either as a variable to be researched or asset to be managed (Glazer, 1998). However, the inherently intangible characteristic of knowledge makes its measurement difficult (Ahna, 2004). In last decade, several techniques in knowledge manage-ment measurement are mentioned.

Generally, three approaches can be referred among various kinds of measurement methods of knowledge management. The first approach is knowledge measurement in products and processes (Holsapple, 2002), which uses various techniques like Saaty's method for measuring intangible assets (Saaty, 2003) or KP3 method for evaluating knowledge in product and process in form of matrix definition of product and process knowledge that

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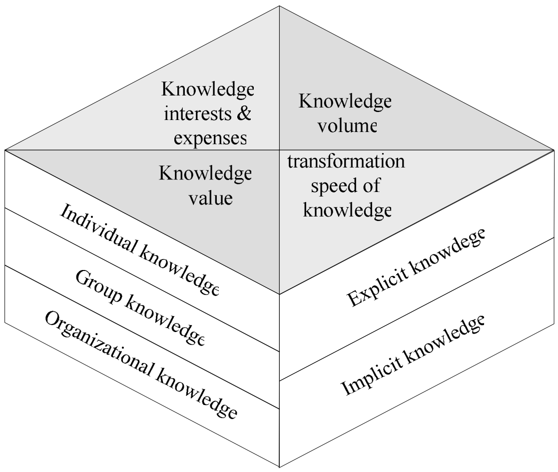


Figure 1. Equipoise cubic model for the establishment of measurement method.

leads to business activities (Ahna, 2003).

The second approach of knowledge management measurement is to determine knowledge value in any organization. Various methods, approximately more than 25 (Wall, 2002; Bontis, 2000; Petty, 2000), have been proposed for the measurement of inner organizational knowledge. Most of these methods focus on knowledge capital or Intellectual Capital (IC) besides other organizational assets in balanced sheets. Edvinsson and Mal's method titled (explained) that guidance of Skandia navigator is one of the most famous ones (Edvinsson, 1997) in this regard. In Lev's method, which is titled as value chain score card method (Lev, 1999), he has tried to design indices in three areas of learning, implementa-tion and commerce with regard to knowledge in organization by drawing non financial matrices.

The third approach is based on, measuring the organization position in the view of knowledge management processes. The methods based on the measurement of organizational knowledge level generally find the position of organization in accordance with one model. The readers are requested to refer Lee's method of KMPI in 2004 for further details (Lee, 2004).

Some aspects which is necessary for KM measurements finds from our review of these three approaches (Afrazeh, 2005; Afrazeh and Nezafati, 2007). According to these aspects, we need to measure different types of knowledge.

There are two types of knowledge, implicit and explicit knowledge (Nonaka and Takeuchi, 1995). Knowledge is not merely considered as individual one; instead it exists in group, individuals or organizations (Nonaka and Konno, 1998). Therefore, we should measure these different types of knowledge in the four aspects including "knowledge volume", "knowledge value", "knowledge interest and expenses" and "transformation speed of knowledge". These aspects are shown in Figure 1.

(Afrazeh and Nezafati, 2007).

"Knowledge volume" is the amount of knowledge that exists in organization or group or individual. By considering an index as a knowledge volume, we can measure knowledge in the different life cycles of organization and estimate its increase and decrease, if any.

"Knowledge value" illustrates the importance and weight of existing knowledge in organization or group or individual. This factor is important for all performance-oriented measuring methods (Choi and Lee, 2003).

"Transformation speed of knowledge type" is defined based on the transformation of different kinds of knowledge into each other. Because transfer of existing knowledge and creation of new knowledge have become two major management tasks, both should be considered together (Krogh and Grand, 2000). "Interests and expenses of knowledge" indicates the production expenses and transfer of knowledge and their interests. If produc-tion expenses and knowledge transfer is high and its interests is low, organization will not try to increase or boost its volume (Liebowitz, 1999).

Now we should find a knowledge management model which is capable of integrating this cognitive equipoise cube model. Nonaka and Takeuchi Model is a suitable one to reconcile with this cognitive equipoise cube model and can be considered as a basis for the establishment of measurement model (Afrazeh and Nezafati, 2007).

Nonaka and Takeuchi Model as a cognitive model are based on various types of knowledge. Explicit and tacit knowledge have been discussed exactly in this model. In this model, individual, group and organizational knowledge are converted to each other in a model form (Brannback, 2003). Then SECI Model can be delineated as measurement Model base. But it should be mentioned here that this model has a dynamic nature (Nonaka and Konno, 2000).

Previous approaches in knowledge management have some difficulties in clarifying this relationship. Most studies fail to incorporate the dynamic characteristic of knowledge management strategies (Hansen et al., 1999; Jordan and Jones, 1997), because the variation of knowledge depends upon knowledge processes, locations, or time (Wiig et al., 1997).

There are several important indices, such as "Dependence to time", "Cause and effect relationships" and ”Feedback circles" (Sterman, 2000), that separate dynamic models from static ones. Feedback circles separate seriously dynamic models from static ones.

