The Impact of Firm Knowledge Strategy on its Competitive Knowledge: A System Dynamics Approach

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Abstract

Recent movements towards a 'knowledge-based' view of firm have emphasized the importance of knowledge in enabling the firm to gain competitive advantage. Different dimensions of knowledge are explicated in the knowledge management literature such as explicit vs. tacit knowledge, internal vs. external knowledge, etc. Based on SECI model, firms create knowledge through social interaction between tacit and explicit knowledge. It is important for them to acquire external knowledge and combine it with internal knowledge to create new knowledge as well. Acquiring external knowledge is a very complex process and several scholars have considered this process from different perspectives. In this paper, we try to integrate these perspectives and propose a System Dynamics (SD) model for knowledge transfer and creation dynamics within an industry. Using this model, we can test the impact of knowledge strategy adopted by a firm on its success in different knowledge situations.

Key words: knowledge management, knowledge creation, knowledge acquisition, knowledge strategy, SECI model, System Dynamics

1. Introduction

Researchers have begun constructing a knowledge-based view of firm (e.g., Grant, 1996; Teece, 1998), which is built on the resource-based view of the firm (Barney, 1991). These researchers suggest that knowledge is the key resource - and perhaps the only resource - capable of creating sustainable competitive advantage. Therefore, companies have been trying to find ways that help them manage this critical resource. Davenport and Prusak (Davenport and Prusak, 1998) offer working definition of knowledge within organizations, as follows:

> "Knowledge is a fluid mix of framed experience, values, contextual information and expert insight that provides a framework for evaluating and incorporating new experiences and information."

Several scholars explicated different dimensions and characteristics of knowledge. Based on Michael Polanyi's conception of tacit knowledge, Nonaka (Nonaka, 1994) has developed the taxonomy of tacit and explicit knowledge that are on a continuum. Explicit knowledge can be expressed in words and numbers and shared in the form of data, scientific formula, specifications and manuals. This kind of knowledge can migrate in the business community, and be accessible for most companies regardless of their cooperative activity. It is codified and stored in databases where it can be accessed and used easily by anyone in the company. At the opposite end of the spectrum is tacit

knowledge - knowledge that people carry in their minds and is, therefore, highly personal and hard to formalize, making it difficult to communicate or share with others.
Knowledge can also be categorized according to the location of knowledge source. Knowledge that resides within the firm is internal knowledge and the knowledge that resides outside the firm is external knowledge (Zack, 1999a). Sridharan, *et al.* refer to the knowledge that a firm can claim ownership of, as internal knowledge and the knowledge that it cannot claim ownership of, as external knowledge (Sridharan, Crossan and Bapuji, 2007). Internal knowledge may reside within peoples' heads; be embedded in behaviors, procedures, software and equipment; be recorded in various documents; or stored in databases and online repositories. By contrast, common sources of external knowledge include publications, universities, government agencies, professional associations, consultants, vendors, knowledge brokers, and interorganizational alliances (Zack, 1999a). Further, knowledge is viewed to reside at multiple levels: individual, group, organization and inter-organization (Nonaka, 1994).
It is important for firms to access external knowledge for two reasons: *first*, to create new knowledge and *second*, to avoid learning traps due to excessive reliance on internal knowledge. Firms, therefore, make efforts to access the knowledge residing outside their boundaries. Acquiring external knowledge, however, is far from easy because of the complex and multi-dimensional nature of knowledge (Sridharan, Crossan and Bapuji, 2007).
In this paper, we try to integrate various perspectives on external knowledge acquisition and to help decision makers gain insights into the dynamics behaviour of knowledge acquisition.
Based on SECI model for knowledge creation dynamics within firms proposed by Nonaka and Takeuchi (Nonaka and Takeuchi, 1995) and its extension to industry level suggested by Zack (Zack, 1999a), we have proposed a System Dynamics (SD) model in which a firm is located on an industry and the transfer and exchange of knowledge occures among the firm and its competitors within the industry. In this model, we describe an explicit dynamic theory grounded in the relevant literature, with which we can test different conditions for developing a knowledge strategy.
In order to validate the proposed model, we use two research propositions extracted from the knowledge management literature and examine the stock-flow model under different conditions. Then we check if the results confirm our expectations or not.

2. Model structure

As briefly mentioned, we use a system dynamics approach to model the knowledge creation and acquisition dynamics within an industry. In the subsequent sections, first we develop the general model and then we elaborate on external knowledge acquisition dynamics in an industry.

2.1. Knowledge creation within a firm

According to Nonaka and Takeuchi (Nonaka and Takeuchi, 1995), knowledge creation is the capability of a company as a whole to create knowledge, disseminate it throughout the organization, and embody it in products, services, and systems. They established a dynamic model of knowledge creation. In this model, they explained a critical assumtion that human knowledge is created and expanded through social

interaction between tacit knowledge and explicit knowledge. The name of this interaction is knowledge conversion. Knowledge conversion takes place through an iterative and spiral process of *Socialization*, *Externalization*, *Combination* and *Internalization* – or SECI – as an effective means of making individuals' tacit knowledge available to the broader organization in order to create new knowledge and then apply this new knowledge within their business processes towards achieving the organization's vision, objectives and performance standards (figure 1).

