Interorganizational Learning: A Dynamic View on Knowledge Development in Strategic Alliances

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Abstract

The objective of this paper is to develop a dynamic theory of interorganizational learning and knowledge acquisition in strategic alliances. Strategic alliances are becoming an increasingly important organizational form to gain access to new knowledge and to leverage existing knowledge. By establishing an alliance with one or more partners, an organization will gain valuable learning opportunities to acquire knowledge and to enhance its competitiveness. The degree with which the partners can realize their learning objectives is dependent on their absorptive capacities and the collaborative strategies adopted by the partners. These collaborative strategies may include the trust between alliance partners as well as the willingness to share existing knowledge. In order to gain insights into the dynamics of interorganizational learning and knowledge acquisition we propose a simulation model to test different conditions influencing the outcome of an alliance. Although the model is highly aggregated the results can improve our understanding of the key factors that influence the acquisition of knowledge in strategic alliances. We conclude the paper with a discussion for guidelines to assess and manage the outcome of strategic alliances.

Keywords: Strategic alliances, interorganizational learning, knowledge acquisition, collaborative strategies, system dynamics

Introduction

Alliances in its various forms are not longer a strategic option but a necessity in many markets and industries. An alliance can be broadly defined as a situation where two or more organizations are coming together because of their mutual interest in interorganizational learning and as a result of this collaboration leveraging existing knowledge levels. The number of U.S. corporate alliances has grown by more than 25 percent annually for the past five years (Harbison 1989). Drucker (1995) suggested that the greatest change in the way business is being conducted is the accelerating growth of relationships based not on ownership but on partnership. An important explanatory factor in the growth of alliances is that theses forms of cooperation provide a platform for organizational learning and access to new knowledge gained during the alliance (Grant 1996; Hamel 1991; Khanna 1998; Kogut 1998).

The motivations for an organization to enter an alliance are, for example, attempts to achieve competitive advantages by gaining market access, scale economies, and competence development through collaboration (e.g. Astley 1989; Hamel 1989; Lorange 1992). While the number of alliances has grown over the last few years, the actual performance of strategic alliances seems to be disappointing (e.g. Harrigan 1988; Porter 1987). Doz (1996) suggests that a key to better understand the pitfalls of strategic alliances can be found in the benefits and difficulties of organizational learning among the cooperating firms. Other researchers have identified particular learning problems, such as the risk of uncontrolled information disclosure and asymmetric diffusion of core competencies to partner firms as constraints for a successful alliance (Bresser 1988; Hamel 1991; Inkpen 1997).

The literature is replete with theoretical research (e.g. Kumar 1998; Makhija 1997; Mody 1993) as well as empirical studies (e.g. Dodgson 1993; Lane 1998; Simonin 1999) addressing the issues of alliance learning. While this stream of research addresses some important questions concerning the conditions under which organizations exploit alliance learning opportunities, little is known about the dynamic nature of interorganizational learning that occurs among cooperative firms. The primary objective of this paper is to integrate various perspectives on learning in alliances and to extend existing frameworks of interorganizational learning by making explicit causal feedback

loops that, we contend, will help decision makers gain insights into the dynamic behavior of alliance learning.

The model described in this paper is an explicit dynamic theory expressed in a micro-world simulation, grounded in the relevant literature, with which we can test different conditions for strategic alliances. Although the representation of the system along with the outcomes of joint learning is highly aggregated, reflecting on simulation experiments with the model nevertheless provides insights into the dynamic behavior of interorganizational learning.

An Interorganizational Learning Framework

During strategic alliances, interorganizational learning can be achieved by transferring existing knowledge from one organization to another organization, as well as by creating completely new knowledge through interaction among the organizations (Larsson et al. 1998). The framework we apply assumes conditions where two organizations form an alliance to create completely new knowledge.

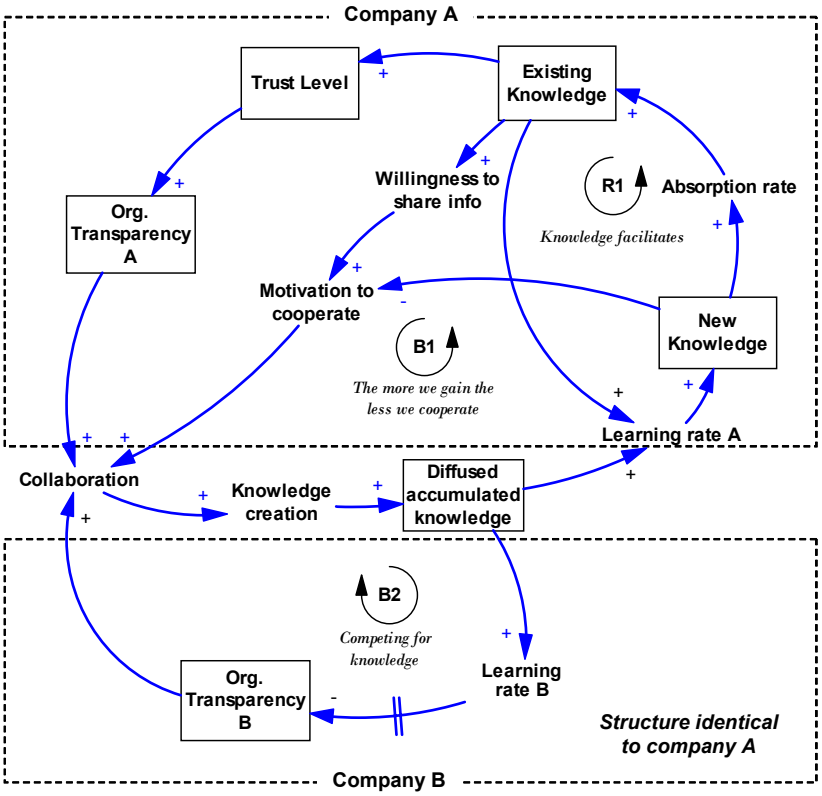

Figure 1: Causal feedback loop framework for interorganizational learning

The proposed framework is a feedback view of two individual firms with collective organizational actions to form new knowledge during a strategic alliance. The presentation begins with a basic framework which is gradually detailed and expanded in the following sections of the paper to create a model appropriate to support corporate policy discussions.