Generally speaking, most human models (the models in which human plays an important role) have dynamic characteristics (Sterman, 2000). Because SECI model has social entity, it is dynamic. According to Nonaka and Takeuchi Model, different kinds of knowledge are significantly affected by common indices in organization and "Thesis and Antithesis" links are established between them (Takeuchi and Nonaka, 2004). In other view points, these indexes have many cause and effect relationships

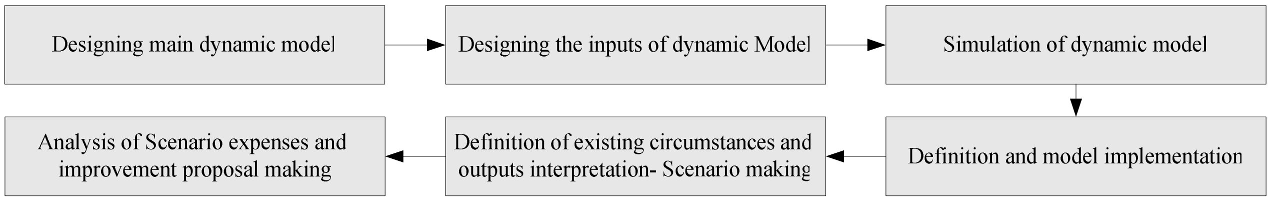


Figure 2. Generalization of measurement method

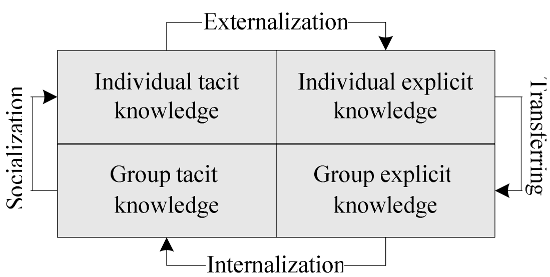


Figure 3: Nonaka and Takeuchi model.

that have many interactions too (Nonaka et al., 2001). Also feedback circles can be seen in form of impact of knowledge on other type of knowledge or the impact of one index on itself indirectly (Ahmadjian, 2004).

The rest of the paper is organized as follows: Section 2 explains the background generalization of measurement method. The dynamic simulated model of Nonaka and Takeuchi model is described in section 3. In section 4, dynamic inputs for dynamic model are illustrated. Then, in section 5, implementation of dynamic model in 68 Iranian organizations is presented. In section 6, scenario making and scenario expense analysis in an organization is discussed. Finally, we conclude in section 7.

GENERALIZATION OF MEASUREMENT METHOD

In this part, generalization of measurement method is described in brief and will be discussed in detail in further chapters. The measurement method in this research must be based on the cubical structure (Figure 1) and in accordance with the dynamic characteristics of basic cognitive model (Nonaka and Takeuchi model), the generalization of various routes for designing this measurement method is shown in Figure 2. In this method, first a major dynamic model has been designed for indicating the path of all types of knowledge in organization based on Nonaka and Takeuchi model.

This dynamic model has been planned in form of close loop based on information delay model for Nonaka and Takeuchi model. This dynamic model has different types of knowledge sharing in Nonaka and Takeuchi model. In this model, "Stocks" demonstrate the level of knowledge types and "Rates" indicates the transfer of knowledge types into each other. These rates and stocks are affected by inputs, "the degree of primary knowledge" and "the duration or time of knowledge transfer", which have a dynamic entity too. In this section, dynamic inputs to each stock and rate are designed based on their effective indices (in accordance with literature review).

In the third part, this dynamic model is tested and implemented in simulation software. This dynamic model needs some inputs to be performed. These inputs have influence on different indices position of knowledge management in organization.

Generally speaking, each operative index in this model has two main variables. The first variable (xi) reveals the index position in organization. The second variable (wi) illustrates the importance and value of index in knowledge management process of organization. These two indices are important for the basis of tetragonal model (Figure 1). Xis and Wis are extracted through questionnaires that attain score with 5 point Likert scale (Likert, 1932) in organizations.

