Dynamics of Organizational Learning in Catching-Up Process

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Abstract

In this work the role of organizational learning in catching-up process is studied by means of system dynamics modeling. This model includes major transform/creation phases of knowledge, i.e. internalization, socialization, externalization and combination and shows how these mechanisms cause increase of organizational knowledge level and its catching-up with the level of pioneer organizations. This work is the first step of dynamical modeling of catching-up process by means of system dynamics and will be followed by future works on how intelligent policy making can be modeled and implemented practically in organizations.

Keywords: Organizational Learning, Catching-up process, Dynamical system modeling

1   Introduction

Recently organizational learning and innovation, especially in catching-up process have become crucially important subject in management. "Models that capture organizational learning and technological change in developing countries are essential to understand the dynamic process of capability building in catching-up process in such countries", says Kim [1]. Nowadays the role of organizational learning is considered beyond just the level of technology embodied in organization's capital stock.

As one of first people who studied the structure of catching up process, Abramovitz relates the catching up process of some countries in post Wolrd War II global market to the level of technology embodied in a country's capital stock [2]. He argues that when a "leading country" discards its old stock and replaces it with a new technology, the accompanying productivity increase is limited by the intrinsic advance of knowledge between the old and new technologies. However, technological age of follower countries' stock is so old that by adopting the discarded technology of the leader there's a potential for sudden jump in follower's productivity. However, Abramovitz debates that a country's potential is growth when it is technologically backward but "socially" advanced which means having high "social capability". The term "social capability" is a term introduced by Ohkawa [3] and reused by Abramovitz [2] which refers to tenacious societal characteristics keeping a backward country from making the full technological leap.

Abramovitz shows one aspect of "social capabilities" as countries capacity to adapt new entries and deduces from it that there's an interaction between social capability and technological opportunity [2]. Later he adds openness to competition and establishment of new firms as what social capacity may depend upon. This is the key concept which is not limited as follower's technological level converges to the leader's. Moreover, if social capacity grows within the country, it raises the possibility of the follower to overtake the leader. Still, no exact definition of social capabilities was given by Abramovitz.

In 20th century huge social and technological changes especially in communication and international mobility were accompanied by a paradigm shift in organizations which caused new ways of thinking that put higher value for organizational knowledge and learning. Therefore old routines and adaptive strategies became less effective and major reconstruction and engineering occurred as a main step for new adaptation techniques. All these new approaches are based on the post-modern concept of "organizational learning". The first major theories which was developed for organizational learning were done by Argrys and Schön [4], Daft and Weick [5], Fiol and Lyles [6], and Levitt and March [7].

Argrys an Schön [4] assumed organizational learning as an error detection and correction process involving inquiry by which organizational "theories-in-use" are constructed and modified. Theories in se are basic cultural assumptions which guided behaviors and mental models of organizational members [8]. They described single-loop learning as behavioral change and double-loop learning as a cognitive change.

Daft and Weick suggest that "organizations differ systematically in the mode or process by which they interpret the environment" [5]. They envisioned organizational learning as a collective process but not just summation of what occurs individually. According to Daft and Weick the distinctive feature of organizational learning is the sharing of data, perceptions and causes convergence among organizational members.

The third category of organizational learning was introduced by Fiol and Lyles [6], who actually "synthesized the work of a number of scholars in their well-known literature review" say Collinson and Cook [9]. They proposed a distinction between "organizational adaptation" and

"organizational learning" where organizational adaptation is a pure behavioral change and more related to the single-loop learning while organizational learning is the behavioral change as a result of cognitive change and highly intertwined with double-loop learning.

The fourth source of theories for organizational learning is in the work of Levitt and March who saw organizations as "learning by encoding interferences from history into routines that guide behaviors" [7]. They believe that routines represent experiential knowledge recorded in organizational memory and reliance on tacit organizational memory is prone to many dangers. They look into a few of these threats among which superstitious learning and ambiguity of success interpretation and recognition, and competency trap are mentioned as the highest dangers for tacit knowledge.

All these theories are dominated by a paradigm which assumes that the solution can be found by just absorbing, processing and producing output from information received or gathered from the environment. However Nonaka questions this paradigm by pointing at the this passive and static view of organization [10]. He believes that in changing environment organizations have a dynamic and mutual interaction and organizations and must not only process but also create knowledge. In his model Nonaka distinct "tacit" and "explicit" knowledge and presents their interaction as a continuous and dynamic dialogue resulting in creation of new knowledge. Nonaka introduces two dimensions of knowledge creation in organizational learning: First "epistemological" dimension related to separation of tacit and explicit knowledge, and second "ontological" dimension, representing the extent of social interaction between individuals that share and develop knowledge. A "spiral" model is proposed by him to show the relationship of these two dimensions [10].

This sequence of studies suggest that the vague concept of "social capability" used by Ohkawa [3] and Abramovitz [2] deeply originates from the organizational learning and concepts related to them such as "adaptation capability", "knowledge creation" and etc. Moreover, mere acquisition of a technology even if it is accompanied by bringing the knowledge into the organization, doesn't guarantee a leap in productivity or a possible catching up process. This is actually where the role of cognitive change plays an important role. We believe that what drives the heart of catching up process is organizational learning which is a very complex and totally dynamic phenomenon.

In this paper, we propose a dynamical model for the fundamental structure of organizational learning in catching-up process based on the Nonaka's model [10]. The model shows how tacit and explicit knowledge levels of organization develop based on both migratory knowledge and internal mechanisms of knowledge creation. These external and internal mechanisms are the four modes of knowledge transfer/creation (socialization, externalization, internalization, combination) proposed by Nonaka [10]. However the model contains details of how these modes interact and intrinsically lead to one another.

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2   Concern and Problem Definition

Catching-up process is a significant problem of the now days developing organizations, and understanding its elements and how they interact with each other will lead to useful insights for such organizations. In developing countries, such as Iran, organizations usually do not experience a successful catching-up process. Therefore after a while their technological knowledge acquired from different foreign sources obsolete and the organization loses its capability/productivity even more. This comes from the ongoing progress of the technical knowledge of the day which is schematically shown in Figure 1 as a primary guess of how technical knowledge within an organization changes in contrast to the up-to-date level. Here, K_O is the "Implemented technical knowledge level within the organization" and K_D is the "Implemented technical knowledge in developed countries" (assumed to be the highest in the environment). These kinds of knowledge are to be measured in a same industry context (automobile, television, etc.).
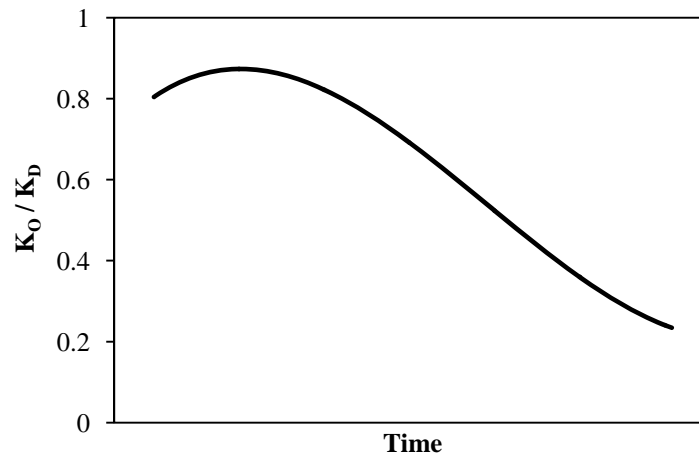
Figure 1- Schematic evolution of ratio of implemented technical knowledge within an aging organization to that of the environment

Figure 1 indicates that despite the financial investment in an organization the relative productivity diminishes by time. This, results in a decline in management and members' motivation and expectation level and therefore the industry capability will decrease and remain low forever.

On the other hand, there are numerous cases in which organizations experienced a successful catching-up process and capability building in their life. Among these organizations, Hyundai Motor Company is noteworthy, because of its rapid growth and remarkable progress in automobile industry. Utilizing crisis construction in order to intensify organizational efforts in

various levels, it managed to heighten the organizational learning in different ways. An assumed behavior of knowledge level within such an organization is shown in Figure 2.

Success story of Hyundai shows the significance of studying the dynamic process of catching-up and how proper answers can be found for the research questions brought up by Kim [1]:

1- How did Hyundai acquire the technological capability to transform itself so expeditiously from imitative "learning by doing" to innovative "learning by research"?
2- Why crisis construction is an effective way of organizational learning?
3- Can Hyundai's learning model be emulated by other catching-up firms?
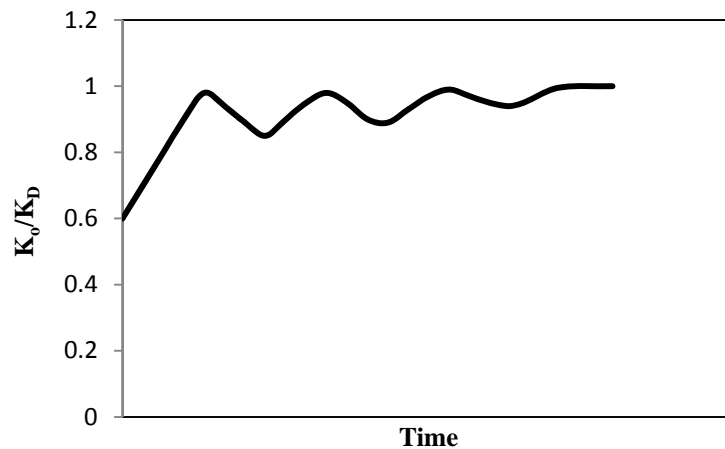
Figure 2- Hypothetical trend of ratio of knowledge level within a successful organization to that of environment

3   Dynamic Hypothesis and Reference Modes

Being a necessity for effective organizational learning, absorptive capacity has two major elements: i) prior knowledge base and ii) intensity of effort [1]. As a start to model the dynamic process of organizational learning, we may use a schematic sector map which is mentioned in Kim's work. Figure 3 illustrates the "Dynamics of Organizational Learning in Catching-up".