Organizational learning, as opposed to individual learning, is learning at a collective level that occurs as knowledge is transformed from an individual to a collective state (Spender 1996). The central proposition of our framework captures organizational learning as a multi-stage process following Nonaka (1994) and Tushman and Scanlon (1981). In the first stage knowledge is created through collaboration between two or more partners. This interactive and collaborative process creates the alliance knowledge, which in turn leads to diffused accumulated knowledge. The level of collaboration is determined by the transparency of each firm as well as the levels of their motivation to cooperate. If either firm is not transparent, no existing knowledge is disclosed and thereby cannot be reviewed by the other or used collectively to generate new knowledge (Larsson et al. 1998). Transparency in a firm is a choice, determined mainly by the individual trust level of each firm, which is influenced by the existing knowledge level. As the organizations gain new knowledge, the level of existing knowledge increases, and trust grows. The lack of interorganizational trust is therefore a barrier to organizational knowledge creation (cf. Dodgson 1993; Nonaka 1994). The learning rate is influenced by the level of diffused accumulated knowledge as well as the existing knowledge of an organization. As Powell et al. (1996) argued, knowledge facilitates the use of other knowledge. If new knowledge becomes available various organizational factors determine how fast new knowledge can be absorbed into the existing knowledge level of an organization. Thus, the absorptive capacity of a firm is considered as a limiting ability factor of interorganizational learning (Kumar 1998; Lane 1998).

The two variables “willingness to share” and “motivation to cooperate” in our framework can either positively or negatively influence the level of cooperation between the alliance partners. While the level of existing knowledge determines the willingness to share, new knowledge influences the motivation to cooperate. The balancing loop (B1) in

Figure 1 suggests that gaining new knowledge may reduce the motivation to cooperate. This construct is based on Hamel's (1991) study of interpartner learning in international strategic alliances. He found that the firms behaving as "good partners" with high transparency and collaborative intent tended to be exploited by the more selfish partners with lower transparency and more competitive intent. This observation addresses the opportunistic benefits of competitive learning within the alliance. Larrson et al. (1998) describe this behavior as an interorganizational learning dilemma where an organization pursues the maximum organizational share of the joint learning by taking more knowledge than is gives. This competitive learning strategy will result in gaining more knowledge and power relative to the other more transparent partner. We conceptualize this trade-off based on the assumption that if one partner gains new knowledge, he behaves opportunistic by reducing the motivation to cooperate and thus withholding knowledge from the other partner.

The second construct in our framework, which influences the motivation of an organization to cooperate, is a link from existing knowledge to the variable "willingness to share". Based on Larsson et al. (1998) we formulate this construct so that the level of existing knowledge influences how willing an organization is to share its knowledge with one (or more) partners. Other structural elements of the proposed framework will be explained in more details later in the paper.

Research Proposition

To explore the conditions under which firms exploit learning opportunities in alliances, we propose two important conditions influencing the outcome of an alliance between two firms.

Proposition 1: A firm's learning intent and ability are positively associated with the level of existing knowledge and the rate with which new knowledge can be absorbed.

Proposition 2: With more trusted partners, firms increase their willingness to share knowledge and tend to acquire more new knowledge due to higher levels of interorganizational transparency.

These propositions will be examined using a system dynamics approach. Substantive interpretation of testing the knowledge acquisition policies with the simulation model will be discussed. In the next section we provide a more detailed description of the model structure.

Model Structure

We assume that partners who establish an alliance have similar positions within an industry sector and similar resources. The model captures knowledge generation ('exploration') but not explicitly knowledge application ('exploitation'). Thus we assume that gaining new knowledge will contribute to the efficiency in the application of knowledge (e.g., improving the efficiency with which knowledge is integrated into a production or service process). The model shows how new knowledge is created during an alliance, constrained by the motivation to collaborate, the collaborative transparency, and the effect of existing knowledge on the learning rate. (See Figure 2 for a picture of these structural assumptions.) Existing knowledge is conceptualized as a stock with an inflow from learning while doing internal tasks (independent of the collaboration) and another inflow from absorbing new knowledge, which is gained during an alliance. For the outflow from the stock of existing knowledge we use a constant fractional knowledge decay to capture an obsolescence rate for organizational knowledge. The level of existing knowledge influences the absorption rate of new knowledge and the learning rate with which diffused accumulated knowledge is acquired.

New knowledge is determined by a learning rate and constrained by the level of diffused accumulated knowledge, which is created during the alliance. The learning rate of new knowledge is based on the trust level and the level of existing knowledge. The level of new knowledge then determines the motivation rate, which we conceptualize in our model following Hamel's (1991) suggestion that gaining new knowledge may eventually reduce the motivation to cooperate. In turn, motivation to collaborate and willingness to share influence the level of organizational transparency a firm provides during an alliance. The outflow from the stock of organizational transparency of firm A

or B is determined by the level of interorganizational trust that is the rate of how much trust is created among the two firms in the alliance.