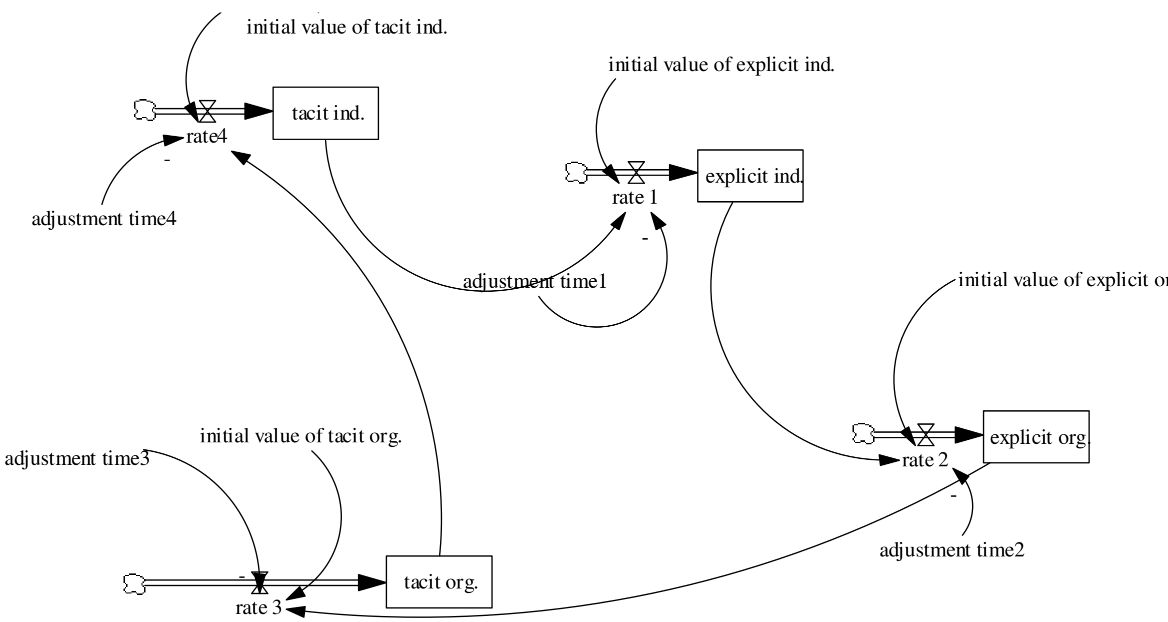
In the fifth step, dynamic system is implemented by inputs of Xi and Wi and tis outputs, that is, graphs of different levels of knowledge types, and conversion rate are attained. These graphs show the existing condition of various kinds of knowledge and its future situation in case of continuing the scenario of existing condition. In this stage, various scenarios can be performed easily. Each Xi can be changed in proportion to probable policies of organization in various scenarios that results in alternations in the level of knowledge type's graphs.

Finally, the expense of each scenario is computed with a linear programming formula, and prominent scenarios, which have better results with expense limitation, are selected and proposed.

Dynamic simulated model of Nonaka and Takeuchi model

SECI model demonstrates the transformation of different types of knowledge in organization, group and individuals (Gray and Densten, 2004). As shown in Figure 3, based on this model, different kinds of knowledge can be the source of another one and can be expanded and developed in group, individual and organizational level in a spiral shape (McAdam and McCreedy, 1999).

In a dynamic approach, this model contains four stocks and four rates as shown in Table 1, four stocks represent



Figurer 4. Dynamic primary model of Nonaka and Takeuchi in form of information delay.

Table 1. Stocks and rates in SECI model.

Nonaka and Takeuchi model	Inputs of dynamic system
Tacit Individual	Stock1
Tacit Individual to Explicit Individual	Rate1
Explicit Individual	Stock2
Explicit Individual to Explicit Organizational	Rate2
Explicit Organizational	Stock3
Explicit Organizational to Tacit Organizational	Rate3
Tacit Organizational	Stock4
Tacit Organization to Tacit Individual	Rate4

explicit and tacit knowledge in organization and individual, and four rates represent their transformations.

So a dynamic loop could be generated for simulating Nonaka and Takeuchi model, which is shown in Figure 4. Four stocks are established as for types of knowledge and four rates as transformation connections. Knowledge transformations in this model are based on information delay (Sterman, 2000). Each stock is a place for gathering and collecting knowledge and gradually it is added to next knowledge. Also each stock has its own special initial volume. This addition occurs with a time delay, which can be formulized in the following form: [For example for transferring Explicit Individual knowledge (EI) to Explicit]:

Organization (EO) $EO = 1/TEIEO \int EI + IEO$
TEIEO = adjustment time for adopting EI to EO
IEO = Initial value of EO (1)

As it is seen, two key factors exist in this formula, IEO and TEIEO. The less TEIEO means that adjustment of EI over EO happens quickly and the amount of EO increases fast. It confirms with SECI model. Those organizations, which apply more proper methods for knowledge management, can make and grow SECI loop faster and more constant with a group of spiral activities (Wierzbicki, 2007). In another view, IEO is the sample of independent processes that does not have any impact on adjustment time and can increase the amount of EO. Simulation of this model in simulation software generates some curves for each stock.

Dynamic inputs for dynamic model

Eight inputs of dynamic system shown in Figure 4 corresponding with eight concepts in Nonaka and Takeuchi model is provided in Table 2.

Table 2. Correspondence of SECI model and dynamic model inputs

Nonaka and Takeuchi model	Inputs of dynamic system
Tacit Individual	ITI
Tacit Individual to Explicit Individual	TTIEI
Explicit Individual	IEI
Explicit Individual to Explicit Org.	TEIEO
Explicit Organizational	IEO
Explicit Org. to Tacit Org.	TEOTO
Tacit Organizational	ITO
Tacit Org. to Tacit Individual	TTOTI