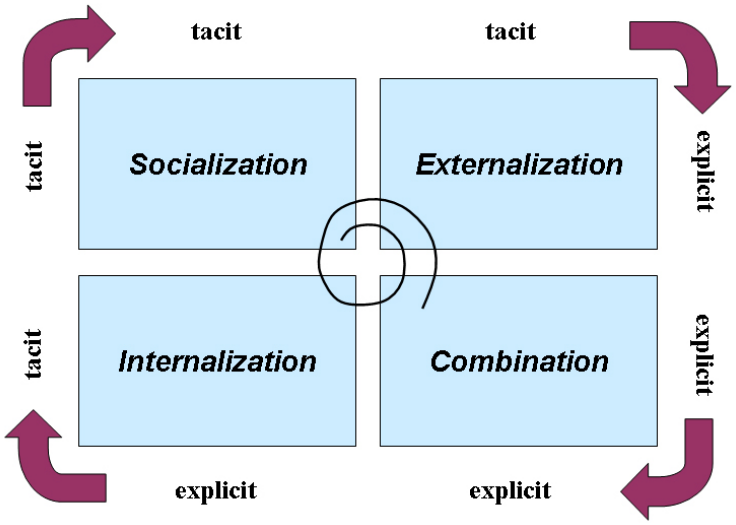

Figure 1: Four modes of knowledge conversion (source: Nonaka and Takeuchi, 1995)

- In Socialization, the first stage, each person's tacit knowledge is converted to tacit knowledge now also held by other members in the firm. Socialization is primarily a process between individuals and occures in settings such as apprenticeships and at conferences.
- In the next stage, Externalization, tacit knowledge is articulated and converted to explicit knowledge comprehensible to others, e.g. writing a report after attending a workshop. Externalization is a process among individuals within a group.
- During Combination, the third stage, this newly explicit knowledge becomes widely disseminated, discussed, redesigned and modified. This is the area where information technology is most helpful, because explicit knowledge can be conveyed in documents, email, databases, as well as through meetings and briefings.
- The final stage is Internalization. Internalization converts the changed, explicit knowledge again to a tacit form, this time held by many people. The internalization process is closely related to 'learning by doing' and transfers organization and group explicit knowledge to the individual.

According to SECI model, the simple feedback loop representation of the dynamic model for the knowledge creation in a firm is plotted in figure 2. In this closed loop, each arrow represents one of the four steps in knowledge creation process.

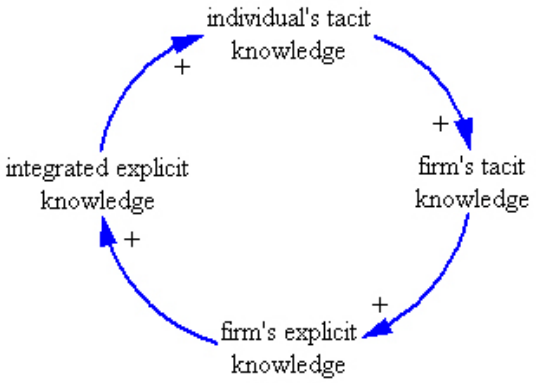

Figure 2: knowledge creation cycle in organizations

2.2. Knowledge transfer and creation within an industry

Similar to Nonaka's framework whereby tacit knowledge developed within one organizational unit is made explicit, transferred to another unit, applied within the new unit and thereby made tacit again; firms develop and transfer knowledge among themselves within their industry (Zack, 1999a). An organization develops tacit knowledge as a byproduct of its activities. This knowledge may be made explicit to facilitate its transfer among other units of the organization. In doing so, it may leak out of the organization into the industry at large. At the same time, the organization may be absorbing knowledge leaking out of other firms within its industry, and internalizing that knowledge through its reapplication within the firm.
Figure 3 shows the issue discussed above.

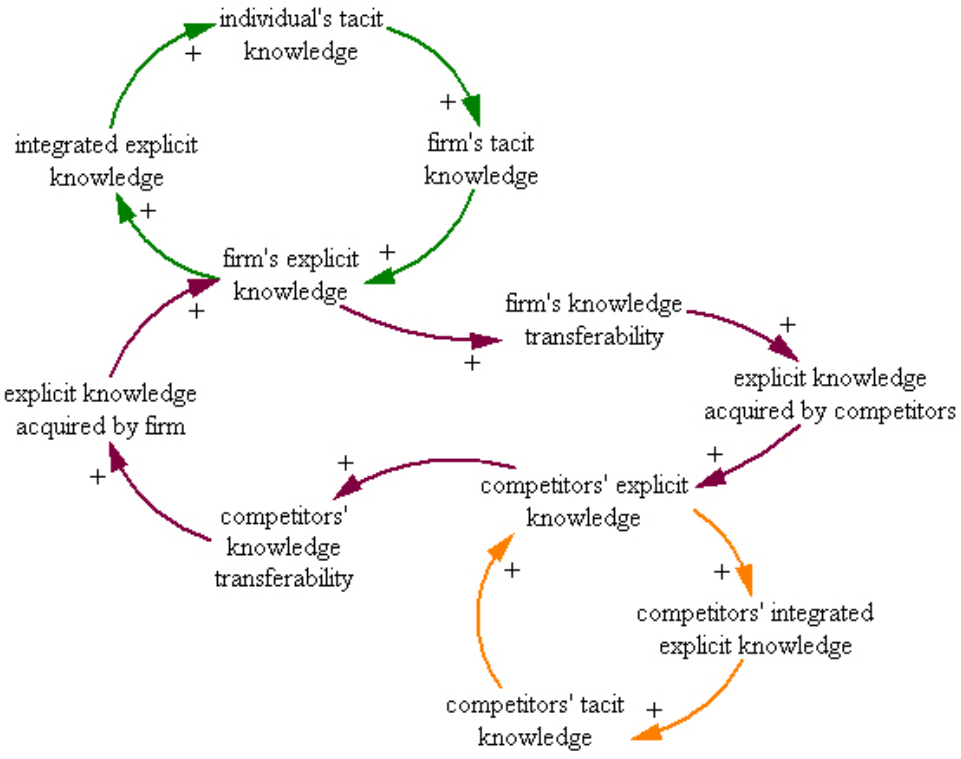

Figure 3: causal-loop diagram of knowledge creation and transfer dynamics within an industry

2.3. Competitive knowledge and financial resources

We can expand the causal loop for knowledge creation and transfer within an industry with what Zack has defined as Strategic Knowledge - the knowledge the firm needs to execute its strategy (Zack, 1999b). He states that just a portion of the knowledge the firm possesses is strategically important as a source of sustainable competitive advantage, because such knowledge is highly valuable, unique to the organization, difficult to imitate and difficult to substitute (Barney, 1991).