To illustrate the dynamics causing the organizational learning process, we get help from the activities that Hyundai Company has gone through during its four phases of catching-up and capability building for our "Dynamic Hypothesis Construction" section.
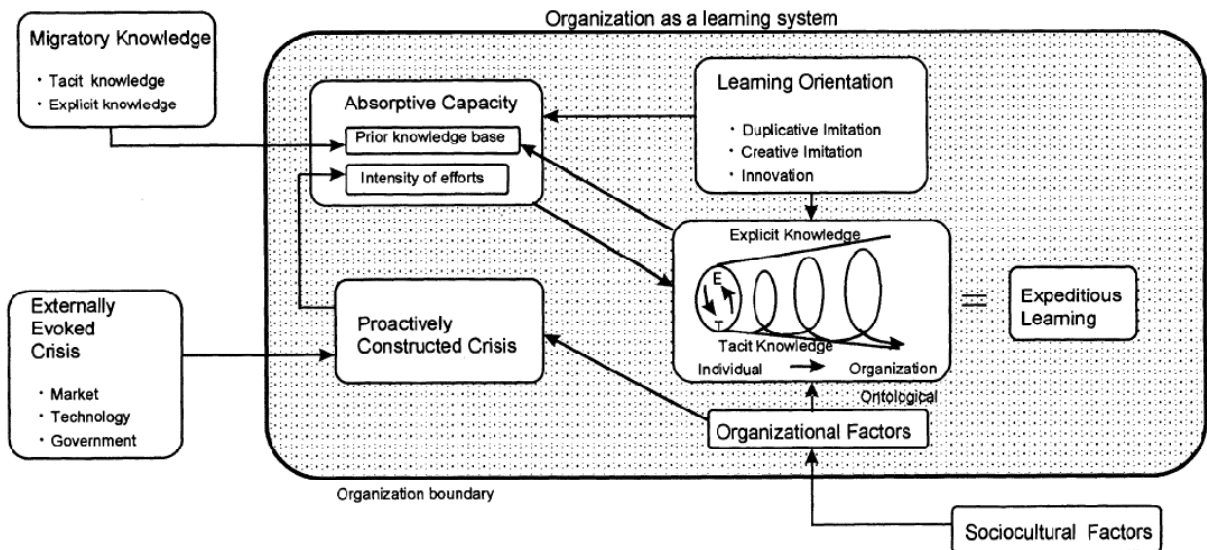
**Figure 3- Dynamics of Organizational Learning in Catching-up [1]**

Each new firm at its starting point lacks absorptive capacity, so the process of organizational learning is nearly zero. Organizations such as Hyundai, which we call them "Successful organizations" from now on, due to lacking of experience and absorptive capacity start with constructing absorptive capacity focusing on its major elements, prior knowledge base and intensity of effort. As will be discussed later, the first one usually is built by heightening explicit and tacit knowledge of organization in different ways and the second element is built by crisis construction within the organization.

Here we define a "Migratory knowledge", as a set of tacit and explicit knowledge which is obtained by the organization through different ways in order to strengthen its prior knowledge base either in individual level or organizational one. Migratory knowledge here in this context means the none-active knowledge which is obtained by the organization but is not used yet. The temporal evolution of migratory knowledge is hypothesized as in the Figure 4. We assume that the migratory knowledge within the organization remains near zero till the time "Catching knowledge techniques" are initiated. Catching knowledge, results in an expeditious rise in the migratory knowledge level (nearly a step change in it or a high slope path). Later decrease of the level is due to transforming it into tacit knowledge within the organiztion.

This migratory knowledge is combination of both explicit and tacit knowledge and it is acquired in various ways. This was phase I in Hyundai Company where a team of experts from construction division with strong project management and engineering background as well as some from other parts with production experience, was established. This team brought migratory knowledge into the production section which increased the **tacit knowledge** level. Moreover, the agreement between Hyundai and Ford for transferring "packaged" technology brought both **explicit knowledge** in form of blueprints, technical specifications and production manuals, and **tacit knowledge** in form of training of engineers from Ford Company into Hyundai.
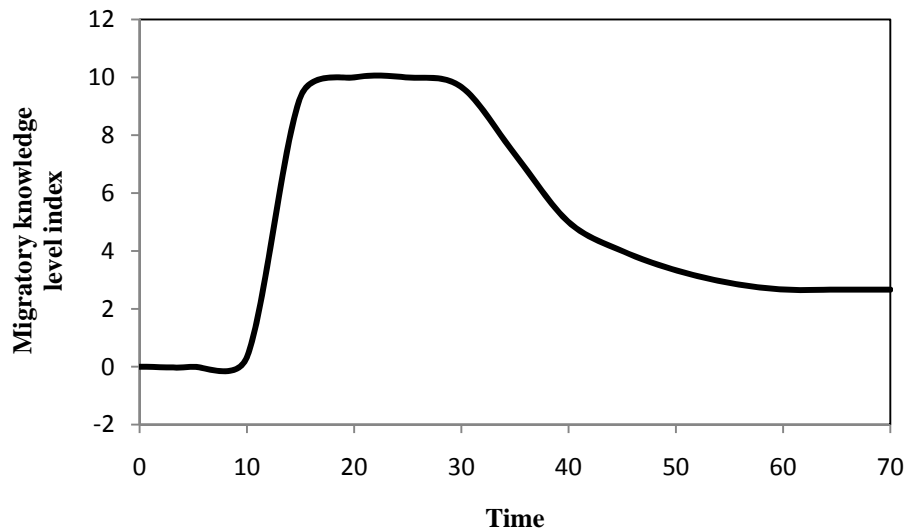
Figure 4- Migratory knowledge in the organization
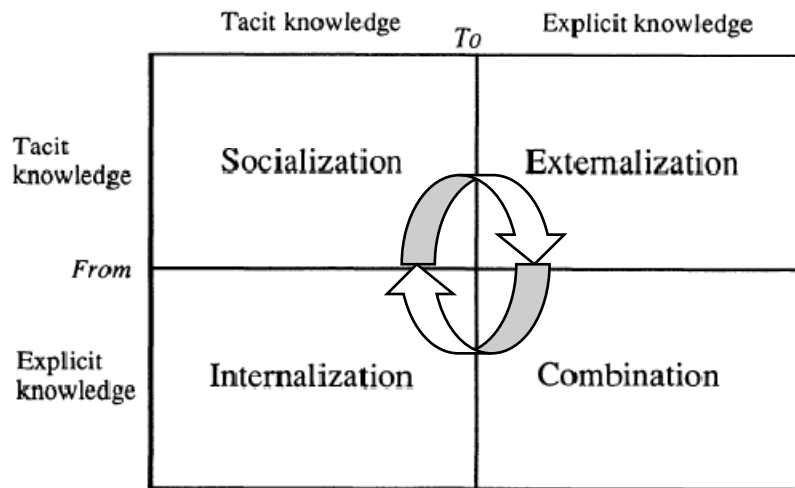
Figure 5-Four Modes of Knowledge Creation

The next steps are **internalization, socialization and** later on **externalization** of the new knowledge. Figure 5 shows the four modes of knowledge creation proposed by Nonaka [10]. Successful organizations are the ones which these four modes are continually and gradually occur in a cyclic form in them.

Migratory knowledge (explicit and tacit), to be useful enough should be converted to the tacit form. So when the migratory knowledge gets to a degree it should be converted into "**Tacit knowledge within the organization**". The hypothesized behavior for the **Tacit knowledge** of the organization is shown in Figure 6. As migratory knowledge is decreases the knowledge is converted to tacit knowledge of individuals of organization.
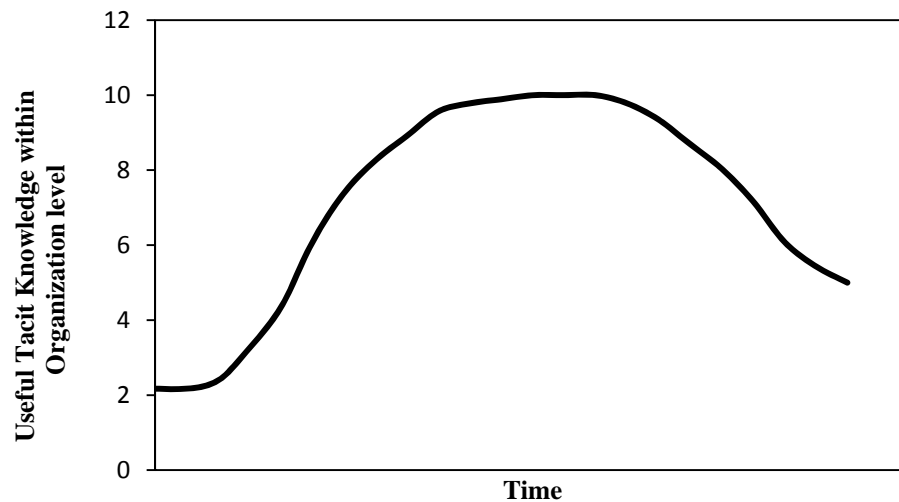
Figure 6-Useful Tacit Knowledge of the Organization

A crisis construction to complete plant construction in the shortest possible time intensified the knowledge conversion at all levels of individuals, groups and organization. Furthermore interaction among engineers, technicians and construction workers resulted in tacit knowledge conversion and socialization.