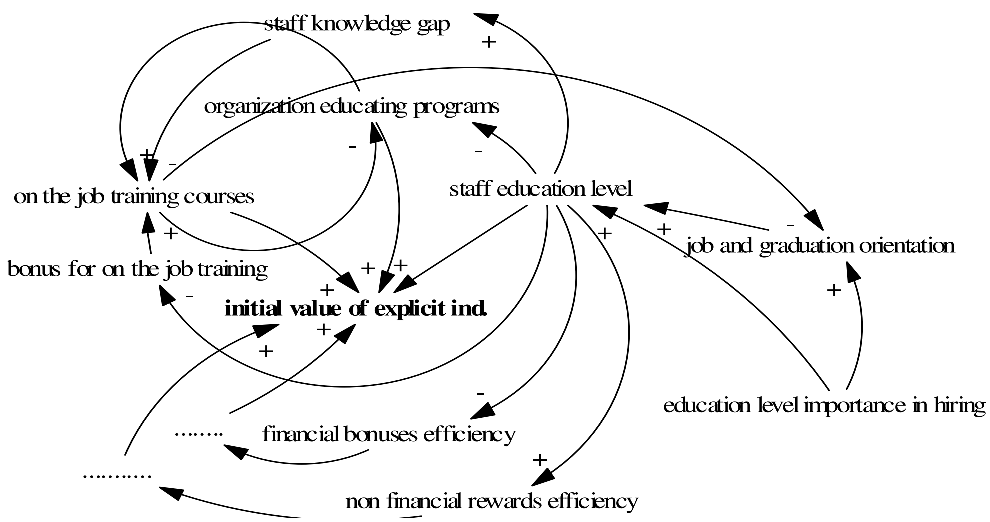


Figure. 5. Dynamic diagram of the effect of staff education level on IEI

Each input is influenced by several indicators in organizations. For example, transformation of "Individual tacit" to "Individual explicit" knowledge is influenced by "documentation technologies", "knowledge sharing awards", "IP protocols," etc.

These indicators are influenced by each other in a causal and feedback system.

The dynamic relationship among some indicators is illustrated in Figure 5.

As shown in this diagram, staff education level has a direct positive influence on initial value of EI (individual explicit knowledge). But this index may have a negative effect on organization educational programs and therefore on the job training courses. Also financial and non financial rewards affected on IEI unlikely. The dynamic behaviours are seen in this small diagram.

A literature review on various factors that have influence on knowledge management was performed, and several indicators were identified. Generally, indices can be extracted based on the methods in various articles (such as Roos, ICM, etc) in accordance with eight inputs of dynamic model of Nonaka and Takeuchi model (Cinca, 2003; Roos, 1997).

These indicators are illustrated in appendix table. As demonstrated, each effective index on eight items of Nonaka and Takeuchi model is affected by many other indices. In some cases, an index has been repeated from the column of subsidiary and in other places. It seems that without designing a system including feedback, bilateral cause and effective elements, it is impossible to simulate the reciprocal impacts of indexes. Then each line of this table must be designed in the form of a dynamic loop (like Figure 5), and loops must not be independent from each other. According to the brief literature presented in appendix table, dynamic relationships among indices were extracted.

For any octal conditions of Nonaka and Takeuchi model, we have: (In this formula, explicit individual knowledge is transformed to explicit group)

$$EO = 1/TEIEO \int EI + IEO$$
$$TEIEO = 1/\Sigma w_i X_i$$
$$IEO = \Sigma w_j X_j \quad (2)$$

Wi and wj are the indices which demonstrate the weight of efficiency of each factor on Tα and Iβ (here α =