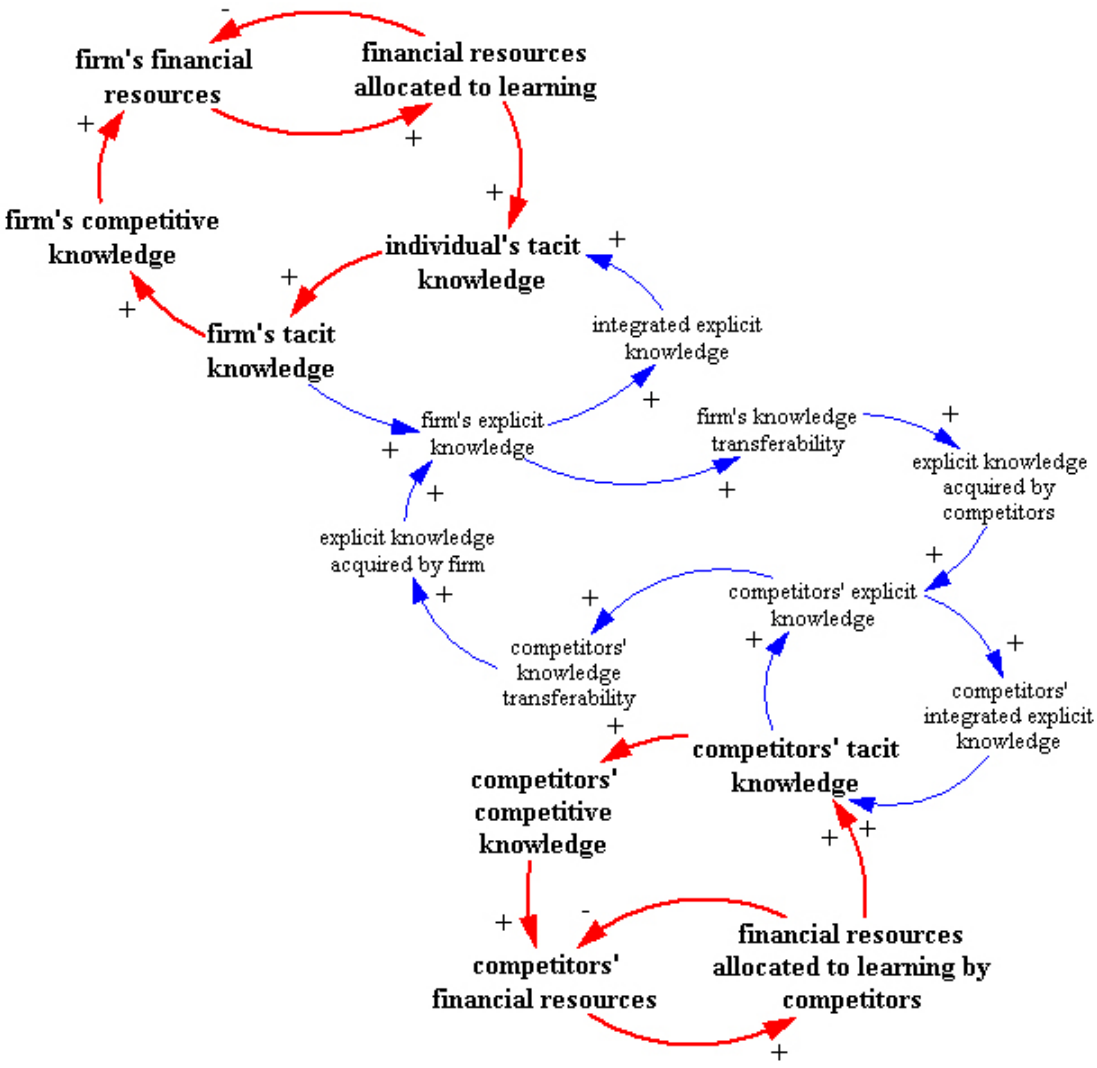

Figure 4: the role of competitive knowledge in knowledge creation

According to Zack (Zack, 1999b) every firm's strategic knowledge can be categorized by its ability to support a competitive position.
Core knowledge represents the basic knowledge required to operate in an industry. And it is usually common to all members of an industry.
Advanced knowledge differentiates a firm, enabling it to compete and remain viable. Some firms compete head-on in particular knowledge domains, hoping that their

knowledge is better than the competitors. Other firms seek to differentiate themselves based on what they know.
Innovative knowledge is truly unique and enables a firm to significantly differentiate itself from its competitors. It is obvious that knowledge is not static and what is innovative knowledge today will ultimately become the core knowledge of tomorrow.
In our model, the advanced knowledge and innovative knowledge are unified into a variable called competitive knowledge. By employing this important resource, an organization is able to create a higher economic value for its customers. This in turn implies that the firm can gain more financial resources than can its competitors (Almor and Hashai, 2004). The more financial resources the firm possesses, the more it can allocate to knowledge sharing and combination within the firm and therefore, it can accelerate its learning cycle (figure 4).

