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著者	Haruo Horaguchi
出版者	The Research Institute of Innovation Management, Hosei University
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法政大学イノベーション・マネジメント研究センター
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Summary

This paper combines the concept of *Collective Knowledge* with the one of *Collective Strategy*, which will be to give new foundations on the theory of knowledge management. Depending on four types of Collective Strategies, corresponding types of Collective Knowledge is created. One type of Collective Knowledge, Symbiotic Knowledge, stands out as it embodies a new dimension for problem solving by a usage of collaboration with different field of expertise. The applicability of Symbiotic Knowledge is exemplified by the business-university-government alliances in Toyama, Japan. The selection of who to invite as participants plays a decisively important role in knowledge creation. The symbiotic knowledge creation is limited by those who are allowed to participate in the organization. In this process, the coordinators play the most important role for the performance of inter-organizational alliances.

Introduction

A significant number of papers report on-going policy implementation of University-Business-Government Alliances. Creating cluster with Center-of-Excellence is a policy target and the university is expected to play a role of hub in collaboration network. Analytical framework for the University-Business-Government Alliances has, however, not yet proposed to answer the following questions. Why collaboration with different organizational setting is preferred as compared to the research done by a single organization? Under what conditions the University-Business-Government Alliances can show better performance than a performance resulting from a single research organization such as a central research and development center of a company? What are the merits of combining different organizations and their people to a single project?

This paper draws the answers by combining the concept of *Collective Knowledge* with the one of *Collective Strategy*, which will be to give new foundations on the theory of knowledge management. I explicate that Collective Knowledge is created by participants after adoption of Collective Strategy and that the creation Collective Knowledge explain how a starting point of innovation process is nurtured. The example of Collective Strategy in this paper is the University-Business-Government Alliances and the resulting knowledge is created collectively.

Collective Strategies and Collective Knowledge have been independently proposed by two strands of researchers. Section 1 of this paper surveys theories of knowledge management in relation to Collective Knowledge. The Collective Knowledge and/or Collective Intelligence are defined by researchers from artificial intelligence, complex system, network theory, social capital, and knowledge management. The flourishing discussions on Collective Knowledge and Collective Intelligence, as well as Collective Creativity mark an growing importance in not only intellectual trend but in the field of information communication society.

In Section 2, the theory of Collective Strategy will be surveyed. Theory of Collective Strategy is based upon an analogy from Population Ecology and describes a human organization and corporate strategy. The proposition I want to make is that Collective Strategy is a strategy to select a corresponding type of Collective Knowledge and the strategic choice gives decisive effects on the characters of Collective Knowledge. In the process of research and development universities, firms, or governments are obliged to choose strategy of accumulating knowledge. The concept of Collective Knowledge is useful to identify the organizing pattern of knowledge creation. One type of Collective Knowledge, Symbiotic Knowledge, is particularly fascinating as it embodies a new

dimension for problem solving by a usage of collaboration with different field of expertise. The applicability of Symbiotic Knowledge is wide and collaborative research by the business-university-government is merely a typical example.

In Section 3 I introduce a case of the University-Business-Government Alliances in Japan where they create bio-chip analytical machine as a result of the collaboration among local researchers, business person, and coordinators. This case is interpreted as a successful application of Collective Strategy and creating Collective Knowledge. The role of coordinator was particularly important in such a case. So in Section 4 some statistical analysis is performed to see how the coordinators acted in the areas of “Knowledge-Cluster Initiative” in Japan. Here the theory of Symbiotic Knowledge is developed to show how the University-Business-Government Alliances works under the Conjugate Strategy. In conclusion, I want to identify the uniqueness and usability of this approach.