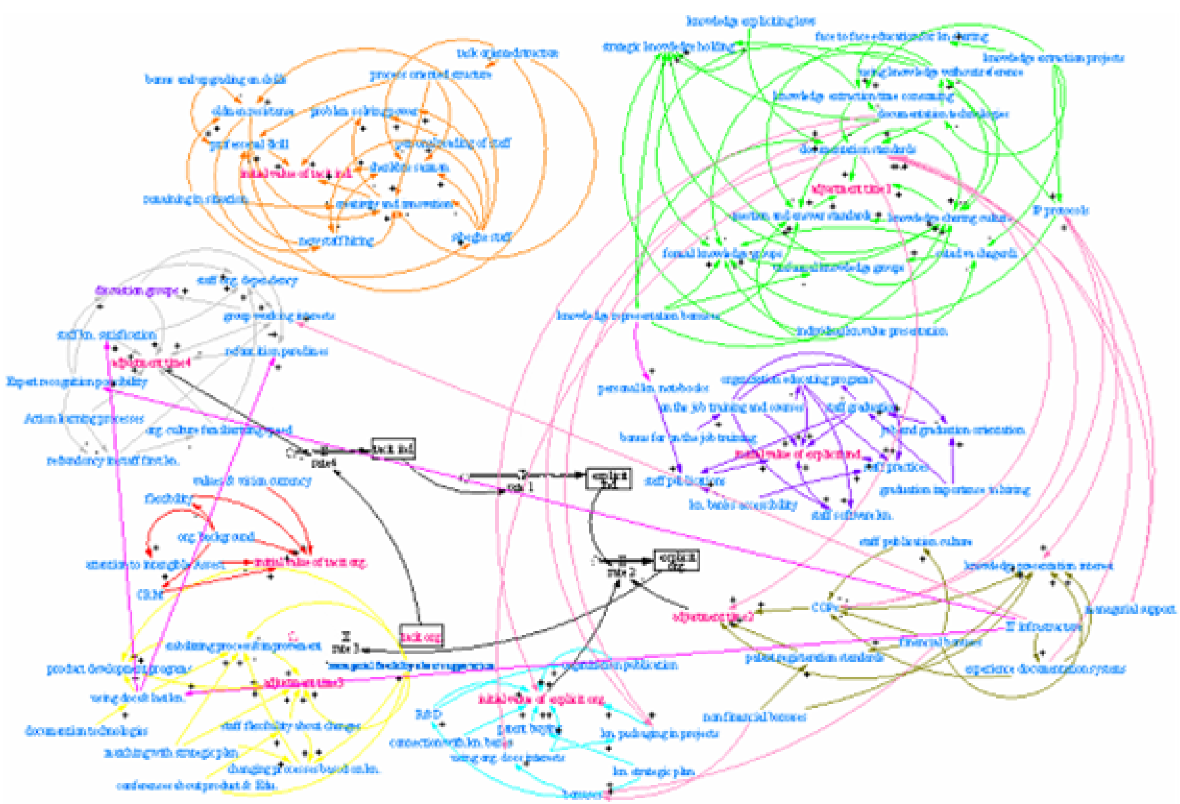


Figure 6. Complete dynamic model of Nonaka and Takeuchi loop with dynamic inputs

EIEO and β = EO). The calculation way of Ws has been mentioned in this section. Each Xi has a dynamic relationship with other factors:

$$Xi = \Sigma MkXk \quad (3)$$

Mk is the weight of efficient indices on Xi, which are dynamically related to each other under this condition.

Based on interrelation factors for eight inputs of SECI dynamic model, an advanced dynamic model is generated, which is shown in Figure 6. This dynamic model has been performed in Vensim software and its outputs has been tested and validated with acquired data of 68 Iranian organizations. In Vensim, input formula of each item is obtained as shown in the following form and is simulated in dynamic structure. This validation is performed in a way that all information related to organization obtained from various variables is entered to system, only few are not entered. This information is gathered from each organization through questionnaires.

The system is run and by the comparison of the obtained information from variable that does not have initiative input information with real degree and by performing Cochran (Conover, 1999) Test, (Ho) hypothesis with x 2 > 0/67 are confirmed with reality (Hall et al., 1999).

This validation method of dynamic systems has been discussed in chapter 13 of Sterman book (Sterman, 2000). This model (which is abstracted for demonstration) is a dynamic model of inner organizational knowledge, which has two main inputs:

a.) The primary amount of indices (Xi).
b.) The weight of each index in its dynamic formula (Wi).

Both of these items are exclusive numbers for various indices in any organization. These numbers, which are homologous with indices of Table 2, have been collected through distributed questionnaire among experts in 68 Iranian organizations in form of five point (Holeman, 2005).

Each expert specifies a primary amount for each variable (the existing condition in organization) and same weight items (the impact amount of variable on the other variables in organization) in form of scores from 1 to 5.

The acquired numbers from experts of organization (30 experts in each organization) are averaged (Digressive numbers with variance analysis are omitted).

Xis and Wis are entered into dynamic system and the system is run. In this condition, the quartet stocks charts can be set, these charts show organizational knowledge condition in four knowledge kinds of SECI model with scenario of continuing existing condition.

Any changes of each input (including Xi and Wi) indicates that knowledge management policy leads to alteration of stock charts, and these fluctuations are easily observable

Table 3. Various Types of organizations selected for the study

Number	type of organization
6	Media
6	public services
7	research Institute
7	IT
6	Gas and petroleum
6	Petrochemical
6	Communication
5	Auto industry
7	Health and medicine
6	Contractors
6	Education

Table 4. Sorting results of organizations.

Rank	Type of organization
1	research Institute
2	petrochemical
3	IT
4	Gas and petroleum
5	communication
6	Auto industry
7	media
8	Contractors
9	education
10	public services
11	health and medicine

in graphs.

Implementation of dynamic model in 68 Iranian organizations

Dynamic model is implemented in 68 Iranian organizations. Different kinds of organizations selected for this study have been presented in Table 3. For all these 68 organizations, a questionnaire was provided in which some indices as indicators were asked. In each index, in addition to existing condition (homologous with Xis in model), weight of items (homologous with Wis) had also been asked. This questionnaire contained about 60 questions of Xi and questions of Wi, and replies were obtained in form of 5 points Likert scale.

The questionnaires were presented and corrected by some experts. The questionnaire was edited by an expert team during collecting and gathering information.

The procedure was continued for about 4 months in 3 stages including 23, 27 and 18 organizations. At least 30 questionnaires were filled in each organization (including about 60 questions of Xi and 60 questions of Wis in each questionnaire). A group of university students also participated in the same study for 1.5 years. All questionnaires were about the implemented analysis in each organization (by omitting unrelated responses). Therefore, we had all Xis and Wis in 68 organizations. Next stage included the entering of Xis and Wis in dynamic system.

This procedure was performed in all 68 organizations, and 4 main stocks with 11 curves were obtained (each curve is the average of organizational groups); these curves are shown in figure 7.

In a sorting procedure among organizations and averaging the results of each organizational group in a particular subject, proper to weak knowledge condition of organizations were obtained as shown table 4.