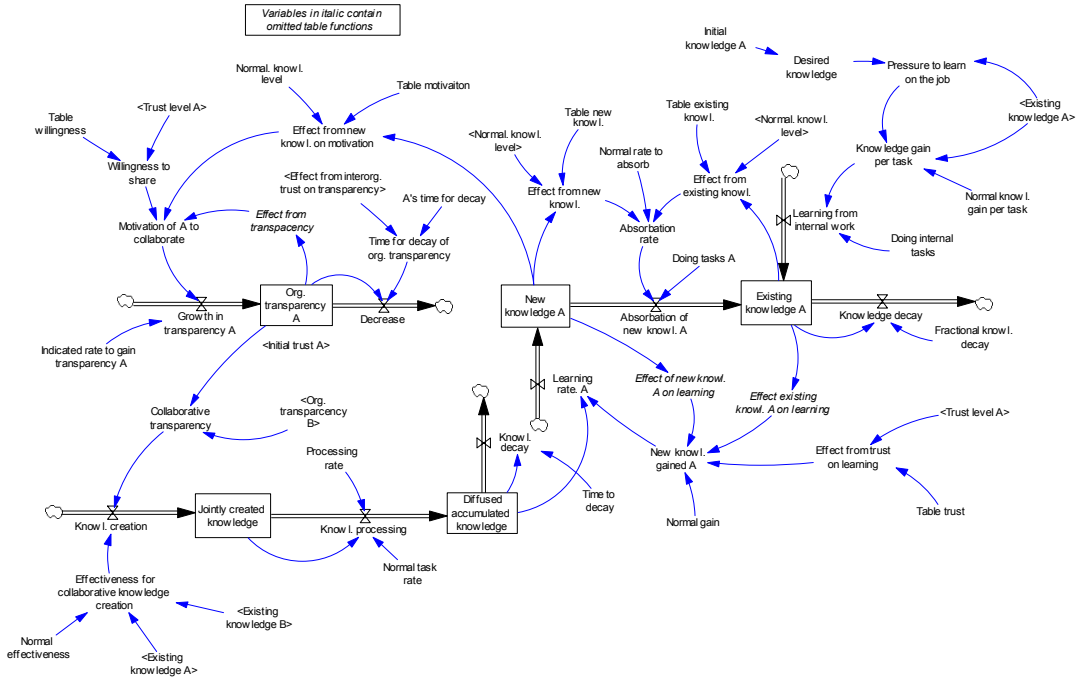

Figure 2: High level representation of knowledge sector

The structure for the partner firm is not shown in figure 2; however, all structural elements, i.e. new knowledge, existing knowledge, and organizational transparency, are identical. To enhance our ability to learn from the model in stages, we have not yet incorporated different dimensions of knowledge resources (tacit, explicit, and complex) aggregate all forms of knowledge into one concept. Thus, we capture the creation of aggregate new knowledge as a function of how much collaborative transparency exists between the partner firms, influenced by the knowledge processing rate, and the learning rate of the individual firms.

Sector View: Trust

Figure 3 illustrates how individual trust of the partner firms is created (the structure for the trust level of firm B is identical with firms A but not shown in this diagram) and how interorganizational trust is established.

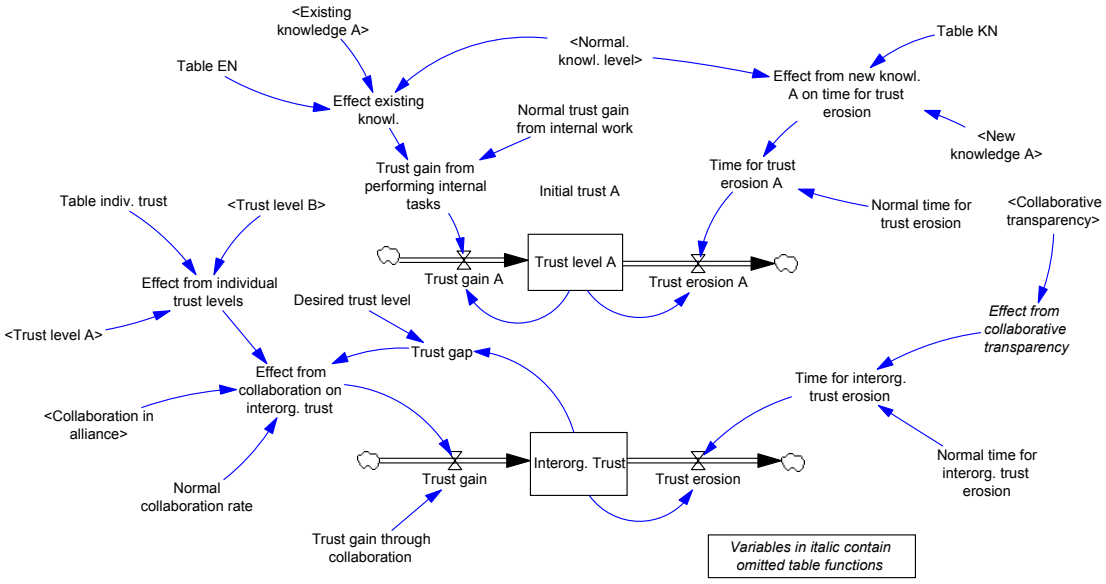

Figure 3: Conceptualization of individual and interorganizational trust

As noted, a lack of interorganizational trust is a barrier to organizational knowledge creation. Thus, the learning rate of new knowledge is influenced on a partner's intent and ability to learn as well as on the trust the firm has in the partner. The trust level of a partner is determined by its initial existing knowledge and subject to the newly gained knowledge. Interorganizational trust, on the other hand, is increased through the trust levels of the two partners and decreased through the collaborative transparency.

Reference Behavior Modes

The literature on knowledge acquisition during alliances suggests we might expect the following dynamic behavior patterns. The graphs in figure 4 depicts the hope and fear behavior of gaining new knowledge when two firms establish an alliance.

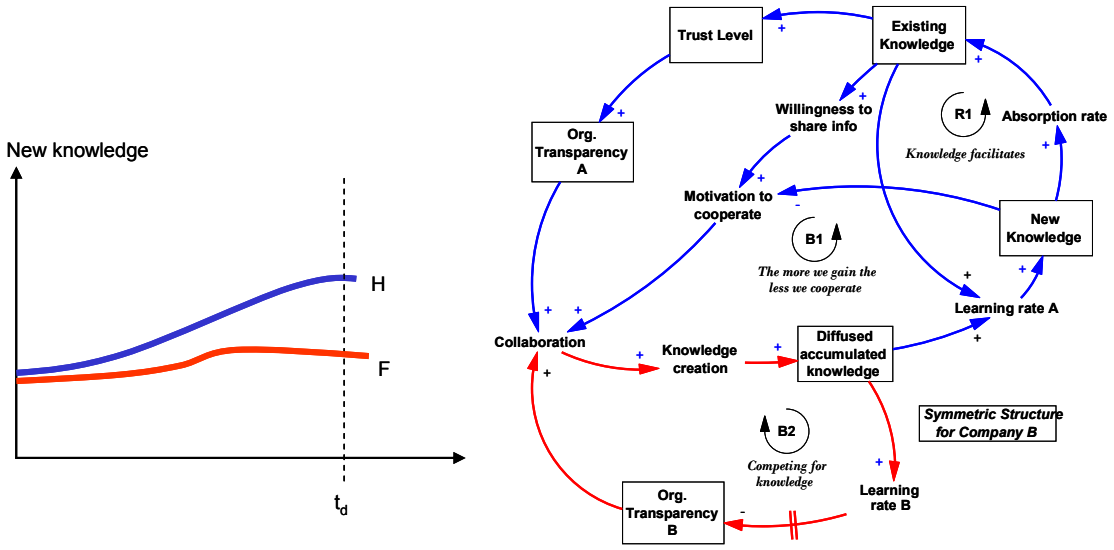

Figure 4: Reference modes for new knowledge gain (H stands for hoped for behavior, F stands for behavior firms might fear to expect)

The feedback loops shown on the right side in figure 4 suggest an identical structure for two firms working in collaboration. The time (x-axis) on the graph suggests that alliances have a pre-defined beginning and end, (t_d) thus we would measure how much new knowledge a company gained during an alliance. While the hope behavior (H) depicts the expected behavior under symmetric conditions, the fear behavior (F) suggests that one of the two companies embodies tendencies that constrain diffusion and the learning of new knowledge. The theory on knowledge acquisition in alliances, which we have endeavored to capture in this formal model, suggests that the company with lower trust levels or lower existing knowledge will gain less new knowledge during an alliance and give rise to the "feared" behavior in Figure 4.