1. Collective Strategy and Collective Knowledge: Literature Survey

1-1.Knowledge and Management

Popper (1957) criticized a developmental stage theory as "the historicism", and he attached great importance to the presentation of the hypothesis and a process of empirical tests as a procedure of the scientific research. A counteractive argument on Popper was submitted afterwards by two scholars independently. The first was a concept of “paradigm” by Kuhn (1962), and the second was discussion of “tacit knowledge” and the “emergence” by Polanyi (1966). According to Kuhn (1962), an old paradigm is superseded when a group of scientists compete with another generation in the process of the scientific discovery, and the hypothesis testing plays only a minor role when the paradigm shifts. In an existing paradigm, everyday-research is called “normal science” and contributes to step-by-step progress. If we grasp submission of the hypothesis and following tests as a cyclical process, Kuhn (1962) concludes that there is a paradigm as the macro unit in the higher dimension above the hypothesis and empirical tests.

The concept of the tacit knowledge by Polanyi (1966) widened a definition of knowledge. People know more than what is expressed by words and a person obtains "tacit knowledge", which is not yet codified. Knowledge expressed by words is called explicit knowledge and the tacit knowledge is transformed into words as explicit knowledge. Koike and Inoki (1987) conducted an empirical study of the skill formation in the Asian manufacturing industry. They did interview survey at the workplace to verify a concept of the tacit knowledge in the working place of

manufacturing. Nonaka (1990), Nonaka and Takeuchi (1996) insisted that knowledge was generated in a process of transforming tacit knowledge to the explicit knowledge. They explicate this process by describing the development process of the electric baking oven and the design process of the passenger car.

1-2. Collective Knowledge and Collective Intelligence

Collectively accumulated knowledge are called in various concepts. Those are the literature on Collective Intelligence, Collective Knowledge, Collective Creativity and “Wisdom of Crowd.”

Brown and Lauder (2000) define collective intelligence as “empowerment through the development and pooling of intelligence to attain common goals or resolve common problems” (p.234). They emphasize that knowledge is created upon some relations with the society and each individual behaves differently when they take advantage of Collective Intelligence. People can connect knowledge in home, in school, in the workplace and in community. The argument of Brown and Lauder (2000) is akin to the perspectives from Social Capital. Avis (2002) connects social capital, Collective Intelligence, and expansive learning, to discuss that the knowledge based society requires a new education method for younger generation.

Japan Academy of Artificial Intelligence featured “Collective Intelligence” in 2003, and several papers were proposed in the journal. Ikegami (2003) grasps Collective Intelligence as micro and macro feed back loop. Micro-action can induce emergence of behavioral pattern in which self-organization process was observed. Then the emerged pattern acts as macro constraint for each actor. This constraint can be called as an emergence, or the emergence of behavioral pattern. For example, the pattern that the march of ants makes is an example of the self-organization. On the contrary, the emerging pattern by the march of ant sets limits ways by which the ants find feed for their lives. Micro-influence can create Collective Intelligence and then it gives knowledge flow to each individual. Collective Knowledge is regarded as macro phenomena although there is a micro feedback.

Takadama (2003) defines Collective Intelligence as "intelligence held by interacting independent groups or individuals". Collective intelligence has the characteristics of problem solving, adaptation and robustness. Problem solving ability is to solve difficult task by cooperating various entities. Adaptation ability refers to easiness of adding participants. Robustness is a capability of changing a participant by some others so that the group itself can maintain its total functions. These

characteristics are called as fault tolerance, robustness, stability, and reliability. Factors affecting interaction are a goal setting, communication, information sharing.

Surowiecki (2004) explicate “the wisdom of crowds” and summarizes its characteristics. Diversity, Independence, Decentralization and Coordination are four characteristics of the collective activities by people. They are wiser than an individual expert in recognition, coordination, and cooperation. In an “Afterword” of paper back version of Surowiecki (2005), he replys to the question as to why “a group of people off the street can know more about a complex question than an expert.” The answer is that “ ‘crowds’ will include experts as well as amateurs” (p.277). He also adds that it is hard to identify true experts and even brilliant experts have biases and blind spots (p.278). Surowiecki (2004, 2005) suggests that his “crowds” means intellectual group of people who are the experts with detailed knowledge yet their popularity is low.