2.4. External knowledge acquisition

Each firm in an industry has some capability for engaging in the learning cycle shown in figure 3. It may be more or less capable of identifying its own tacit knowledge, explicating and sharing it within the firm, limiting its transfer out of the firm, absorbing external knowledge from the industry and reapplying that external knowledge in some unique and strategic way. We develop the external knowledge acquisition mechanism in this section.
For this purpose, we use the concept of *knowledge gap* - the gap between what the firm must know to execute its strategy, and what it does know (Zack, 2002). Zack refers to two distinct aspects of the knowledge gap, *internal knowledge gap* (the firm's current strategic knowledge vis-à-vis its desired strategic knowledge profile) and *external knowledge gap* (the firm's current strategic knowledge vis-à-vis its competitors').
To the extent that many competitors in the industry are operating at higher levels of knowledge across many more knowledge positions than an organization, it takes a high level of knowledge acquisition and creation to close the external competitive knowledge gap. In this situation, the firm is motivated to increase the knowledge sharing within the firm as well as with its competitors. Since explicit knowledge can be shared more easily, the firm explicates its tacit knowledge more drastically. Simultaneously, it is less concerned with erecting barriers to the diffusion or transfer of that knowledge out of the firm such as encrypting the documents, controling employees' e-mails, limiting access to classified documents, forbidding the use of personal data transfer devices in the firm, etc. We refer to this factor as 'degree of knowledge protection'. We intentionally differentiate between degree of knowledge protection and some other barriers to knowledge diffusion caused by specific characteristics of industry i.e. existence of strong patents, stickiness of technology in technology intensive industries, lack or nonexistence of industry standards, etc. (Reed and DeFillippi, 1990), because the origins of these barriers are different as well as their strength.
In summary, degree of knowledge protection by the firm, industry barriers to knowledge diffusion and degree of firm's knowledge codification can affect the firm's knowledge transferability.
This reasoning is also applicable to the other firms in the industry; therefore we explain the remaining structure of the model for a firm. First we consider the explicit knowledge acquisition and tacit knowledge acquisition will be described later.

The more transferable knowledge provided by competitors, the more knowledge acquired by the firm. In addition, the rapid developments in information technology (IT) are clearly carrying knowledge transfer to a more global scale (Cowana, Jonard and Özman, 2004). IT plays two important roles in this area: first, it offers new opportunities for codifying knowledge and information, which may facilitate knowledge sharing activities (Grimshaw, 2001) and second, by increasing data processing and transmission capacities, IT applications change the nature of the trade-off between the degree of codification of knowledge and the speed and extent of its diffusion within a target population (O'Callaghan and Andreu, 2006). This implies that at a given level of codification, the population to which a message can be diffused increases. 'IT infrastructure effectiveness' is assumed to be an exogenous variable.

Another important factor affecting the extent of explicit knowledge acquired by a firm is *'absorptive capacity*' of the firm. Absorptive capacity is the ability of an organization to learn and integrate knowledge that is available (Cowana, Jonard and Özman, 2004) and determines how fast new knowledge can be absorbed into the existing knowledge level of the organization (Otto and Richardson, 2004). This ability represents one of the two dimensions of knowledge internalization, which is knowledge applicative capability or the ability to apply knowledge in real situations. Knowledge creation capability is the other dimension and is the ability to create new beneficial knowledge by combining and extending existing knowledge with the acquired knowledge (Tsai and Lee, 2006).

Absorptive capacity depends on factors such as the level of prior related knowledge (O'Callaghan and Andreu, 2006) and the extent to which the sender and receiver share tacit knowledge (Cowana, Jonard and Özman, 2004). Thus, the absorptive capacity of the firm, the explicit knowledge acquired by the firm and the level of prior related knowledge increase through a dynamic reinforcing loop.

Absorptive capacity of the firm has an effect not only on explicit knowledge acquisition, but also on tacit knowledge acquisition. Furthermore, some other factors such as the extent of competitors' tacit knowledge, barriers to knowledge diffusion and competitors' motivation for knowledge sharing can affect the extent of tacit knowledge acquired by the firm. We should also consider the essential role of communities in facilitating tacit knowledge transfer within an industry. Two types of communities are distinguished in the Knowledge Management literature: *epistemic communities* and *communities of practice* (O'Callaghan and Andreu, 2006). Within communities of practice, the privileged knowledge is essentially the know-how, which is tacit and socially localized, whereas epistemic communities share a common goal of knowledge creation. We here define a facor called as 'effectiveness of communities' that indicates quality and capacity of the communities in which tacit knowledge trnasfers and is an exogenous variable.

The more acquired tacit knowledge and explicit knowledge, the more level of related knowledge and the more knowledge similarity in the industry. Therefore, that part of competitors' competitive knowledge which is acquired by the firm can no longer provide competitive advantage and becomes the core knowledge of industry.

In addition, external knowledge acquisition creates a knowledge dependency on the remainder of the knowledge that is more highly protected by competitors. Some competitors sell this supplemental knowledge directly - that is, proactively explicating and transferring it out of the organization at a price. Thus, the firm is forced to allocate more financial resources for obtaining the complementary knowledge, implying a decrease in the firm's financial resources as well as an increase in competitors' financial resources.

Figure 5 illustrates how external knowledge is acquired by a firm. The structure for competitors is not shown; however, all structural elements e.g. motivation for knowledge sharing, absorptive capacity, and barriers to knowledge diffusion, are identical.