The knowledge gained through migratory knowledge, internalization and socialization should be documented for safe keeping and transfer among members. The externalization should be in the form of organization specifications, organizational principals, member's and management attitudes and strategies so it can be implemented more easily. Therefore, another important variable in the organizational learning is "**implemented explicit knowledge**" meaning the externalized knowledge is used currently in the organization and is exactly the aim of all organizational learning. The hypothesized behavior of implemented explicit knowledge is shown in Figure 7.
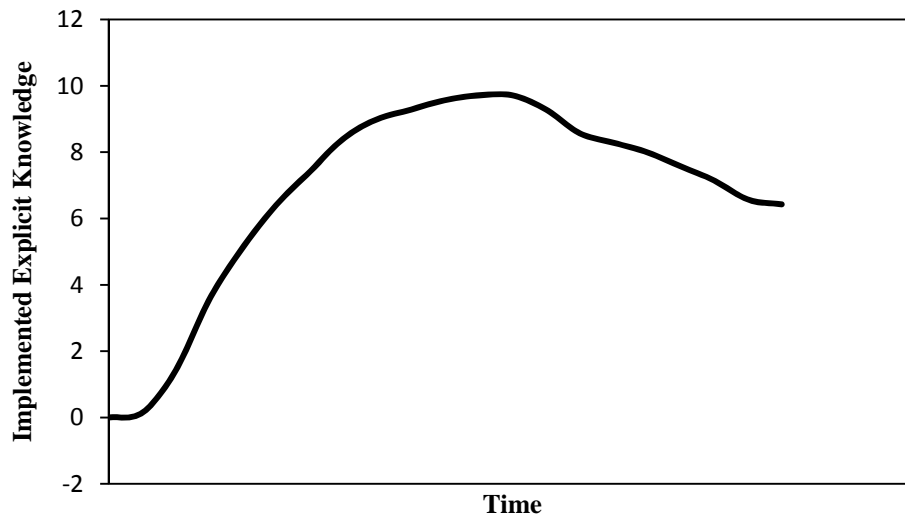
**Figure 7- Implemented Explicit Knowledge**

By increasing the explicit knowledge within the organization, the process of conversion of explicit to explicit knowledge will occur which is known as **Combination**. This results in a changing of learning orientation from imitation to innovation.

This sequence is started again and another internalization, socialization, externalization and combination cycle is created to keep the learning process fresh. Successful organizations predict the profitability of the current cycle and just before the useful implemented knowledge obsoletes, another cycle is initiated. Therefore, it seems that in successful organizations, the migratory knowledge changes as in Figure 8.

This behavior results in a cyclic ratio of K_O/K_D which the is first step to change the learning orientation towards innovation (Figure 9). It is worthy of note that this graph is assumed in a situations which there is no innovation in the organization.
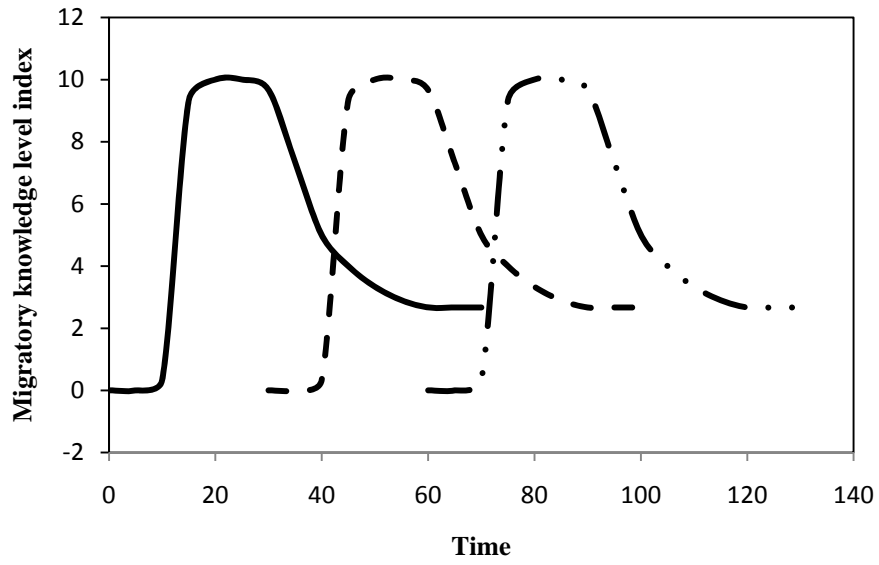
Figure 8 – Continues Migratory knowledge acquisition in successful organizations
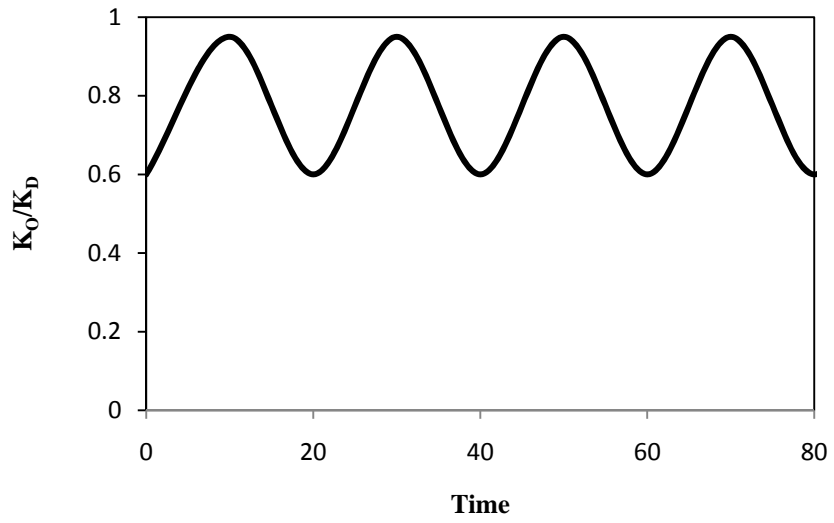
Figure 9- K_O/K_D with no innovation assumption

4   Conceptual Map Design

According to what was said in the previous section, dynamic hypotheses can be summarized as below:

- When an organization starts the catch-up process it initiates a kind of knowledge acquisition and diffusion cycle, which directly is affected by the learning orientation of the organization. As the knowledge of the company is in a primary level, migratory knowledge in the form of tacit or explicit one is gained to raise the prior knowledge base of the organization. During efforts and interaction of members, these two category of knowledge, change through time to a deeper and more organizational level. The detail process was described in the previous part.

Organizational learning whether to imitate or to innovate, takes place at two levels: the "individual and organizational". Besides, each learning process leads to a more profound level of knowledge so a concept of "Depth of knowledge" in an organization came to notice. Another concept which is worthy of consideration is that any organization which works in a specific field has different "aspects of knowledge". For example in automobile industry knowledge aspects are well known such as CAD/CAM, design, manufacture and etc. Therefore, three main concepts are noticed in designing the conceptual map:

1. Organizational level of knowledge
2. Depth of knowledge
3. Aspects of knowledge

By this description, it is obvious that in existence and improvement of knowledge in the organization through time these three characteristics of knowledge are important and should be analyzed. Figure 10 illustrates a simple three dimensional space whit these concepts as main axes. The final purpose of this work is to track knowledge in an organization through this domain.
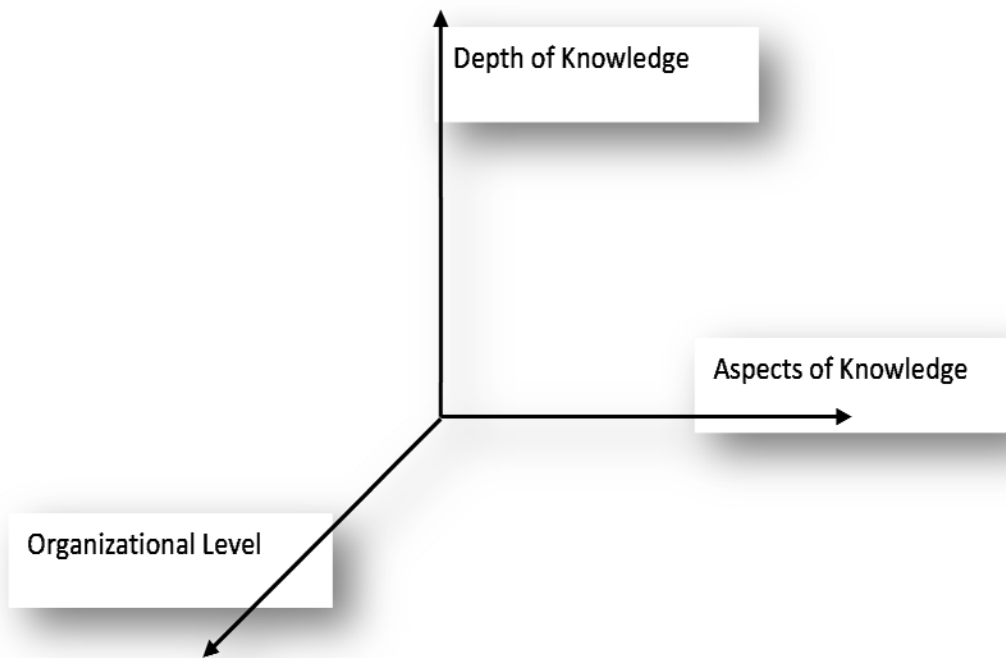
Figure 10- Schematic View of Knowledge Concepts

To look at the dynamics of the problem precisely and orderly, three sectors are designed. In order to distinguish the different steps in the hypothesized cycle mentioned before, the sectors are as below:

1. Tacit Knowledge Diffusion Sector
2. Explicit Knowledge Diffusion Sector
3. Policy and Learning orientation design Sector

To make the concepts simpler in this work we generate the sector conceptual map with this assumption: "The knowledge we are tracking through organization is made of one aspect" (we track one aspect as an example). Therefore one of dimensions of Figure 10 is eliminated from current model construction making model analysis easier.