Liang (2004) attaches great importance to Collective Intelligence accumulated in the inside of the organization and states that the "intelligent organization" expands when it exchanges with resources of knowledge. He points out that the organization is a complex system adapting itself to the higher intellectual dimension. Ohmukai (2006) catches Collective Intelligence as contents in an internet site in such as "Wikipedia", or “Jinriki Kensaku Hatena (a Japanese Human Power Search System), which act as the community in the Web sites. He points out that Collective Intelligence possesses characteristics of Diversity, Independence, Decentralization and Coordination. Boder (2006) takes an example of Collective Intelligence from a medical unit for diabetic patients in Geneva. The member of medical staffs such as medical doctors, nurses, assistant-nurses, psychologists and nutritionists work together to take advantage of their expertise from mutual collaboration.

Some Researchers are influenced by complex system or the network theory when they discuss Collective Intelligence. Fukuda and Kurihara (2003) point out that Collective Intelligence is supported by the Small World which is linked by the network. According to their definition, Collective Intelligence emerges when participants interact to become intelligent even though each individual act simply.

Nakakoji (2001) defined “Collective Creation" as personal creative activity by using the expression which was already made for it. For example, a supporting system to write thesis, the supporting system for conducting research by rearranging the notes or memos, and a product development support system by the mapping of brand image or products. According to Nakakoji (2001) “Collective Creation" has the following characteristics. First, it is impossible to define the

domain of problem to be solved. Second, it is impossible to define knowledge and information needed before the problem solving starts. Third, there is interdependence of understanding what the problem is and what shall be the solution to it. And this interaction evolves progressively over time. Polanyi (1962) already discussed that scientific progress is achieved after “collective creativity” is effectively promoted and coordinated under the principles of organization.

1-3. Collective Intelligence and Organization Theory

Although Takadama (2003) does not explicitly mention by himself, it is extremely interesting that the factors he points out on Collective Intelligence are similar to the definition of formal organization prescribed by Barnard (1938) and Simon (1945). The definition of the formal organization is the common goal, communication and cooperation. According to Takadama (2003), Collective Intelligence is enacted when a goal, communication, and information sharing exist. Looking at the definition of Organization and Collective Intelligence, the place in which Collective Knowledge is created shall satisfy the definition of the formal organization.

Ohmukai (2006) introduces Web sites as Collective Intelligence, which has a structure to overcome "bounded rationality" that Simon (1945) explicated. The Web site satisfies the capability of overcoming bounded rationality because existence of such site as Wikipedia grants a common purpose to satisfy the intellectual desire to know some information. Information is accumulated as a result of collaboration by which the desire to “explain what I know.” Rewriting the information contributes to up-grade knowledge in the site, and explicit knowledge is a tool for communication in the site. Those sites in the Web are considered as “an organization” as far as they suffice the definition of the formal organization of Barnard (1938).

In order to understand this point we compare a database with a Web site functioning as Collective Intelligence. The database comprises of numerical value and a pile of the letters hoarded up, which are stored in order for the use. In the Web site, Collective Intelligence establishes a common purpose to exchange information and the structure of the Web site sets macro structure for individual knowledge get a feedback. The individuals then renew the micro-structured knowledge base, which eventually leads to the agglomeration of data for further renewal.

A set of concepts, tacit knowledge and the explicit knowledge, is useful when we make sure a difference between information and knowledge. When explicit knowledge is stored, it is made by letters and it does not differ from information. But there will be tacit knowledge outside from the web site. Tacit knowledge supports the interpretation of information by which knowledge stands

higher dimension than the information itself.

Several concepts coexist when I summarized existing research on Collective Intelligence, Collective Knowledge and Collective Wisdom. As I surveyed, Collective Intelligence has been widely accepted to describe a new wave of "Web 2.0." There are, however, some studies using the concept of Collective Knowledge. Huang (1997) points out an example that the Deepblue, a supercomputer, won a human chess champion. Extensive database was created by IBM consulting group to win the chess match. Collectively constructed information and program was stronger than human ability of calculus and tacit knowledge. Antonelli (2007) discuss punctual change in technological development by describing the change in production frontier, which is caused by accumulation of Collective Knowledge and networking among firms.