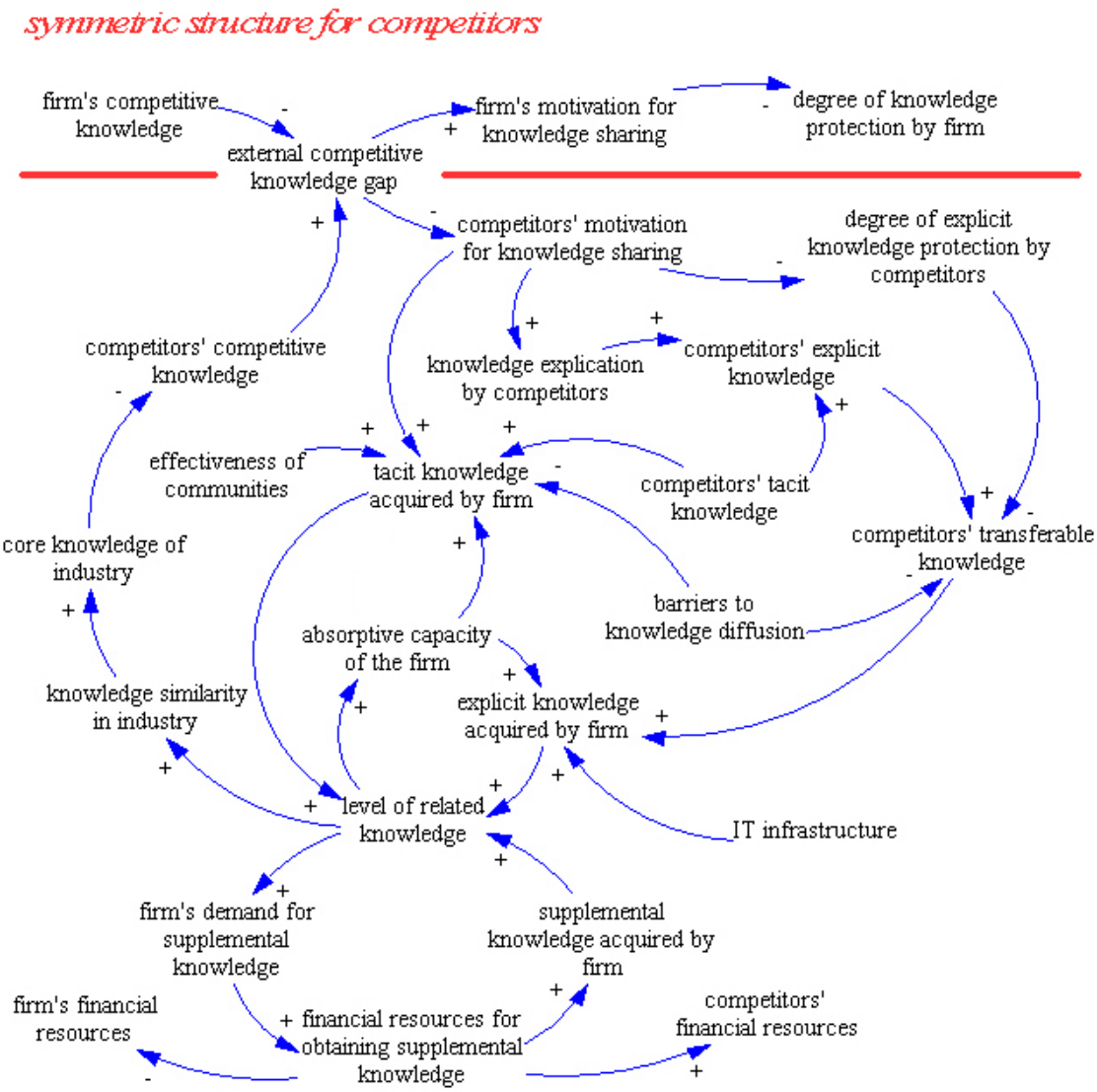

Figure 5: causal-loop diagram of external knowledge acquisition

Since casual models are easier to deal with, we have put them in the text and the stock and flow models are placed in the appendix.

3. Research proposition

Zack (Zack, 1999a) describes organizations which are more exploitative of internal knowledge as having a '*conservative*' knowledge strategy, while those that are exploring external knowledge have a more '*aggressive*' knowledge strategy. However, he points out that a knowledge strategy cannot be made without reference to competitors. Thus,

some industries (where knowledge is changing more rapidly) tend to be characterised by more aggressive firms, while other industries are generally more conservative.
To examine the validity of the model, consider two important conditions that can affect the knowledge strategy adopted by the firm:

- *Proposition 1: The degree of agressiveness in knowledge strategy adopted by a firm is positively associated with the number, variety or size of the initial competitive knowledge gap.*

- *Proposition 2: The degree of agressiveness in knowledge strategy adopted by a firm is positively associated with the volatility of the knowledge base in the industry.*

4. Exercising the model

In this section we describe how the system dynamics model is used to simulate two different knowledge strategies that influence the knowledge level of the firm. To simulate the effect of adopting conservative or aggressive knowledge strategies, we change the various factors that activate the internal knowledge creation and the external knowledge acquisition loops respectively.
First, we simulated a base run. In this simulation, the knowledge life cycle is relatively long and there is not an initial knowledge gap. In all simulations we assume that the firm has approximately the same learning capability as that of competitors. We tested two firms in this situation, one with a conservative knowledge strategy and the other with an aggressive knowledge strategy. Other than this, it is assumed that the firm and its competitors apply the same policies, for example they have the same ratio of financial resources allocated to learning. The results are shown in Figure 6. This result suggests that in this situation both firm and its competitors gain competitive knowledge and the model does not show any significant difference between two strategies. Also, it suggests that a conservative knowledge strategy will works slightly better than an aggressive strategy.

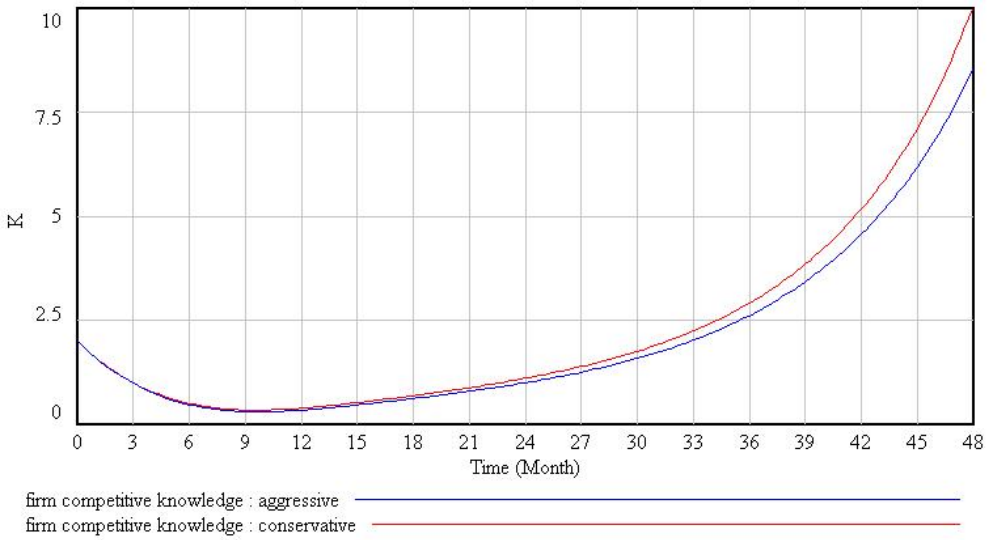

Figure 6: The base run

In the first experiment, in order to show the effect of the initial competitive knowledge gap, we change the initial knowledge level of the firm. The graph in figure 7 depicts the expected behavior of the firm's competitive knowledge with both aggressive and conservative knowledge strategies. In opposition to the base run, in this situation an aggressive strategy will be more successful than a conservative strategy. The results of this experiment confirm what stated in proposition 1. This implies that being other factors equal, the firm must adopt an aggressive knowledge strategy to close its external competitive knowledge gap.