However we know that it defers in real world and not only knowledge has many aspects but also there are multi-aspect interactions which should be modeled. This issue is under research and the results would be presented as model completion in future works.
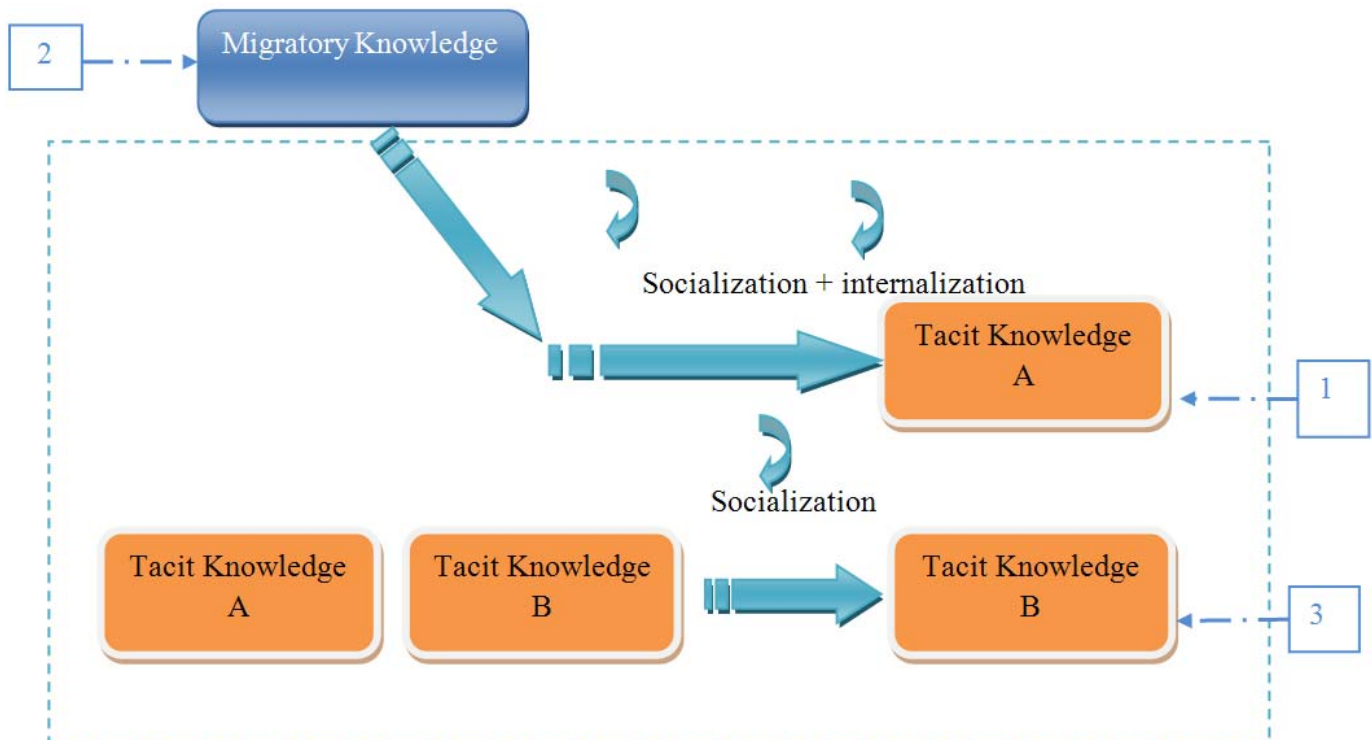
4.1 Tacit Knowledge Diffusion Sector

In this sector, tacit knowledge within the organization is followed through time. Here two concepts are generated:

1- "Tacit Knowledge A" which describes the organizational level of one aspect of knowledge. As the amount of this variable increases, the knowledge reaches a higher level of being organizational and it has changed from an individual level to an organizational one.

2- "Tacit Knowledge B" which represents the depth of acquired tacit knowledge.

The sector modeling the dynamic interaction of these concepts is shown in Figure 11.

Migratory knowledge is assumed to be an exogenous variable which adds up the knowledge in the organization in a very short time. As mentioned before, migratory knowledge is a combination of tacit and explicit knowledge in the field. Therefore, these two kinds of knowledge came to the form of "Tacit Knowledge A" by socialization and internalization. Migratory knowledge which is in form of explicit knowledge is internalized through time and interaction among members. On the other hand, tacit knowledge is socialized to improve it from the individual level to the organizational one.

Tacit knowledge entered in the organization, becomes deeper and more profound due to socialization processes. Furthermore, tacit knowledge itself cause more capability of self-learning which leads to even deeper tacit knowledge.

Figure 11- Tacit Knowledge Diffusion Sector

4.2 Explicit Knowledge Diffusion Sector

This sector describes the process in which tacit knowledge turns to explicit knowledge through time due to externalization and combination which is shown in Figure 12. Here two new concepts "Explicit Knowledge A" and "Explicit Knowledge B" are used which are the explicit forms of "Implicit Knowledge A and B".

Tacit knowledge which is made to be organizational, will externalize through time and creates the explicit knowledge A. Amount of this variable illustrates the level of being organizational of the knowledge. On the other hand, Tacit knowledge B can be externalized to create a deeper explicit knowledge forming "Explicit Knowledge B". Same as tacit knowledge, as explicit knowledge of an organization grows it creates a more suitable circumstance to raise the explicit knowledge itself. Therefore, prior explicit knowledge leads to new explicit knowledge through combination processes.
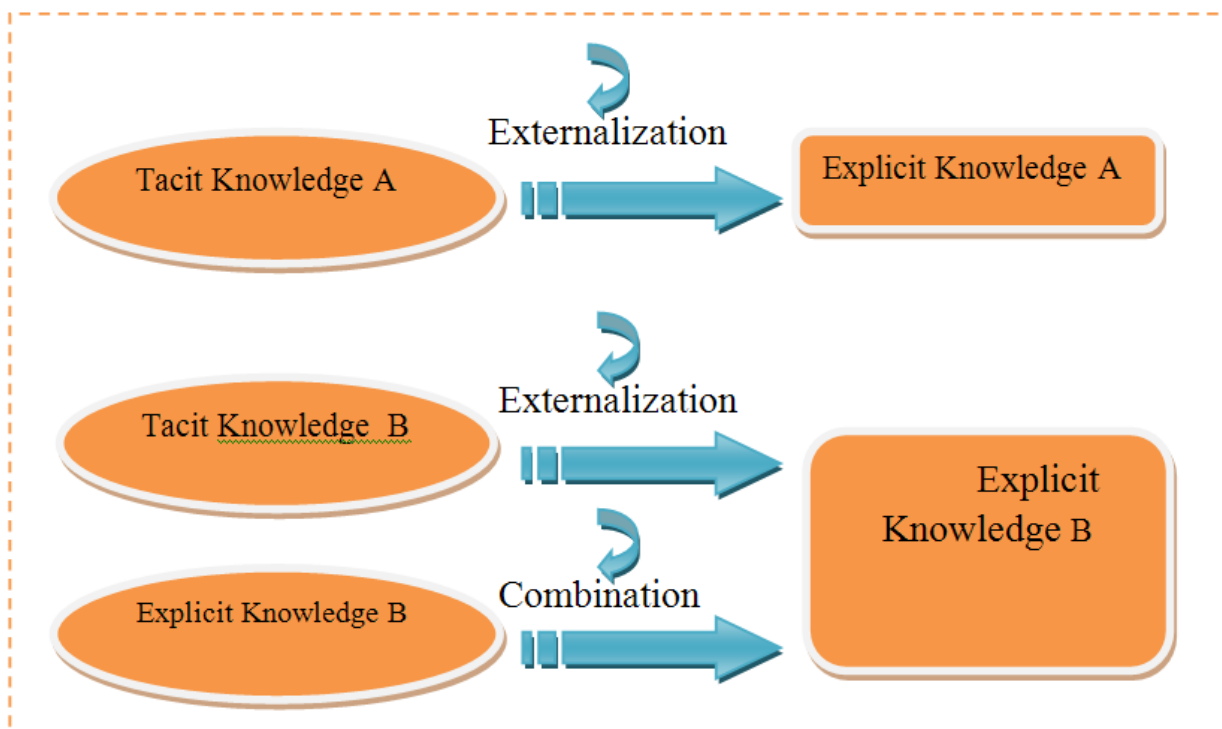

Figure 12- Explicit Knowledge Diffusion Sector

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4.3 Policy and Learning orientation design Sector

This sector is designed to illustrate the process of policy design in successful organizations. Knowledge depth which is directly affected by the tacit and explicit knowledge of type B, and organizational level of the knowledge are the link to previous sectors. Figure 13 illustrates this sector and shows the role of crisis construction as a policy for catching-up process.

Comparing organization capability with the world pioneers of this field capability and using some proper policy design dynamics will lead to a better understanding of where an organization is standing right now and deciding the most useful path to create a crisis and best utilization of that.
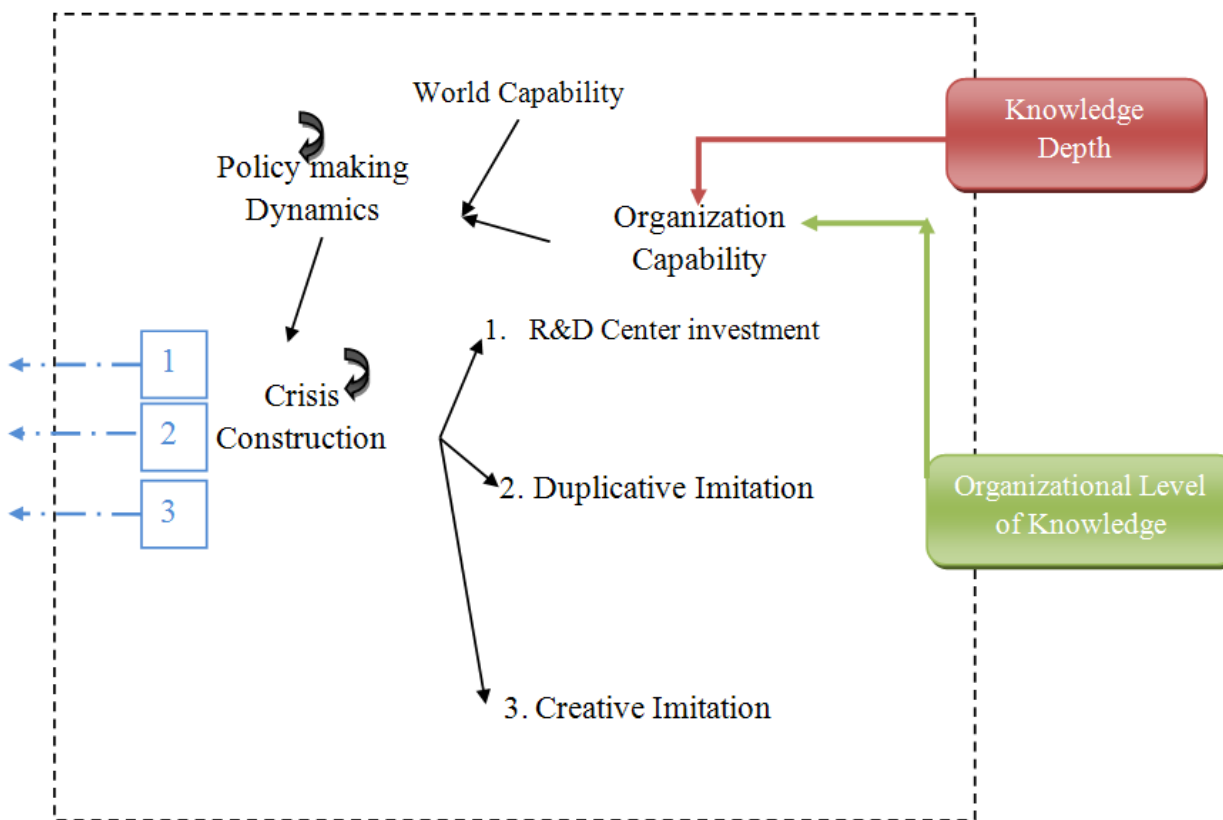