Henceforth, I discuss Collective Knowledge. It is because I want to place Collective Knowledge as a theoretical concept of the knowledge management, which gives higher meta-dimension onto existing theory of explicit knowledge and tacit knowledge.

Collective Knowledge is created as the combination of explicit and tacit knowledge. The method of creating Collective Knowledge is not confined to the case of "Wikipedia" to which information technology contributes. There exist various methods from traditional way to current trends. In the second section of this paper, I show that the Collective Knowledge follows the Collective Strategy.

1-4. Literature Survey on Collective Strategy: Typology

Collective Strategy is one of the analytical frames for inter-organizational relations. Astley and Fombrun (1983) and Astley (1984) proposed the concept of the Collective Strategy, which is based on an idea of population ecology. The idea assumes that the symbiotic relations are applicable to corporate strategy. Such a relationship as between a crocodile and a heron is applicable to two corporate interactions. They classify the collective strategy into four types of strategic forms, namely Confederate, Conjugate, Agglomerate, and Organic. Their terminology has been applied to corporate strategy such as merger and acquisition, interlocking directorate, or joint ventures. They took a view called the ecology of the organization (table 1).

Table 1

Collective Strategy by Astley and Fombrun (1983)

		Mode of Interdependence	
		Commensalistic	Symbiotic
Type of Association	Direct	Confederate	Conjugate
	Indirect	Agglomerate	Organic

Source: Astley & Fombrun (1983).

Astley and Fombrun (1983) call Confederate type of Collective Strategy when mode of interdependence is commesalistic, and when direct association is made. If it has indirect associations and commensalistic mode, it is called Agglomeration type. When the mode is symbiotic and association is direct it is called Conjugate type. The combination of symbiotic and indirect is referred to as Organic.

It is explained that strategic partnership are different in type depending on the limitation of the participant of the Collective Strategy. Astley (1984) discusses that business strategy, corporate strategy, industrial strategy (competitive strategy) and Collective Strategy emerge according as strategic application enhances its domain to be enlarged. The research by Astley and Fombrun (1983) has been succeeded by series of researches and has gradually prevailed among academics in the world.

Dollinger (1990) explicates the generation of the Collective Strategy quoting an argument of Axelrod (1984), by which cooperation is born as a result of repeated games. Bresser and Harl (1986) noticed that Collective Strategy acts as anti-competitively, such as a cartel. In Japan, Yamakura (1993) surveyed the works of Astley and Fombrun (1983) in relation to inter-organizational behaviors and Mitsuzawa (1996) stressed the negative side of Collective Strategy, which eventually requires anti-monopoly public policy.

In the 2000s, the concept of the Collective Strategy has got academic attention by European researchers and was applied in empirical research. Yami (2006) edited a featuring issue of Collective Strategy in *Revue Française de Gestion*, (*Review of French Business Administration*) and proposed his survey on Collective Strategies in France. Le Roy (2003), for example, interprets the fishery cooperatives in France as an Agglomeration strategy and analyzes them as one of Collective Strategies. Mione (2006) captured that the setting process of industrial standardization as a

Collective Strategy. Mione (2006) carried out questionnaire survey to the product development personnel and to the marketing personnel in companies. As a result of questionnaire survey, it is concluded that the personnel who are in charge of product development is more eager to collecitve standardization. A German scholar of management, Haak (2004) analyses a case of international joint venture in China as an example of Collective Strategy.

Astley (1984) explicates that Collective Strategy is one of the wider variety of strategic alternatives among business strategy, corporate strategy, industrial strategy (competitive strategy) and Collective Strategy. Therefore, it seems to be obvious that the distinction between “commensalistic” and “symbiotic” corresponds to the distinction between whether a similar organization or a different organization. In other words, an organization is considered as commensalistic when the organization belongs to an identical industry. If the organization belongs to a different industry it may corresponds to the definition of symbiotic. However, as for the adjective “commensalistic” adopted in Astley and Fombrun (1983), there seem to exist deeper meaning in population ecology.