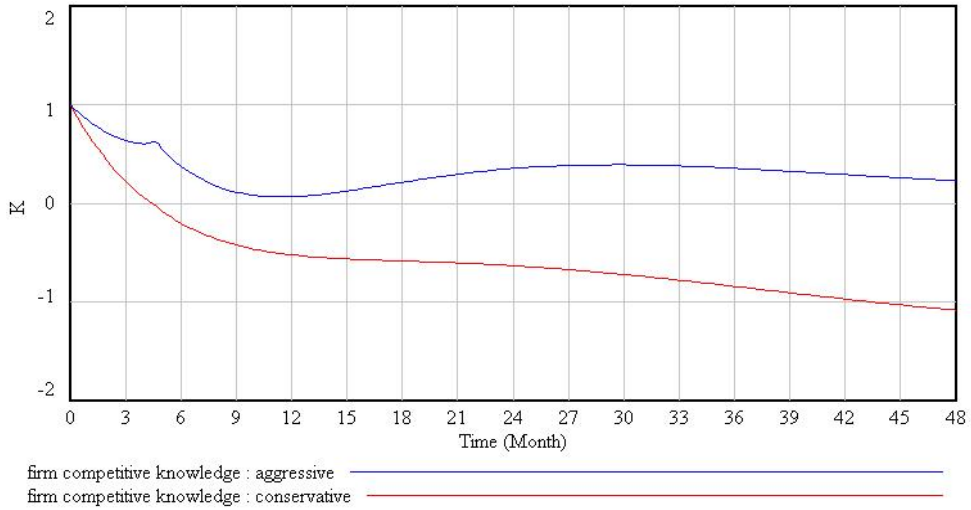

Figure 7: The effect of knowledge strategy on firm's competitive knowledge level (Higher external competitive knowledge gap in comparison to the base run)

In order to test the second proposition, we examine a situation in which there is not an initial gap between the firm's competitive knowledge and its competitors', but knowledge life cycle is shorter in comparison to the base run. The results are shown in figure 8. These results imply that when knowledge in the industry changes rapidly, if other things remain the same, the organization should adopt a more aggressive knowledge strategy to become and to remain competitive in its strategic position.

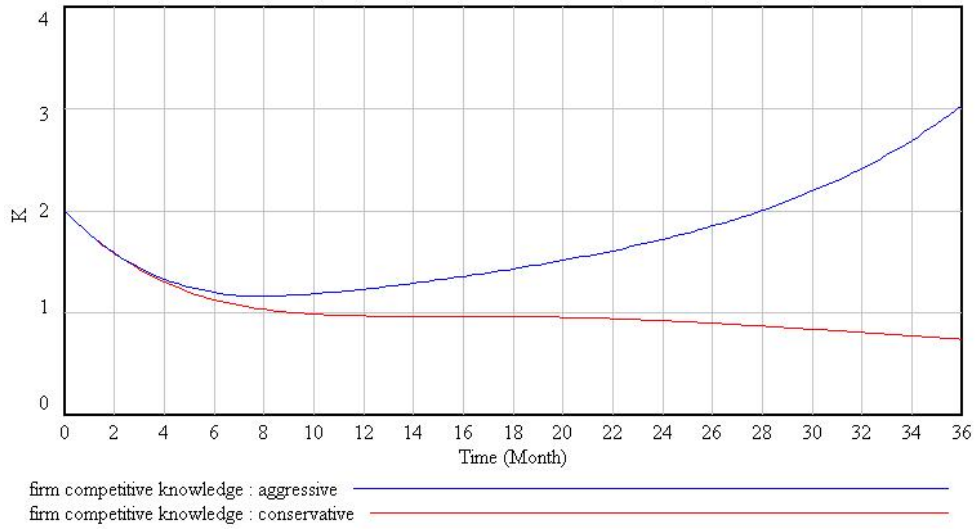

Figure 8: The effect of knowledge strategy on firm's competitive knowledge level (Lower knowledge life time in comparison to the base run)

5. Summary and conclusion

Organizational knowledge is very complex and has multiple dimensions. Several scholars have emphasized the importance of both tacit and explicit knowledge as well as internal and external knowledge and this notion has two important implications for knowledge management: *First*, the knowledge residing outside the boundaries of organization must be managed along with the internal knowledge. *Second*, knowledge management efforts must address both tacit and explicit knowledge. Therefore, organizations need to understand the dynamics of their knowledge capital and knowledge acquisition policy. We used a system dynamics approach to explicate dynamic theory grounded in the relevant literature. In the proposed model, we tried to integrate various perspectives on knowledge acquisition process in both tacit and explicit forms. In order to model the bahaviour of other firms in the industry, we have constructed the model for a typical competitor which represents the status of the majority of the firm's competitors in that industry. What's more, we assume that firm's decisions about knowledge sharing do not change in short term and we used constant variables to simulate this situation. Using this model, we showed that an aggressive knowledge strategy will be more successful if there is an initial gap betwean the firm's competitive knowledge and its competitors' and if the knowledge in the industry changes rapidly.

In this model, we assumed that learning capabilities of both firm and competitors are static and exagenous to our model, although in real world learning capabilities may change by time. A more comprehensive model which addresses both learning capability and knowledge of the firm may give a better insight into the dynamics of knowledge creation within the firm and knowledge acquisition from the outsiders.