Figure 13- Policy and Learning Orientation Sector

Three kinds of general policy and learning orientation exist, which according to the success of knowledge diffusion in the organization can be chosen. At the first stages of an organization life, because of not a very strong prior knowledge base, duplicative imitation usually is more suitable. As organization grows and obtains more tacit and explicit knowledge base, creative imitation can arise. At the last stage of growth for an organization to get to the top in its field, and to be a leader in the industry, creative imitation should be replaced by a more innovative strategy like investment on R&D centers.

Each of these strategies has effects on previous sectors. R&D centers investment will cause increase in tacit knowledge A without any interfere of migratory knowledge while imitation whether duplicative or creative will effect on the migratory knowledge acquisition process.

4.4 Full Sector Map

Three sector maps mentioned before are illustrated in the Figure 15 in whole. As can be seen the third sector is affected by the two variables of depth of knowledge and organizational level of the knowledge. Each crisis causes an effect on previous sectors which are shown by the numbers one to three in the figure.
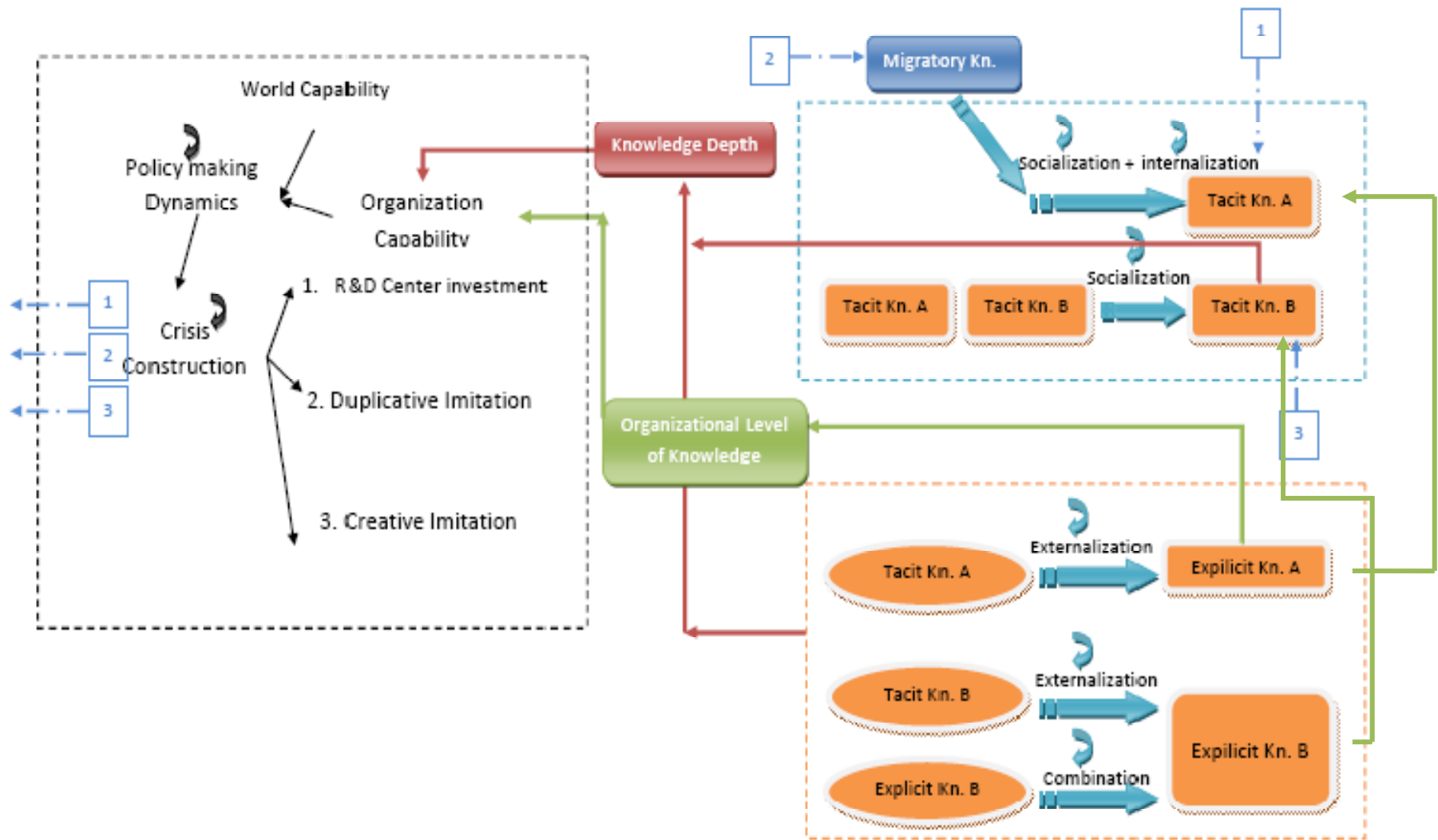
Figure 15- Full Sector Map

5   Causal Loop Description

The full causal loop based on the sector map described before is shown in Figure 16. As can be seen, tacit knowledge A is increased by internalization and socialization. Socialization process has dynamic similar to infectious diseases. On the other hand "tacit knowledge A" will obsolete after some time.

"Tacit knowledge B" is influenced by two processes. First the one in which as the "tacit knowledge A" increases it causes exiting knowledge to be more deepened. Besides, a self learning process is generated because of the amount of the "tacit knowledge B". As tacit knowledge gets deeper it provides more capability for members of the organization to deepen the knowledge even more. Meanwhile a loop of becoming obsolete always exists due to aging.

"Explicit knowledge A" increases as "tacit knowledge A" rises during externalization process. However, "Explicit knowledge B" increases because of first externalization of "Tacit knowledge B", and second a combination process occurs, which means as explicit knowledge increases and gets deeper in the organization, new explicit knowledge can be generated by the combination of the old ones.

At the end the knowledge depth and organizational level of knowledge are created to enter the third sector and generate the organization capability. It is worth of notice that no specific dynamic for the third sector is proposed in this paper because of the its complexity and is postponed for future works. Therefore, the policies are exerted to the model manually instead of an intelligent model to distinguish the best strategy through time.
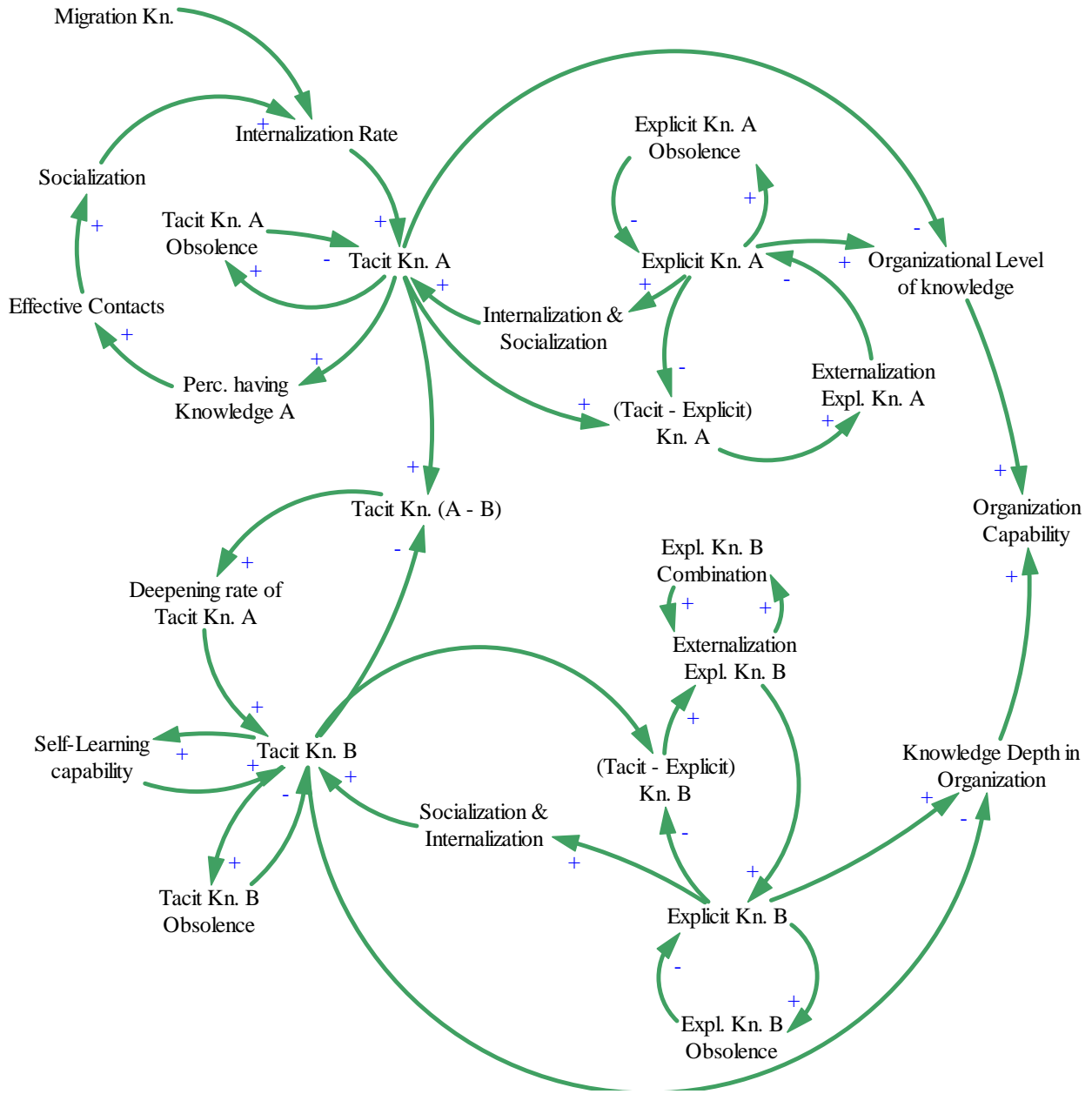
Figure 16- Causal Loop of the system

6 Model Description

In order to justify the developed model with the reference modes of various variables (Tacit and Explicit knowledge types of A and B, Migratory knowledge and Organization Capability) whose behaviors were predicted and reasoned before, the model is built in Vensim PLE® and formulated. Variables are initialized arbitrarily but meaningfully and a numerical simulation is preformed to observe the behavior of mentioned reference variables.