Scenario making and scenario expense analysis in an organization

Implementation of knowledge processes within a firm can be very costly and fragile (Soliman and Spooner, 2000). Therefore, knowledge processes should be guided by appropriate knowledge strategies. Knowledge management strategies of firms have a significant influence on knowledge management processes (Zack, 1999), and significant projects for KM improvement should be selected intelligently. Curves mentioned in Figure 7 are suitable for guiding to appropriate KM efforts. For 11 out of these 68 organizations, the scenario making procedures were done, and five of them offer some solution of knowledge management. Scenarios in all 11 organizations were confirmed by managers and experts very well. In these testing procedures, some questionnaires were distributed among managers to ask about the real situation obtained priorities and proper implementation for organization. One of the organizations in which the measurement stages were run in form of implementing model was Iran pasteur Institute. Pasteur institute is one of the biggest biomedical associations in Iran. Pasteur produced various kinds of vaccines and drugs and has large research departments. This Institute had relatively proper KM activities with about 800 employees. This mentioned questionnaires were distributed in this organization and results were obtained after entering Xis and Wis in simulation system of Nonaka and Takeuchi, some graphs were acquired.

After that, scenario making was performed. In Scenario making, variables are the Xis and Wis of each organization. Wis can be supposed to be fixed, because efficiency weight cannot be changed rapidly. But Xis can be changed in any policies.

Each scenario can be recognized with a new curve. It is possible to recognize the considerable elements in scenario in form of Xis and its degree of increase or decrease by the policy.

As a result, new curve demonstrates simulation of organization condition in new situation. Graph growth can be

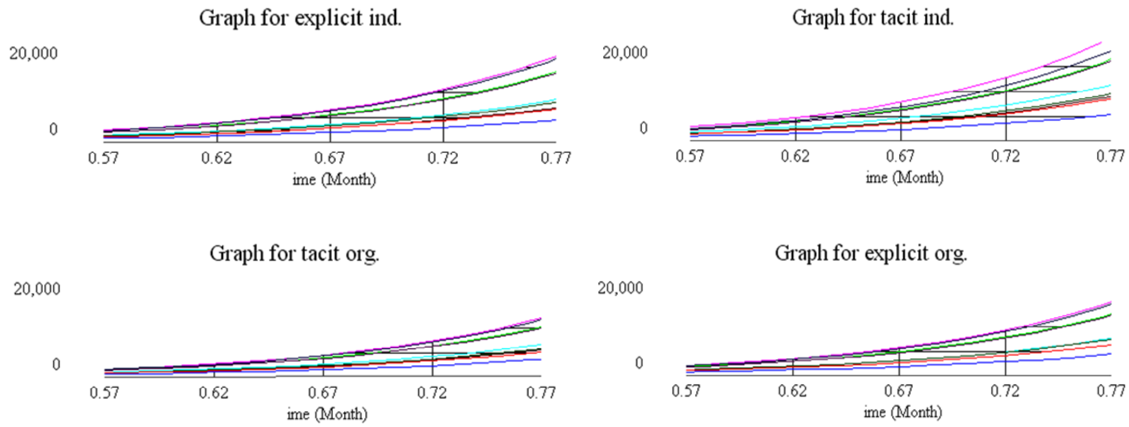


Figure 7. The existing situation in 11 groups of Iranian organizations.

Table 5. The offered working scenarios in Iran PASTEUR Institute.

	Scenario topic	Growing Xis	Scenario expenses	the impact of scenario on curves			
				TI	TO	EI	EO
S1	Promotion based on knowledge	X22,X21,X44,X12	25.000USD	15%	14%	18%	16%
S2	Creating a knowledge network	X7,X33,X18,X65	35.000USD	8%	10%	15%	18%
S3	Cultural activities	X62,X61,X53,X52,X47,X11	37.000USD	13%	23%	18%	21%
S4	Creating KMTs and COPs	X56,X32,X31, X8,X7,X1	17.000USD	7%	15%	10%	14%

shown in proportion to each other by percentage of growth. It has been referred in the right column of scenarios table given in Table 5.

Scenario making is performed concerning with pillar model in which each scenario consists of a combination of many Xis that increase in each 4 columns of model (Stankosky, 2005; Aidemark, 2002), simultaneously. Because of (based on) hypothesis that we want to have equipoise growth in four pillars (Calabrese, 2000; Kaplan and Norton, 1999). Indices (Xis) cover all of these cases.

In this part, scenario tables are designed. Each table contains 7 columns and some rows (according to scenarios). In Table 5, each scenario is situated in one row. For example scenario of "Creating a knowledge network" includes some increase of Xis equivalent with one unit. The column of scenario expense will be possible only by designing table of expenses. Each Xi has its own expense in organization for the growth of a unit, which is a part of that organization. These expenses are relatively calculated in organization. In each Xi, the expense that is spent in organization is considered as a base (cil). The new expense (The expense of new scenario for increasing a unit of Xi) is calculated as follow in formula 4.

$$Ci2 = Ci1 - (1 - (Xi + 1) / Xi) \quad (4)$$

Ci2 is extra expense that the organization should predict for the growth of a unit of Xi. The presupposition is based on linear form of expense growth in this view. After that, we implement main dynamic system with new Xis.