Exercising the Model

This section describes how the system dynamics model is used to simulate the various factors that influence the acquisition of learning in strategic alliances. The base run in figure 5 shows the key variables and their expected behavior of an alliance between two

companies, with relatively high initial levels (0.8) of existing knowledge and trust; we use a scale from 0 – 1.0 to capture initial conditions for knowledge and trust.

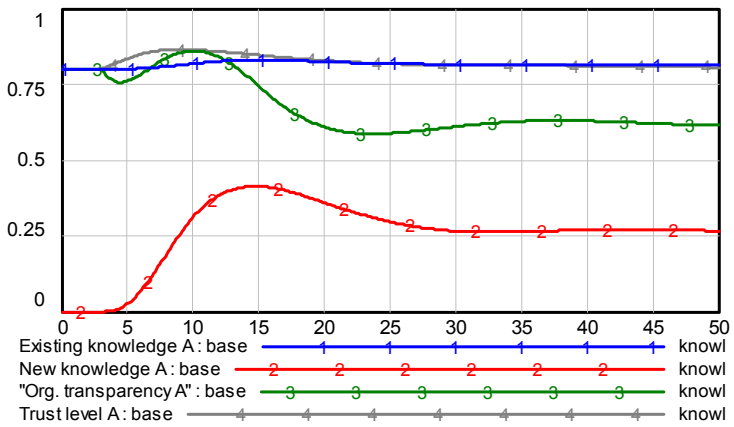

Figure 5: Base run of simulation model[1]

The result from this base (reference) run suggests that both companies will gain new knowledge (line 2) and thus slightly increase their level of existing knowledge (line 1). "Organizational transparency" (line 3) first drops, then rises and then drops again, due to interplays between the delay in gaining new knowledge and the waxing and waining of the firms' motivations to collaborate. As the two firms gain new knowledge, their trust level (line 4) increases and remains high as long as new knowledge is created.

Effect of Asymmetric Knowledge

In the first experiment we change the initial knowledge level of one partner; company A enters an alliance with lower existing knowledge (0.6) while company B's existing knowlege is 0.8. Thus, company B, acting as „good partner", is exploited by the more selfish partner, who enters the alliance with lower knowledge. However, because gaining new knowledge influences motivation to collaborate and subsequently organizational transparency, company B will win out and gain more new knowledge by maintaining a certain level of organizational transparency.

[1] Model begins in equilibrium, assuming that alliance begins at t=3 with identical existing knowledge and trust levels for both companies

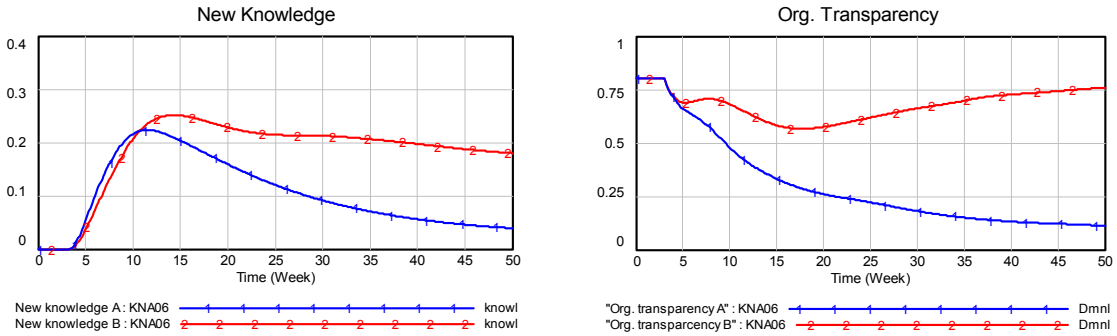

Figure 6 a & b: Comparison of new knowledge and org. transparency between the partner firms

The graph on the left side depicts the expected behavior of gaining new knowledge for company A and B. As long as company B retains its motivation to collaborate, company B will gain more new knowledge during the alliance. The reason why firm A will gain less new knowledge can explained by looking at the graphs in figure 7 a & b. In figure 7a we see that because the initial level of existing knowledge influences how fast we can learn, the firm with lower initial knowledge will not achieve the same learning rate at the other partner.

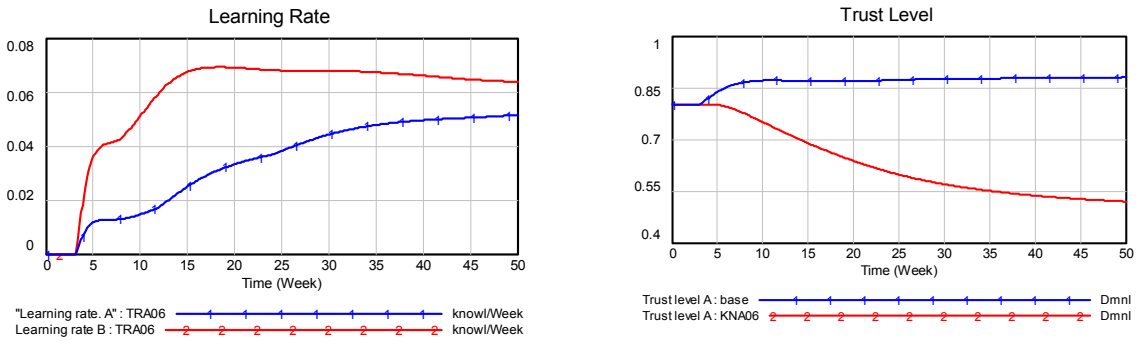

Figure 7 a & b: Learning rate and trust level with asymmetric knowledge levels

Figure 7b shows how the trust level of firm A (the partner with lower existing knowledge) decreases because the new knowledge gained does not meet A's expectations. Gaining new knowledge influences the motivation to collaborate, the

organizational transparency and subsequently the trust level. Thus, existing knowledge influences the opportunity to acquire new knowledge in an alliance.