As the first assumption it is assumed that Migratory Knowledge is being introduced into an organization in a short span of 6 month. It should be noted that acquisition of a new knowledge from outside of organization is not abruptly and is a gradual process. In order to simulate that, the Migratory knowledge increase rate is governed by a time-dependant look up with a time span of half a year shown in Figure 17.

Another assumption governing the model is that, all the stock variables including "Tacit Knowledge A", "Tacit knowledge B", "Explicit knowledge A" and "Explicit knowledge B" are not absolute values and are assumed to be comparative with a reference amount. For example, the amount of "Tacit knowledge A" in the model illustrates the proportion of tacit knowledge in the organization to the maximum amount of tacit knowledge of this kind which exist in the pioneer organizations. Therefore, as can be seen in the results part, the amount of this variables are always less than or equal to one.
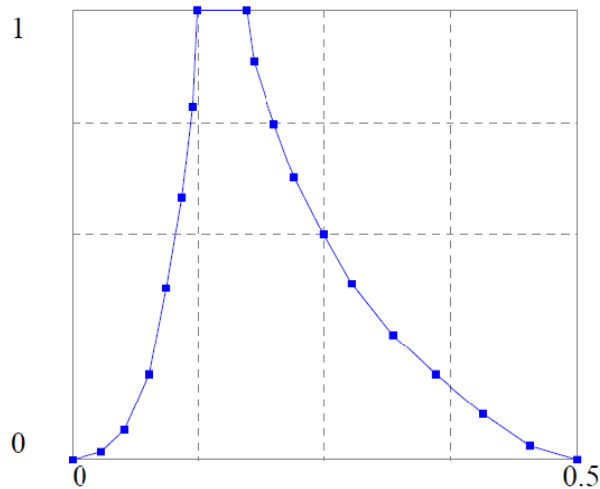
**Figure 17- Time-dependant look up for Migratory knowledge Increase Rate
in a time-span of half a year**

Internalization rate is modeled in form of a delay function. Socialization rate as mentioned before was modeled similar to the dynamics of an infectious disease and an obsolete rate is then added for tacit knowledge A. Tacit knowledge deepening rate is a direct function of socialization rate.

"Explicit knowledge A" increase rate is a function of difference of explicit and tacit knowledge with the effect of a factor for externalization. For the "Explicit knowledge B" two increase rates are externalization rate which described before and combination rate which is modeled as a simple increase factor. The whole model is shown in the Figure 18.
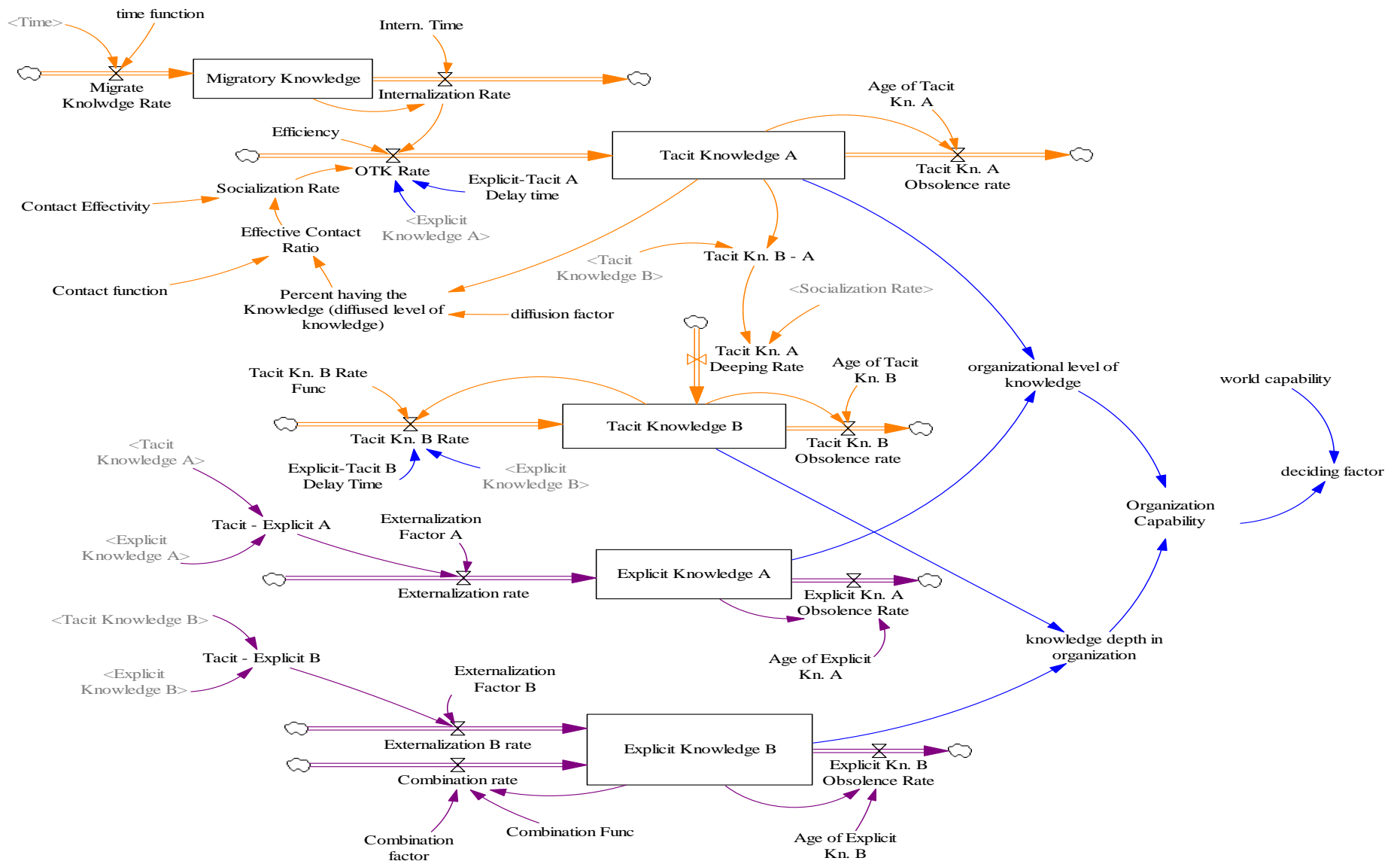
Figure 18- Full Simulating Model

7   Simulation and Results

To illustrate the results of the model, some important variables which were mentioned in reference modes were center of attention and are monitored here.

The not-sudden process of knowledge migration is assumed to be fast at the beginning, remaining at the peak for a short time (almost a month or two) and then decrease. As the result of such rate and the internalization process, the behavior of Migratory knowledge in time would be as is shown in Figure 19. This behavior is similar to the reference mode which was predicted (expected) from Migratory knowledge.

Figure 20 shows the behavior of both Tacit and Explicit Level Index types of Knowledge A. As was predicted in reference modes, the level of these knowledge increase in time due to internalization of Migratory knowledge into Tacit and then externalization into Explicit Knowledge (with a delay). Later, it drops down because the knowledge starts to obsolete in time.