Output graphs show any increase or decrease of Knowledge with the taken policy. Certainly, we can follow a combination of these scenarios. For determining the portion of each scenario in every investment, the following bilateral equation (5) is solved.

$$\begin{aligned} &\text{Min} \quad \Sigma\, Si.Ci \\ &\text{Max} \quad \Sigma\, Si.Li \\ &\text{-----------------------------} \\ &\text{S.t.} \quad \Sigma\, Ci < C \\ &Limin < Li < Limax \qquad (5) \\ &\text{-----------------------------} \end{aligned}$$

Si: portion of Si th scenario
Ci: expense of Si th scenario
Li: The level degree of TI, TO, EI, EO
C: All considered expenses for KM
Limin: The least amount for one Li in a working program
Limax: The most amount for one Li in a working program

By solving this equation, the maximum amount for one Li

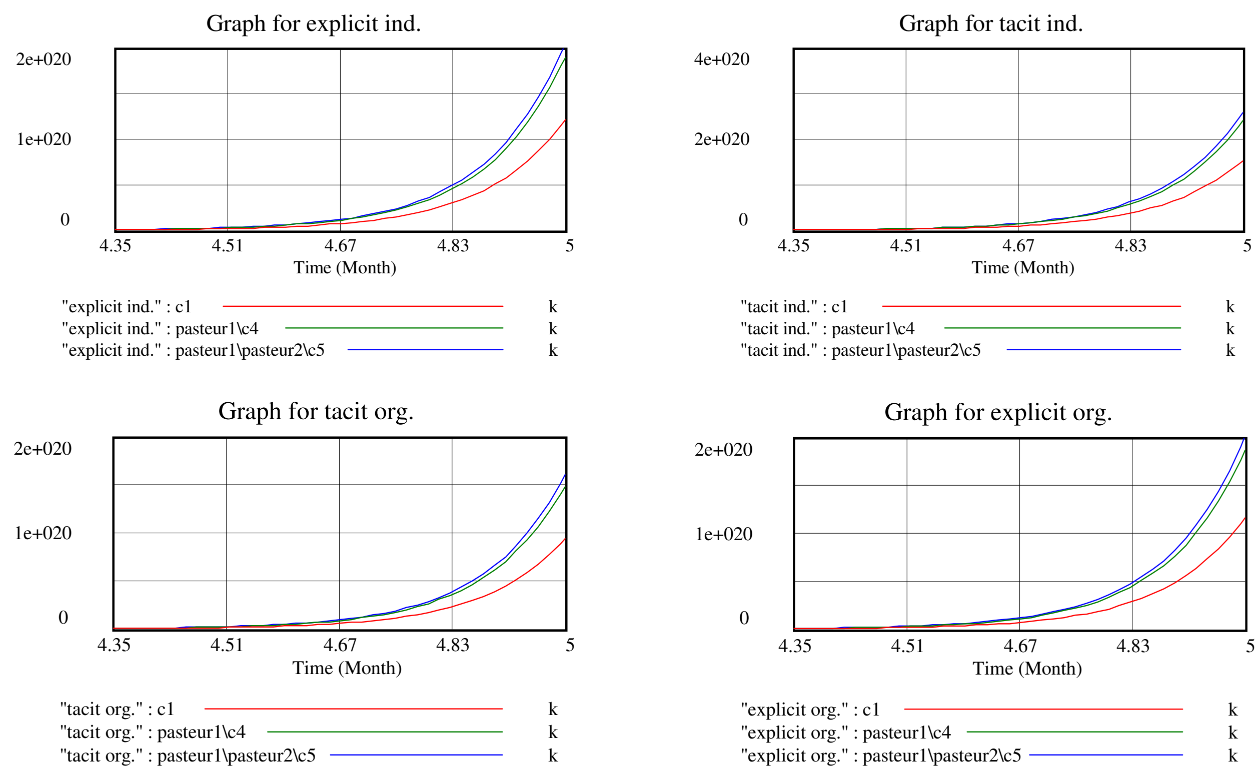


Figure 8. The comparision of existing conditions (a), Favorable (b) and implemented (c)

Table 6. The percentage of budget allocation for proposed scenario according to 2-attribute programming

scenario	investment	Expenses
S1	55%	13750
S2	62%	21700
S3	71%	26270
S4	49%	8330
Total cost		70050 USD

in a working program, proper Sis, which includes maximum knowledge growth in 4 stock level and minimum expense, are obtained. After implementing a 2-attributes programming, the portion of scenarios was specified as given in Table 6. After this measurement, executive activities for implementing of scenarios s1, s2, s3 and s4 and now after padding 80% time elapsing, presenting graphs of Figure 8 has been changed. These graphs indicate that there is little difference between new condition and the calculated one which is favourable.

Now, expert team of this plan in addition to implementting of this model in new organizations tries to extract standards for organizations that have common graphs in stocks. This matter will be discussed in further researches.

Conclusion

There are a variety of methods for measuring knowledge management. But only few ones cover tacit, explicit, individual and organizational knowledge. Nonaka and Takeuchi model can be considered as a base for measurement model, which has a dynamic structure similar to the concept of Nonaka and Takeuchi model. This dynamic model is based on knowledge delay in organizations (besides) monitoring of stock levels of knowledge proposal.

Every stocks and flows influenced by variables in organization, and these variables could define with two factors of their values and weights. This model was implemented in 68 Iranian organizations and favourable results were achieved. Therefore, this model can be utilized for the measurement and scenario making of knowledge management and also for knowledge programming.