Effect of Asymmetric Trust

This experiment simulates a situation where one partner (company A) establishes an alliance with lower trust level (0.6 viz. 0.8) while the second partner's (company B) initial trust level remains 0.8.

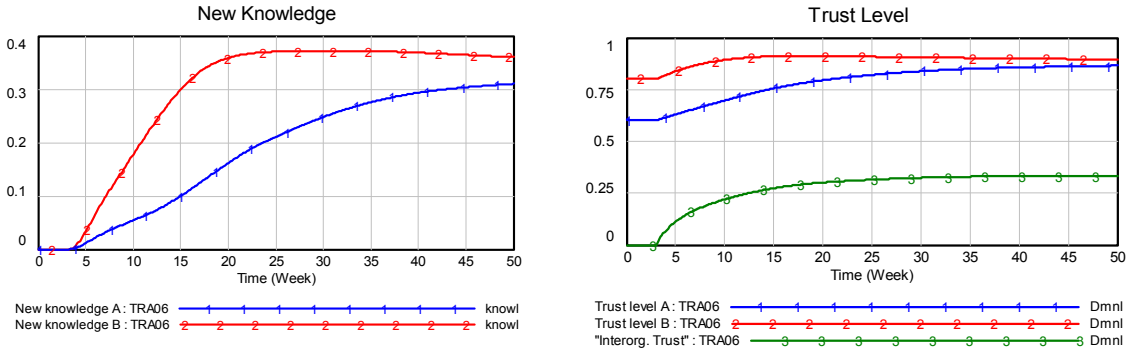

Figure 8 a & b: Knowledge gain with asymmetric trust levels

If company B retains its trust levels, regardless of lower trust at company A, both companies are able to gain new knowledge, (as can be seen in graph 8a) which then increases the trust level of company A and subsequently A's motivation to collaborate, reinforcing new knowledge gain.

As long as learning takes place during the alliance, that is, as long as the "good partner" keeps up his trust level, the other partner will gain new knowledge and thus increase his trust level for the alliance. The trust level of both partners then determines the rate of interorganizational trust (line 3 in figure 8b) which can be operationalized as the collaborative culture in the alliance. This shared interorganizational trust influences both partners' willingness to cooperate and knowledge sharing in joint learning activities. The following table shows a number of parameter tests and compares the results in terms of new knowledge gain for the two partner firms.

Condition	*Parameter*	*Initial value*	*Policy lever*	*New knowl. A*	*New knowl. B*
Changing productivity rate of firm A	Doing tasks	4	8	10% higher	**12% higher**
Firm A's enters alliance with less motivation to collaborate	Indicated rate to gain transparency	1	0.8	0.7% higher	0.7% higher
Firm A's knowledge decay rate	Fractional knowl. decay	2.5	1.5	**40% lower**	5% lower
Low initial levels of knowledge and trust of firm A	initial trust initial knowledge	0.8 0.8	0.6 0.6	90% lower	**45% lower**
Low initial levels of knowledge and increase in knowledge decay rate of firm A	initial knowledge Fractional knowl. decay	0.8 2.5	0.6 1.5	**97% lower**	93% lower
High initial levels of knowledge and trust of firm A, with little motivation to collaborate	initial knowledge initial trust Rate to gain transp.	0.8 0.8 1	0.9 0.9 0.4	**86% higher**	80% higher
Both firms enter alliance with less motivation to collaborate	Indicated rate to gain transparency	1	0.8	0.3% lower	0.3% lower
Both firms enter alliance with low initial levels of trust	initial trust	0.8	0.6	**3% lower**	**3% lower**
Both firms enter alliance with low initial levels of knowledge	initial knowledge	0.8	0.6	**92% lower**	**92% lower**

Table 1: Results of changes in initial conditions (the values for new knowledge gain or loss is always measured against the base case)

Effect of higher productivity

It is intriguing to note that increasing the productivity rate of one firm (in our model firm A) yields a higher new knowledge gain for firm B. Increasing the task rate of one firm results in higher accumulation of new knowledge, which in turn increases the motivation to collaborate and subsequently the organizational transparency.

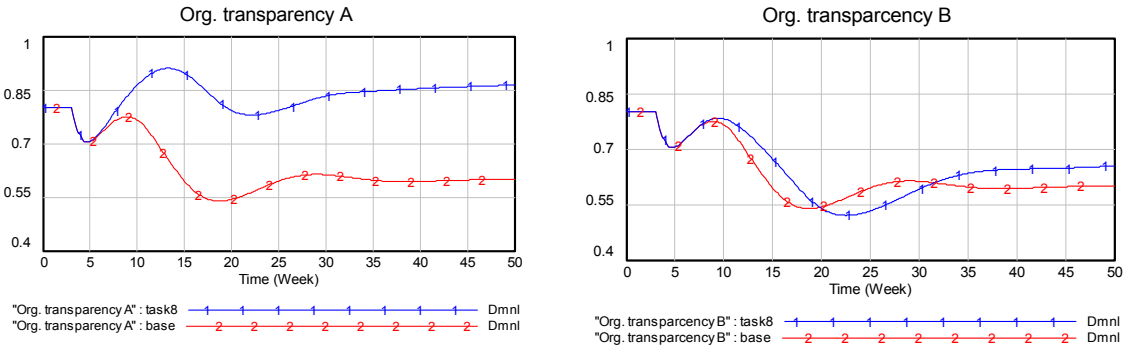

Figure 9 a & b: Organizational transparency when partner A increases its task rate

Hence, while one partner provides a high level of organizational transparency, as shown in figure 9a, resulting in more jointly created knowledge, the other partner could selfishly restrain his transparency and use the resources from the "good partner". As a result of this selfish behavior, firm B will gain 12 percent more knowledge against the base case as opposed to a 10 percent gain for firm A, who increased its productivity rate substantially. The willingness of one partner to devote additional resources builds capacity, or in our model "jointly created knowledge", from which the other partner will gain without adding resources on his part. Choosing a partner who acts as "workhorse" seems to be a valid proposition considering the results from our simulation and yet, this avenue might have some ethical implications.