As a further study, the model could be examined by using emprical data to study an organization’s knowledge strategy and its knowledge level. Furthermore, we can examine different knowledge strategies for competitors and compare the results with previous situations.

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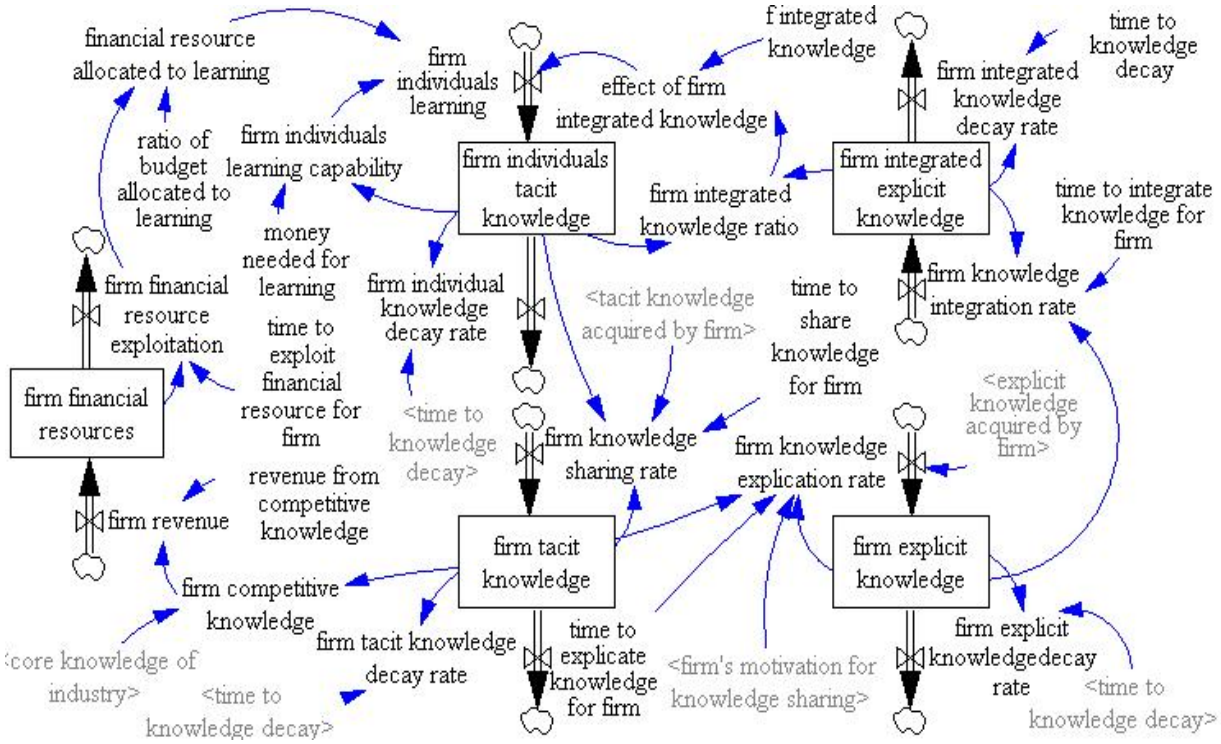
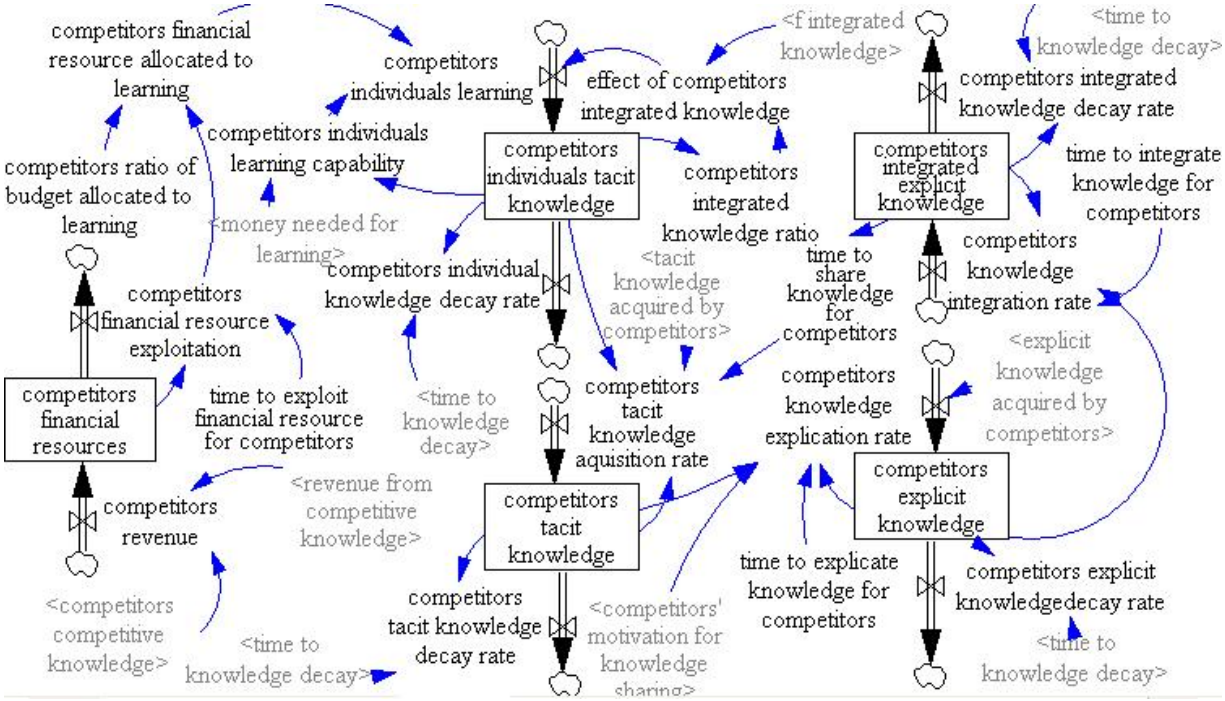
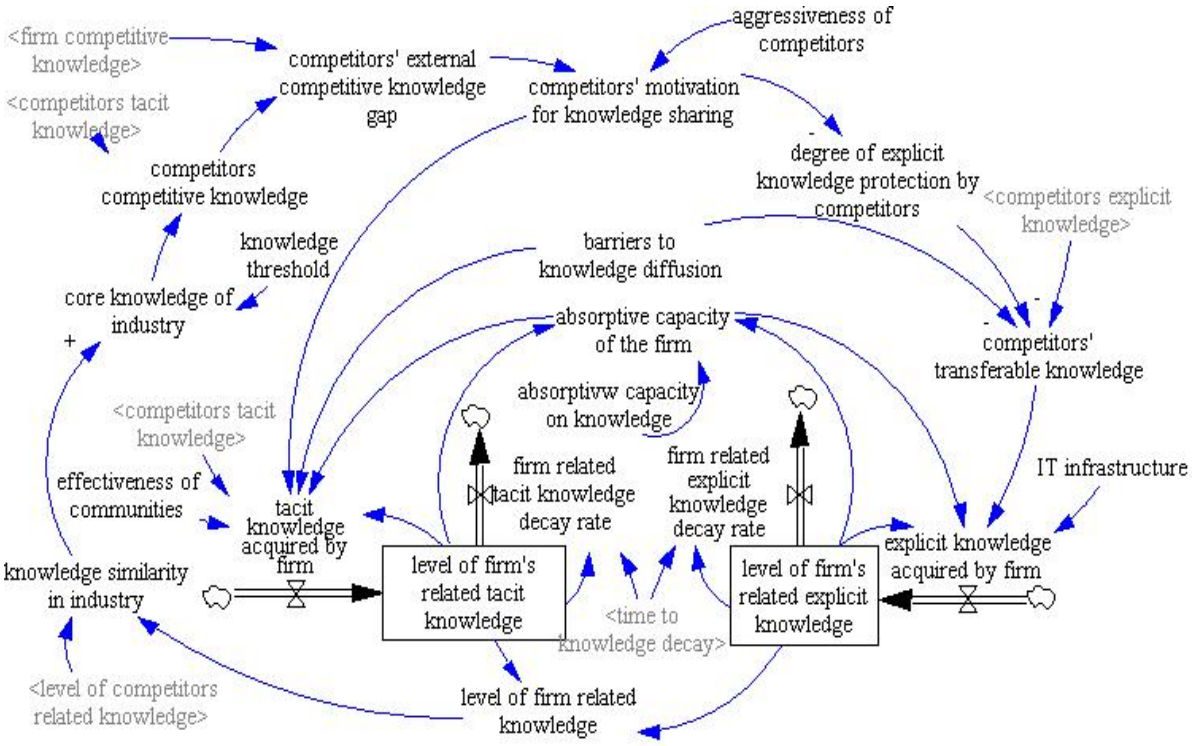
Appendix