A similar behavior with similar reasons exists for Tacit and Explicit Knowledge B level indices which are shown Figure 21. It can be seen that both explicit knowledge A and B are less than the corresponding tacit level, which is due to the fact that some of tacit knowledge obsoletes before it is turned into explicit knowledge.
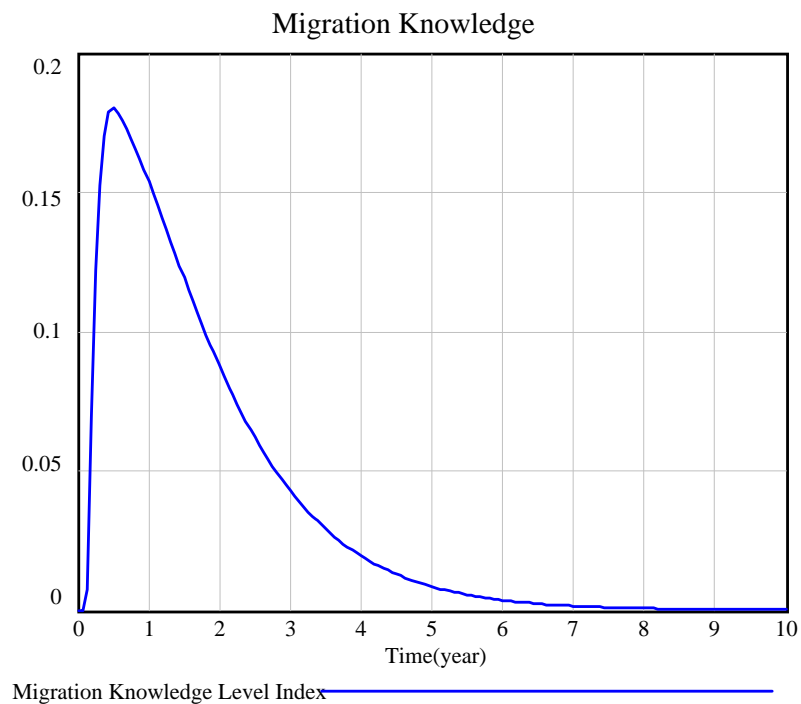
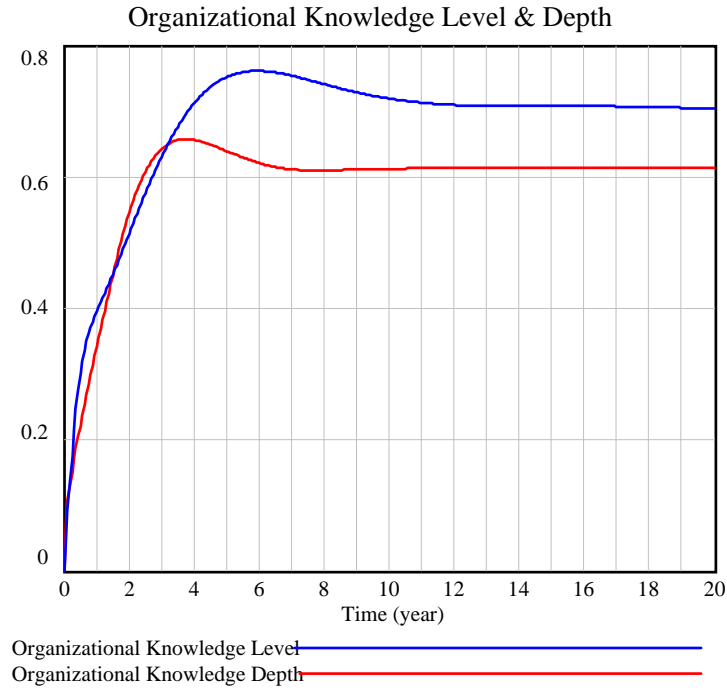**Figure 19- Time history of Migratory knowledge Level Index**
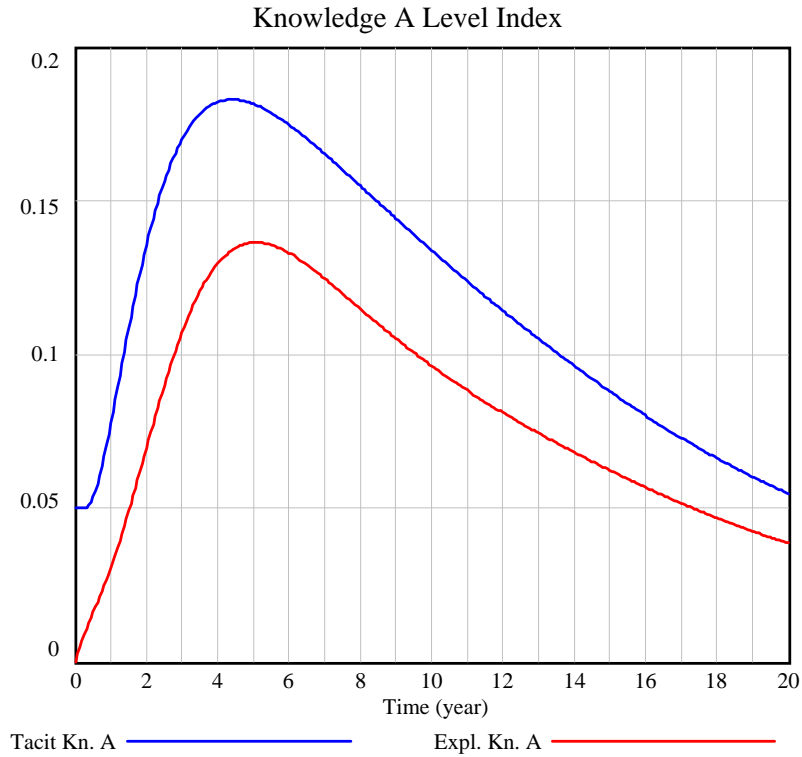
Figure 20- Time history of Tacit and Explicit "Knowledge A" Level Indices
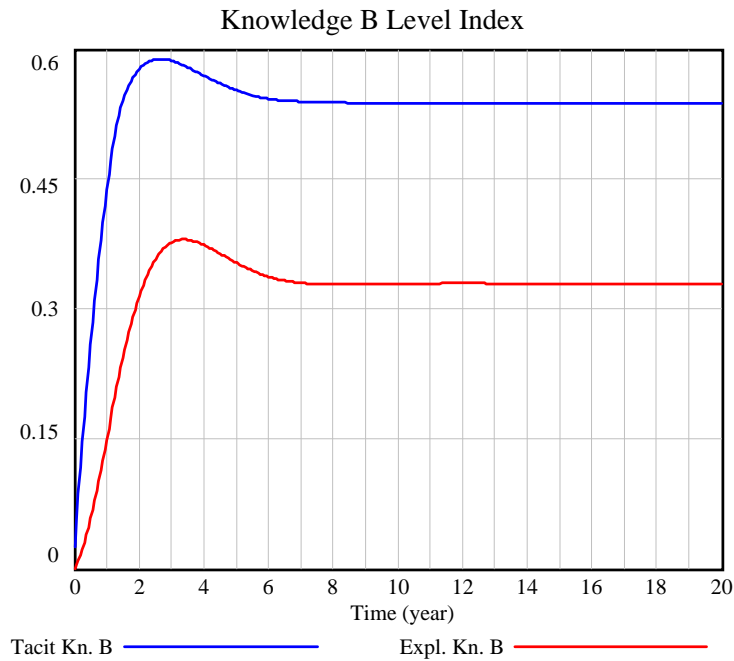
Figure 21- Time-dependant history of Tacit and Explicit Knowledge B level indices

Organizational Knowledge Level & Depth

Organizational Knowledge Level ——————
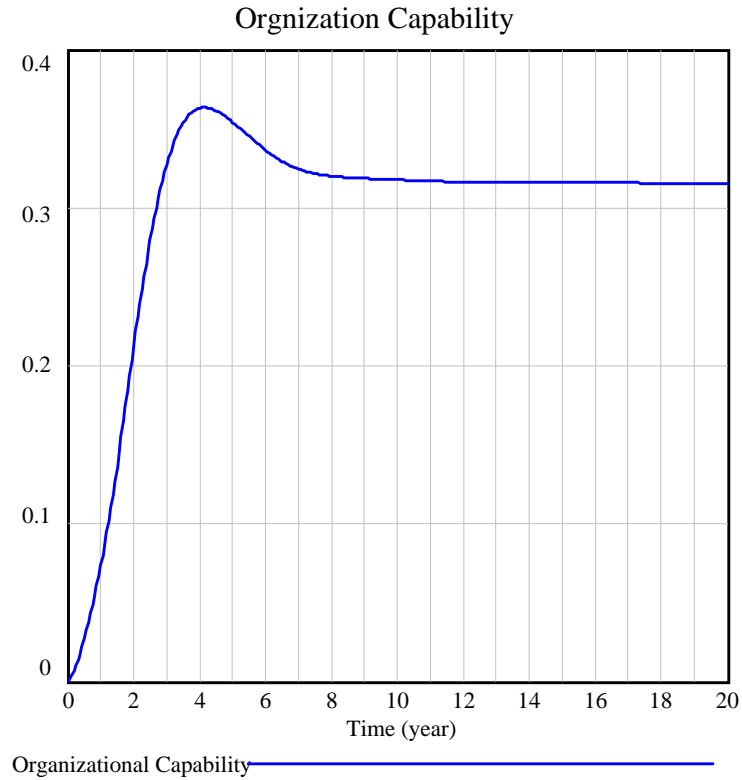Organizational Knowledge Depth ——————

Figure 22- Time history of Organizational Knowledge Level and its Depth

According to behaviors of all tacit and explicit knowledge level indices, the Organization Knowledge Level (i.e. the ratio of Explicit Knowledge A to Tacit Knowledge A) and Organization Knowledge Depth (i.e. the ratio of Explicit Knowledge B to Tacit Knowledge B) show a behavior like what is shown in Figure 22, during time. Moreover, Figure 23 shows the simulated behavior of Organization Capability during time which is similar to the predicted reference mode. Organization Capability is defined as being dependant of both Organizational Knowledge Level and Depth.

Organization Capability =

$$\textbf{\textit{Organization Knowledge LeveL}}^{\alpha} \times \textbf{\textit{Organization Knowledge Depth}}^{\beta}$$

where in this simulation it is supposed that the dependency of Organizational Capability on Knowledge Depth is higher. So, it is assumed that $\alpha = 0.5$ and $\beta = 2.0$.

Orgnization Capability

Organizational Capability

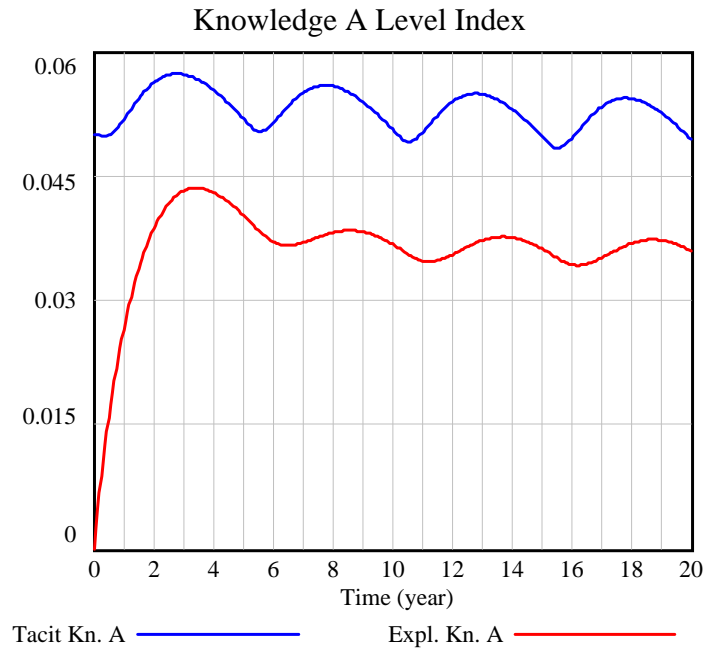**Figure 23- Time history of Organization Capability**

Here, a further step can be taken by studying the behavior of these variables under the circumstance that the organization keeps to migrate new knowledge into the system in specific time intervals. Simulation is done for a typical introduction of new migratory knowledge every 5 years (Figure 24). This is implemented in the model by superimposing the pre-defined look up of Figure 17 over a sinusoidal curve having a frequency of 5 years.