Effect of changes in staff turnover

Another parameter test shown in table 1 is changing the "knowledge decay rate" of one firm, which could be operationalized as staff turnover rate of a firm is, yields in a 40 percent lower new knowledge gain. The policy meaning from this parameter change suggests that a firm with less staff turnover is able to gain more new knowledge during an alliance.

Effect of lower initial knowledge and trust

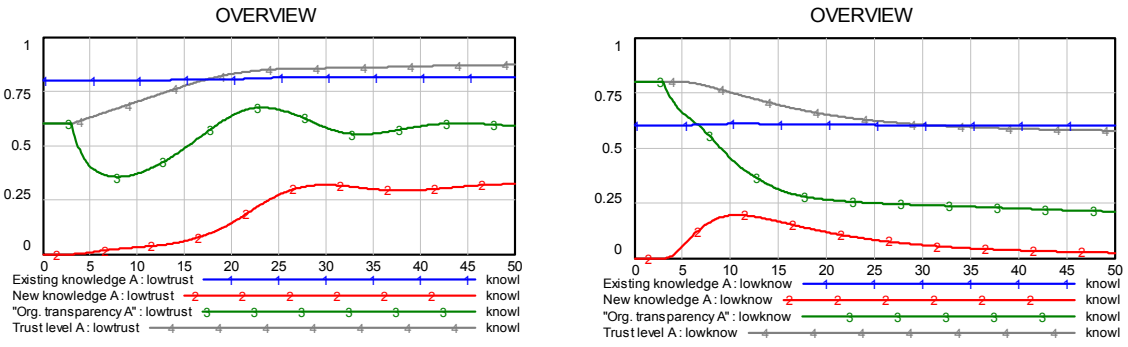

Figure 10 a & b: Comparing low initial trust of both firms versus low initial knowledge levels

It is to be expected that low initial levels of trust and knowledge symmetrically in both firms would lead to disappointing outcomes. Simulations bear out that expectation for low initial knowledge levels in both firms, as shown in figure 10b. Trust, on the other

hand, could be gained over the term of an alliance as long as both firms are keeping up their organizational transparency, shown in figure 10a, which is influenced by the learning rate. The insight from this policy test would lead to the conclusion that if two firms with low initial knowledge establish an alliance, this partnership is doomed to fail, because neither firm is able to learn, even though both firms grow in interorganizational trust.

Discussion

Many factors, internal as well as external, may determine the outcome of an alliance. Given adequate resources and management skill, a strategic alliance can be successfully completed. While previous studies focus on either learning and knowledge acquisition (cf. Grant et al. 2004; Beamish et al. 2003; Holmqvist 2003; Parise 2001; Inkpen 2000; Larsson et al. 1998) or trust (cf. Norman 2004; Selnes et al. 2003; Ireland et al. 2002) our simulation model is able to show that effects from asymmetry between trust and knowledge causes different behavior and outcome of an alliance.

Besides testing the effects of trust and knowledge in collaborative work, we gained a counterintuitive insight from changing the productivity rates of one firm. The results from exercising the model confirm some of the findings in previous research (cf. Hamel 1991; Larrson et al. 1998) but also extend existing theories and frameworks and provide new insights into the possible outcome of an alliance.

The model presented here can be expanded to divide the accumulation of tacit and explicit knowledge in the context of interorganizational. Such disaggregating can be useful to the discussion of value implications when establishing an alliance. In addition, one can extend the model to consider the effects of resource allocation on the rate to acquire new or process existing knowledge. Modeling these details introduces additional model complexity and may not change the basic behavior described in the preceding sections. Moreover, there is little understanding about the interrelated nature between knowledge acquisition and the processing capacity with which new knowledge can be accumulated. Thus adding complexity to the model may not provide more insights into the fundamental performance implication of interorganizational learning in alliances.

However, the simulation model presented in this paper has limitations and can be enhanced in several ways. First, the variable “collaboration in alliance” can be decomposed and represented in greater detail to capture the multifaceted dimensions of assigning adequate resources to collaborative work. Second, the flow rate “absorption of new knowledge” can be refined to consider a variety of context-related attributes, such as the skill set and commitment of organizational members or the influence of tacit and explicit knowledge on the processing capacity of new knowledge.

The results of this study leads to two avenues that future work might pursue. One area for future research is to gather empirical data to calibrate the model. Using real data would enable an optimization of the model and subsequently provide better insights into possible outcome of an alliance. The second avenue is to simulate resource constraints of either partner on interorganizational learning and knowledge acquisition.

Appendix: Equations for Simulation Model

"Fractional knowl. decay B"=
2.5
~ Week

Indicated rate to gain transparency B=
1
~ Dmnl/Week

Doing tasks A=
4
~ task/Week

Doint tasks B=
4
~ task/Week

Gain A=
STEP(Trust gain from performing internal tasks*Trust level A, 3)
~ Dmnl/Week

Effect from collaborative transparency= WITH LOOKUP (
Collaborative transparency,
([(0,0)-(1,1)],(0,1),(0.192661,0.942982),(0.357798,0.850877),(0.544343,0.697368),(0.697248\,0.508772),(0.831804,0.289474),(1,0)))
~ Dmnl

Trust gain=
STEP("Effect from collaboration on interorg. trust"*Normal trust gain through collaboration\
, 3)
~ Dmnl/Week

"Effect from collaboration on interorg. trust"=
Effect from individual trust levels*Effectiveness for collaborative knowledge creation\
*Trust gap/Normal knowledge creation in collaboration
~ Dmnl

Normal trust gain through collaboration=
1
~ Dmnl/Week

Trust gain from performing internal tasks=
"Effect existing knowl."*Fractional trust gain from internal work
~ Dmnl/Week

Gain B=
STEP(Trust gain B from performing internal tasks*Trust level B, 3)
~ Dmnl/Week

Fractional trust gain from internal work=
0.2
~ Dmnl/Week

Trust gain B from performing internal tasks=
"Effect existing knowl. B"*Fractional trust gain from internal work
~ Dmnl/Week

Erosion B=
STEP(Time for trust erosion B*Trust level B, 3)
~ Dmnl/Week

"Time for interorg. trust erosion"=
Effect from collaborative transparency*"Fractional time for interorg. trust erosion"
~ 1/Week