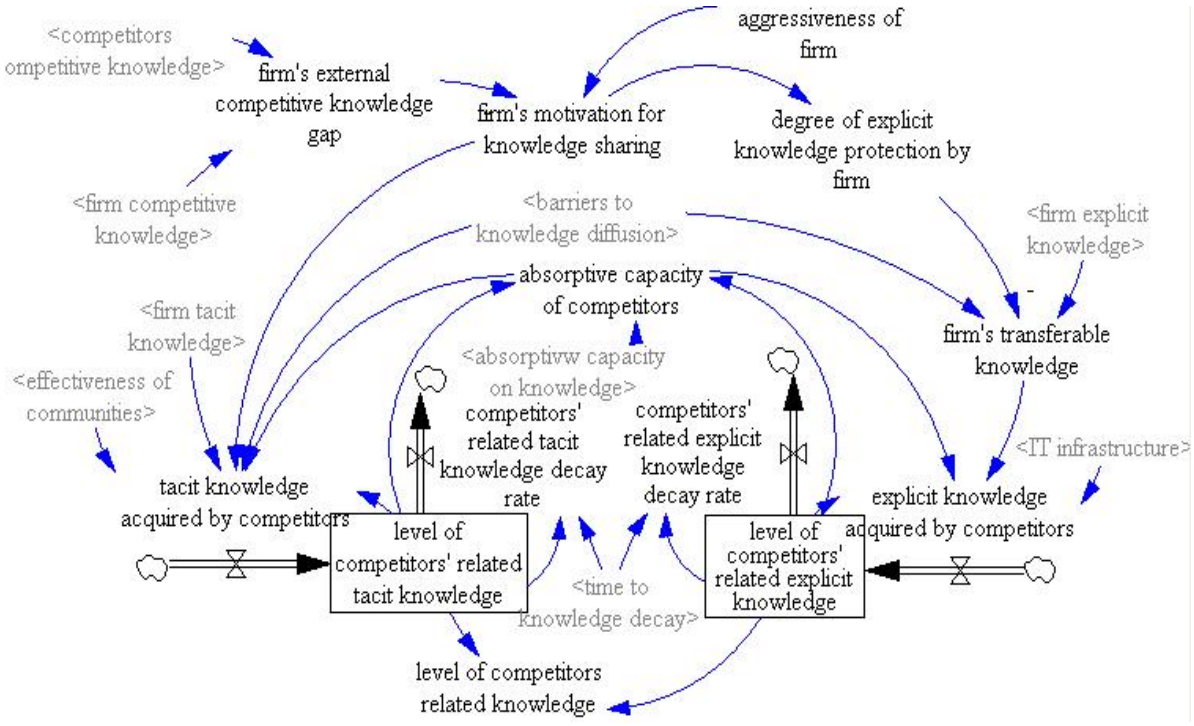
Stock and Flow model for knowledge creation by the firm



Stock and Flow model for knowledge creation by the competitors



Stock and Flow model for knowledge acquisition by the firm



Stock and Flow model for knowledge acquisition by the competitors