Migration Knowledge

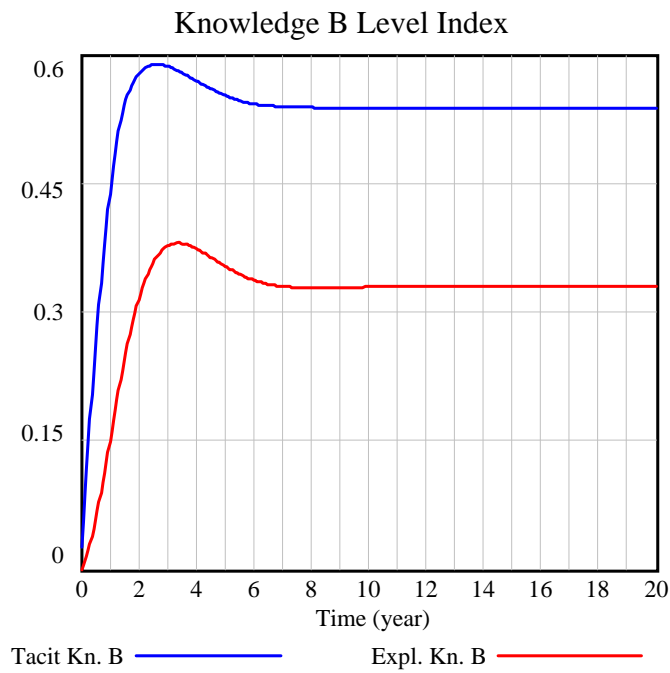Migration Knowledge Level Index
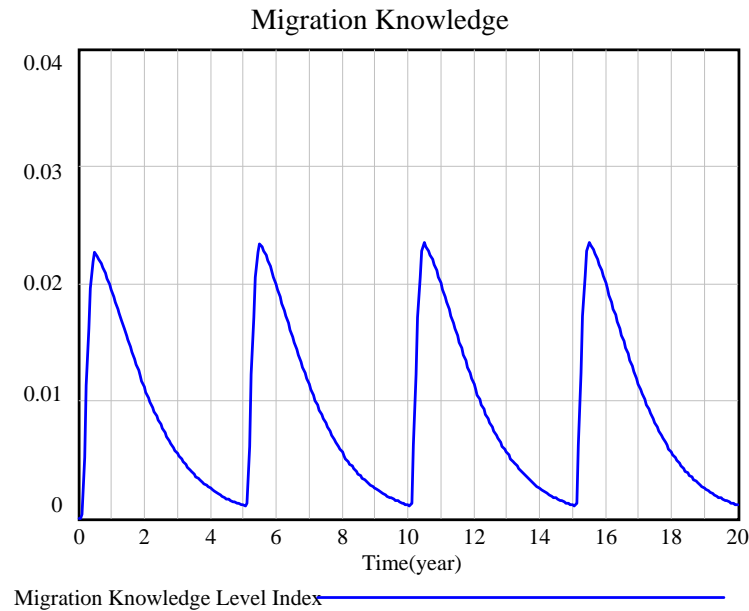
**Figure 24- Time history of repetitive introduction
of a new Migratory knowledge every 5 years**

The resulting behaviors of Tacit and Explicit Knowledge Types (A & B), Knowledge Level and Depth are shown in Figure 25 to Figure 28. The oscillations in Tacit and Explicit Knowledge A are exactly what were predicted in reference modes while such oscillations are not seen in Tacit or in Explicit Knowledge B. The reason seems to be the existence of the inflow rate for Tacit Knowledge B which is independent of such oscillations. The result is oscillations in Organizational Knowledge Level but no significant change in Organizational Knowledge Depth. Such oscillations are dampened in Organization Capability due to dependency of this variable on the unchanged Organizational Knowledge Depth.

Note that the independency of Tacit Knowledge B increase from the oscillations is that it is assumed that in this organization increase of depth of knowledge is only due to gradual increase of organization knowledge through deduction and experience. However, it should be noted that socialization could be a very powerful tool to make the deepening of a new knowledge faster. The lack of such system for knowledge of type B is very common in mismanaged organizations, especially in developing countries such as Iran. This weakness could be one of main focusing points for design of new policies to improve organizational capability (we will take a look at the effect of such policy in policy design section).
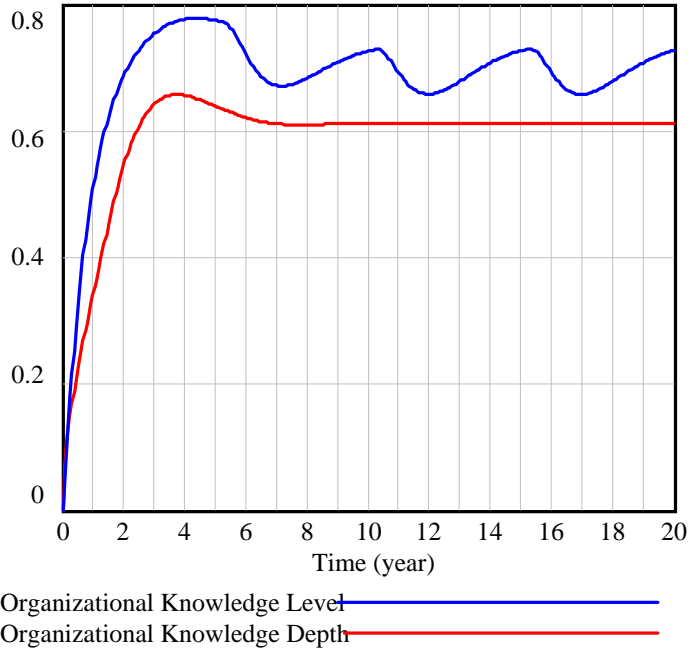
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Knowledge A Level Index

Figure 25- Time history of Tacit and Explicit Knowledge A
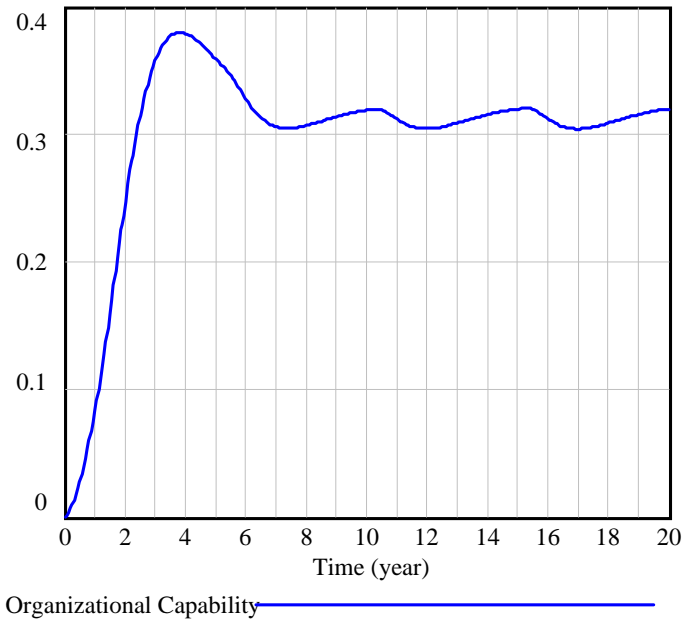for repetitive introduction of Migrated Knowledge

Knowledge B Level Index

Figure 26- Time history of Tacit and Explicit Knowledge B
for repetitive introduction of Migrated Knowledge

Organizational Knowledge Level & Depth

Figure 27- Time history of Organizational Knowledge Level & Depth for repetitive introduction of Migrated Knowledge

Orgnization Capability

Figure 28- Time history of Organization Capability for repetitive introduction of Migrated Knowledge

8   Policy Design

Effective policy design would need a much deeper study on exiting dynamics in this issue. However, some general policies could be studied using the simple model presented in this work.

As the first noticeable strategy for a firm to become successful and pioneer in its field, an organization should follow an independent program. According to the model, this means that the firm should have a planned strategy for the migratory knowledge increase rate. Changing the learning orientation directly effects the method an organization uses external knowledge sources.

One should attention to this point that migratory knowledge is a source to promote the prior knowledge base and dynamics such as socialization and internalizations which are affected by the effort of members. Therefore a suitable combination of these two concepts should be noticed in the strategy plan in the organization. Furthermore it is logical that by several learning cycles, modeled above prior knowledge base turns up to that level in which investment on R&D centers and etc. can be of great use. So this sequence helps the firm to catch up easier and more beneficial.

As can be seen in the results, if no strategy exerted to the model, knowledge depth will peak and then become constant after a while. This behavior exhibits the importance of migratory knowledge role in the knowledge spread in the firm. This means if importing the migratory knowledge does not follow a correct strategy, after a while knowledge depth will not increase anymore and due to its obsoleteness the firm level of knowledge will be far away from the world knowledge of the field.

Figure 24 as was described before is another point of attention. As can be seen migratory knowledge follows a cycle so that after decreasing due to internalization, another cycle initiates. This behavior seems useful for the firm but continuing it will leads to the dependence of the organization on external knowledge sources and never opens doors to invest on innovations.

These policies seem to be promising and need further investigation by means of a model and numerical simulation. However, the current model seems to be too simple for implementation of such policies so that all aspects of their influence could be seen. It is why here, no simulation result for policy designs has been presented in this work, but are subjects of future studies.

Therefore the two major points that could be introduces as future works would be:

1- Establishing a more detailed and better model of the introduced dynamical system.
2- Investigating the effect of proposed policies on the organizational learning catch-up process.

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9   References

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