Time for trust erosion B=
"Effect from new knowl. B on time for trust erosion"*Fractional time for trust erosion
~ Dmnl/Week

Trust erosion=
STEP("Interorg. Trust"*"Time for interorg. trust erosion", 3)
~ Dmnl/Week

Fractional time for trust erosion=
0.1625
~ Dmnl/Week

Erosion A=
STEP(Time for trust erosion A*Trust level A, 3)
~ Dmnl/Week
~ |

"Fractional time for interorg. trust erosion"=
0.5
~ 1/Week

Time for trust erosion A=
"Effect from new knowl. A on time for trust erosion"*Fractional time for trust erosion
~ Dmnl/Week

"Effect existing knowl."=
Table EN(Existing knowledge A/"Normal. knowl. level")
~ Dmnl

"Effect existing knowl. B"=
Table EN(Existing knowledge B/"Normal. knowl. level")
~ Dmnl

Table EN(
[(0,0)-(1,1)],(0,0),(0.0978593,0.162281),(0.189602,0.346491),(0.327217,0.570175),(0.477064\,0.736842),(0.681957,0.877193),(0.828746,0.947368),(1,1))
~ Dmnl

"Effect from new knowl. A on time for trust erosion"=
Table KN(New knowledge A/"Normal. knowl. level")
~ Dmnl

Effect from individual trust levels=
"Table indiv. trust"(Trust level B*Trust level A)
~ Dmnl

```
"Table indiv. trust"(
        [(0,0)1.5,1)],(0,0),(0.215596,0.0350877),(0.509174,0.140351),(0.784404,0.385965),(\
                0.93578,0.736842),(1,1),(1.49541,1))
        ~       Dmnl

"Effect from new knowl. B on time for trust erosion"=
        Table KN(New knowledge B/"Normal. knowl. level")
        ~       Dmnl

Trust gap=
        Desired trust level-"Interorg. Trust"
        ~       Dmnl

Desired trust level=
        0.8
        ~       Dmnl

Table KN(
        [(0,0)0,2)],(0,1),(0.143731,1.1),(0.293578,1.15),(0.446483,1.18),(0.629969,1.2),(0.785933\
                ,1.16667),(1,1))
        ~       Dmnl

Knowledge decay B=
        Existing knowledge B/"Fractional knowl. decay B"
        ~       knowl/Week

Growth in transparency B=
        STEP(Indicated rate to gain transparency B*Motivation of B to cooperate, 3)
        ~       Dmnl/Week

"Time for decay of org. transparency B"=
        "Effect from interorg. trust on transparency"/B's time for decay
        ~       Dmnl/Week

"Absorbation of new knowl. A"=
        Absorbation rate*Doing tasks A
        ~       knowl/Week

"Absorbation of new knowl. B"=
        Absorbation rate B*Doint tasks B
        ~       knowl/Week

"Knowl. creation"=
        STEP(Effectiveness for collaborative knowledge creation*Collaborative transparency, \
                3)
        ~       knowl/Week

Effectiveness for collaborative knowledge creation=
        MIN( Existing knowledge A , Existing knowledge B )*Normal effectiveness
        ~       knowl/Week

"Knowl. processing"=
        Jointly created knowledge*Processing rate*Normal task rate
        ~       knowl/Week

Effect existing knowl B on learning= WITH LOOKUP (
        Existing knowledge B/Normal kn,
                ([(0,0)1,1)],(0,1),(0.174312,0.986842),(0.458716,0.802632),(0.75841,0.45614),(1,0\
                ) ))
        ~       Dmnl

Growth in transparency A=
        STEP(Indicated rate to gain transparency A*Motivation of A to collaborate, 3)
        ~       Dmnl/Week

"Effect existing knowl. A on learning"= WITH LOOKUP (
        Existing knowledge A/Normal kn,
                ([(0,0)1,1)],(0,1),(0.174312,0.986842),(0.458716,0.802632),(0.75841,0.45614),(1,0\
                ) ))
        ~       Dmnl

"New knowl. gained B"=
        Effect existing knowl B on learning*Effect from trust on learning B*"Effect of new knowl. on learning B"\*Normal gain
        ~       knowl/Week

Decrease=
        STEP("Org. transparency A"*"Time for decay of org. transparency", 3)
        ~       Dmnl/Week

Decrease B=
        STEP("Org. transparcency B"*"Time for decay of org. transparency B", 3)
        ~       Dmnl/Week

"Effect of new knowl. on learning B"= WITH LOOKUP (
        New knowledge B/Normal kn,
        ([(0,0)1,1)],(0,1),(0.250765,0.986842),(0.415902,0.921053),(0.571865,0.789474),(0.70948\
                ,0.614035),(0.853211,0.390351
                ),(1,0) ))
        ~       Dmnl

"Interorg. Trust"= INTEG (
        +Trust gain-Trust erosion,
                0)
        ~       Dmnl

"New knowl. gained A"=
        "Effect existing knowl. A on learning"*Effect from trust on learning*"Effect of new knowl. A on learning"\
                *Normal gain
        ~       knowl/Week

"Effect of new knowl. A on learning"= WITH LOOKUP (
        New knowledge A/Normal kn,
        ([(0,0)1,1)],(0,1),(0.250765,0.986842),(0.415902,0.921053),(0.571865,0.789474),(0.70948\
                ,0.614035),(0.853211,0.390351
                ),(1,0) ))
        ~       Dmnl

"Time for decay of org. transparency"=
        "Effect from interorg. trust on transparency"/A's time for decay
        ~       Dmnl/Week

"Learning rate. A"=
        Diffused accumulated knowledge*"New knowl. gained A"/Normal kn
        ~       knowl/Week

Motivation of A to collaborate=
        "Effect from new knowl. on motivation"*Effect from transpacency*Willingness to share
```

~ Dmnl

Motivation of B to cooperate=
"Effect from new knowl. B on motivation"*Effect from transparency B*Willingness of B to share
~ Dmnl

Effect from transpacency= WITH LOOKUP (
"Org. transparency A",
([(0,0)1,1)],(0,0),(0.122324,0.27193),(0.238532,0.469298),(0.379205,0.631579),(0.651376\
,0.850877),(1,1)))
~ Dmnl