With this method all aspects of knowledge types (tacit and explicit) are covered and also dynamic aspect of knowledge transferring in organizations is simulated and affects of knowledge management policies can be monitored for better decision making.

Appendix

SECI Major and Minor Indexes (Each index may be questioned and measured with some question in questionnaire, so number of questions is more than number of indexes.)

SECI Model	Major indexes	Minor Indexes		References
TI	-Individual creativity and innovation -Problem solving ability -Professional skill	- Personnel individual studies -qualitative descriptions of employees (commitment, loyalty, entrepreneurial spirit, enthusiasm) -Task oriented structure -Process oriented structure - Organizational recognition degree -Stability in task and position -Policy resistance -New staff hiring	-Individual knowledge degree indicators -Professional skill -Suggestion systems -Skill oriented promotion -Problem solving ability -Higher education -Staff background and experience - average years of service with company - Attention to skill in promotion -Skill base hiring	(Lemon and Sahota, 2004) (Stankosky, 2005) (Takeuchi and Nonaka, 2004) (Darroch, 2005) (Darroch, 2005)
TI→EI	-Documentation standards -Knowledge sharing culture -Question and answer procedures	-COPs -Knowledge sharing motivations -Documentation technologies -Documentation standards -Managerial support - Methods of registration processes and documentaries -Knowledge acquisition methods -Knowledge acquisition time consuming	-Knowledge sharing culture -Knowledge explicating laws -copyright rules -Knowledge sharing culture -Informal knowledge groups -Rewards for explicating knowledge -Knowledge explicating culture - Registration system for processes and documentaries - To keep strategic knowledge	(Wall et al., 2002) (Choi and Lee, 2002) (Choi and Lee, 2002) (Choi and Lee, 2003) (Hooff and Van, 2003) (Nezafati et al., 2007) (Nezafati et al., 2007)
EI	-Education level -On the job training -Staff publications	-Education and career relation -Staff studies and time in training -Skills on softwares -relation between education and hiring -On the job training -On the job courses -Promotion based on trainings	-Knowledge publication culture -Personal knowledge notebooks - knowledge representation rewards -Interior magazines -Educational work shops and seminars - intranet use	(Peeters and Puterrie, 2003) (Edvinsson and Malone, 1997) (Hooff and Van, 2003) (Cuena, 2000) (Cuena, 2000) (Holeman, 2005)
EI→EO	-COPs -Documentation standards -Patent registration procedures -Knowledge publication tendency	-IP protocols - Knowledge publication tendency -Experience documentation systems -Knowledge sharing culture -financial rewards	-Knowledge representation standards -Lessons learned systems -Documentation procedures -non financial bonuses -Copyright laws -Creating manuals and documents on products and services	(Lynn, 1998) (Hall et al., 1999) (Choi and Lee, 2002) (Choi and Lee, 2002) (Choi and Lee, 2003) (Shin, 2004) (Afrazeh et al., 2003)
EO	-R&D -Paperless administration systems -Projects and processes reports -Patent and research purchase -Organization publications	-IT infrastructures -Reporting culture and policies -LL systems and knowledge repository systems -Reports reusing -R&D budget -Development plans	-Managerial supports -Knowledge Strategy -Vision and strategy statements -Professional library -Patents ROI -Documentation laws and procedures -Costumer information -Competitors information	(Peeters and Puterrie, 2003) (Bontis, 2000) (Edvinsson and Malone, 1997) (Hall et al., 1999) (Byrd and Turner, 2001) (Choi and Lee, 2002) (Afazeh, 2006)
EO→TO	-Procedure stabilizing -New plans acceptation -Product development plans -Previous knowledge reusing -Adaptation with strategic plan	-Document reusing -Managers flexibility about suggestions -Seminars about products -IT infrastructure -Strategic plan education -Educational workshops	-Process oriented structure -KM motivation policies -Development plans -Knowledge strategy -Foresight studies -KM cultural activities -Documentation technologies	(Wall et al., 2002) (Choi and Lee, 2002) (Choi and Lee, 2002) (Byrd and Turner, 2001) (Choi and Lee, 2002) (Lemon and Sahota, 2004)]

Appendix Continued

TO	-Attention to intangible assets in organization -CRM -Organization background -Organizational slogans and values	-Knowledge slogan -Costumer requirements transferring -Organization background in present activities -Organization branches -Organizational pioneering in its field	-Costumer requirements conversion to knowledge -Costumer requirements recognition -Organization culture -KM laws - organization flexibility	[(Wall et al., 2002) (Bontis, 2000) (Darroch, 2005) (Gold et al., 2001) (Stankosky, 2005) (Afazeh, 2006)
TO→TI	-Team working interests -On the job training procedures -COPs -familiarity speed with organization culture and strategy -Personnel knowledge satisfaction	-Staff knowledge gap - Staff belonging to organization -On the job training -Cultural activities -COPs - Develop products and services	-Experience and knowledge repository systems -Staff adaptation with organizational culture - Team working activities -Process oriented structure	(Choi and Lee, 2002) (Takeuchi and Nonaka, 2004) (Holeman, 2005) (Darroch, 2005)

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