Effect from transparency B= WITH LOOKUP (
"Org. transparcency B",
([(0,0)1,1)],(0,0),(0.122324,0.27193),(0.238532,0.469298),(0.379205,0.631579),(0.651376\
,0.850877),(1,1)))
~ Dmnl

Learning rate B=
Diffused accumulated knowledge*"New knowl. gained B"/Normal kn
~ knowl/Week

Willingness to share=
Table willingness(Trust level A)
~ Dmnl

Willingness of B to share=
Table willingness(Trust level B)
~ Dmnl

"Effect from new knowl."=
"Table new knowl."(New knowledge A/"Normal. knowl. level")
~ Dmnl

Absorbation rate=
"Effect from existing knowl."*"Effect from new knowl."*Normal rate to absorb
~ knowl/task

Absorbation rate B=
"Effect from existing knowl. B"*"Effect from new knowl. B"*Normal rate to absorb
~ knowl/task

Trust level B= INTEG (
+Gain B-Erosion B,
Initial trust B)
~ Dmnl

"Table new knowl."([(0,0)-(1,1)],(0,0),(0.17737,0.0657895),(0.318043,0.144737),(0.501529,0.29386),(0.715596\
,0.535088),(0.859327,0.741228),(1,1))
~ Dmnl

Diffused accumulated knowledge= INTEG (
"Knowl. processing"-"Knowl. decay",
0)
~ knowl

"Effect from existing knowl. B"=
"Table existing knowl."(Existing knowledge B/"Normal. knowl. level")
~ Dmnl

"Effect from existing knowl."=
"Table existing knowl."(Existing knowledge A/"Normal. knowl. level")
~ Dmnl

"Knowl. decay"=
Diffused accumulated knowledge/Time to decay
~ knowl/Week

Time to decay=
1.2
~ Week

"Effect from new knowl. B"=
"Table new knowl."(New knowledge B/"Normal. knowl. level")
~ Dmnl

"Table existing knowl."(
[(0,0)1,1)],(0,0),(0.088685,0.175439),(0.168196,0.302632),(0.321101,0.486842),(0.46789\
,0.635965),(0.633027,0.776316),(0.804281,0.890351),(1,1))
~ Dmnl

Knowledge gain B per task=
Existing knowledge B*Pressure to learn on the job B*"Normal knowl. gain per task"
~ knowl/task

Knowledge gain per task=
Pressure to learn on the job*Existing knowledge A*"Normal knowl. gain per task"
~ knowl/task

Learning from internal work=
Knowledge gain per task*Doing internal tasks
~ knowl/Week

Learning from internal work B=
Doing internal tasks B*Knowledge gain B per task
~ knowl/Week

Pressure to learn on the job=
Desired knowledge-Existing knowledge A
~ knowl

Effect from trust on learning=
Table trust(Trust level A)
~ Dmnl

Effect from trust on learning B=
Table trust(Trust level B)
~ Dmnl

Normal rate to absorb=
0.1
~ knowl/task

"Effect from new knowl. on motivation"=
Table motivaiton(New knowledge A/"Normal. knowl. level")
~ Dmnl

"Effect from new knowl. B on motivation"=
Table motivaiton(New knowledge B/"Normal. knowl. level")
~ Dmnl

```
Table trust(
	[(0,0)-
	(1.5,1)],(0,0),(0.224771,0.0219298),(0.431193,0.0
	570175),(0.582569,0.0964912)\
	,(0.720183,0.171053),(0.816514,0.315789),(0.876
	147,0.47807),(0.90367,0.627193),(0.93578\
	,0.785088),(0.963303,0.916667),(1,1),(1.5,1))
	~	Dmnl

Table willingness(
	[(0,0)-
	(1.5,1)],(0,0),(0.137615,0.109649),(0.307339,0.23
	6842),(0.513761,0.442982),(0.692661\
	,0.622807),(0.830275,0.780702),(0.931193,0.912
	281),(1,1),(1.49541,1))
	~	Dmnl

Table motivaiton(
	[(0,0)-
	(1,1)],(0,1),(0.125382,0.890351),(0.29052,0.7236
	84),(0.443425,0.552632),(0.602446\
	,0.399123),(0.792049,0.22807),(1,0))
	~	Dmnl

"Effect from interorg. trust on transparency"= WITH
LOOKUP (
	"Interorg. Trust",
	([(0,0)-
	(1,1)],(0,1),(0.131498,1),(0.272171,0.868421),(0.
	422018,0.635965),(0.525994\
	,0.429825),(0.678899,0.236842),(0.834862,0.114
	035),(1,0) ))
	~	Dmnl

Trust level A= INTEG (
	+Gain A-Erosion A,
		Initial trust A)
	~	Dmnl

Collaborative transparency=
	"Org. transparcency B"*"Org. transparency A"
	~	Dmnl

Desired knowledge=
	Initial knowledge A+0.1
	~	knowl

Desired knowledge B=
	Initial knowledge B+0.1
	~	knowl

Doing internal tasks=
	4
	~	task/Week

Doing internal tasks B=
	4
	~	task/Week

Existing knowledge A= INTEG (
	"Absorbation of new knowl. A"+Learning from
	internal work-Knowledge decay,
		Initial knowledge A)
	~	knowl

Existing knowledge B= INTEG (
	"Absorbation of new knowl. B"+Learning from
	internal work B-Knowledge decay B,
		Initial knowledge B)
	~	knowl
"Fractional knowl. decay"=
	2.5
	~	Week

Jointly created knowledge= INTEG (
	"Knowl. creation"-"Knowl. processing",
		0)
	~	knowl

Knowledge decay=
	Existing knowledge A/"Fractional knowl. decay"
	~	knowl/Week

New knowledge A= INTEG (
	+"Learning rate. A"-"Absorbation of new knowl.
	A",
		0)
	~	knowl

New knowledge B= INTEG (
	+Learning rate B-"Absorbation of new knowl. B",
		0)
	~	knowl

"Org. transparcency B"= INTEG (
	+Growth in transparency B-Decrease B,
		Initial trust B)
	~	Dmnl

"Org. transparency A"= INTEG (
	+Growth in transparency A-Decrease,
		Initial trust A)
	~	Dmnl

Pressure to learn on the job B=
	Desired knowledge B-Existing knowledge B
	~	knowl

Processing rate=
	3
	~	task/knowl/Week
```

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Back to the Top