In biology, at least five patterns of coexistence are classified given symbiotic relationship between two kinds of creatures. The table 2 summarized those relationships. In the table, "+" means that influence given by a partner is beneficial, and "－" means that influence of the partner is harmful. "0" means that both influences are neutral. If both sides have the beneficial effects, it is called mutualism. The animals and plants profiting from one another conform to this category. If one party benefits from the other but does not give any minus effect, the relationship is called commensalism. If one sacks the benefit while it does harm the other, it is called parasitism. If one does not benefit from the other, whilst the partner suffers a minus effect is called amensalism. When both sides are in the situation of harming is called competition.

Table 2.

Pattern of Symbioses

	Player B		
Player A	+,+ Mutualism	+,0 Commensalism	+,－ Parasitism
	0,+ Commensalism	0,0	0,－ Amensalism
	－,－ Parasitism	－,+ Amensalism	－,0 Competition

Note: Sign shows the payoff of the players. The left hand sign is the pay off for the Player A and the right hand sign is the payoff of the Player B. “+” means positive payoff or beneficial, “0” means neutral, and “－”means negative payoff, or harmful.

Source: The author draw based on Vandermeer & Goldberg (2007) and the web site of Professor Yoshihiro Yamada at MieUniversity, http://www.bio.mie-u.ac.jp/~yamada-y/ ecology/animal%20ecology.htm

The theory of corporate strategy pushes forward the classification of vague dichotomy of cooperation and competition. The situation that two companies competed fell under “competition" of table 2, and mutualism is the case when two companies cooperate and create Win-Win relations. But from the perspective of population ecology the arguments on competitive strategy in business are not limited in the case of these two patterns. It might be difficult to find examples of business case studies dealing with “commensalism", “parasitism", or “amensalism" resulting from corporate strategy. In the company participating in strategic partnership, there may be a case of “commensalism" in which to mean the participants learn a core competence from the partner companies to raise own competence. On the other hand, there may be the case that joint venture did not succeed because of “amensalism" prevailed from partner company. In some cases merger and acquisition may result in “parasitism" in business relationships. This happens when merged company would have incapable human resources and due diligence before the M&A had not explore hidden bad assets. One must notice that Astley and Fombrun (1983) utilized the concepts of Commensalistic and Symbiotic but not the ones of “parasitism" or “amensalism." Extension of

such a viewpoint into the theory of corporate strategy is, however, left for future.

1-5. Collective Strategy and Collective Knowledge

1-5-1. Strategic Fitness of Collective Knowledge

Each theory of Collective Strategy and Collective Knowledge/Collective Intelligence has been developed independently. These concepts have been applied when inter-organizational activities of firms and behavior of masses are empirically studied. By this paper, I want to propose a proposition that Collective Knowledge varies according to the different types of Collective Strategy. This proposition makes a link between Collective Strategy and the Collective Knowledge.

There are four types of Collective Strategy by Astley and Fombrun (1983), i.e., Confederate, Agglomerate, Conjugate and Organic. Then, depending on each strategic type, a different type of Collective Knowledge emerges because the strategic difference exists in the feedback loops of the participants who are adding new contribution to the knowledge base. I explain in detail how and why these different types of Collective Knowledge emerge through different strategic collaboration on knowledge. I call them Shared Knowledge, Local Knowledge, Symbiotic knowledge, and Common knowledge.

Table 3

The Correspondence between Collective Strategy and Collective Knowledge

		Mode of Interdependence	
		Commensalistic	Symbiotic
Type of Association	Direct	(Confederate) Shared knowledge	(Conjugate) Symbiotic knowledge
	Indirect	(Agglomerate) Local knowledge	(Organic) Common knowledge

1-5-2.Confederate Strategy and Shared Knowledge

Confederate Strategy creates Shared Knowledge. A typical example is sharing information and knowledge base in one company, which is based upon information system built for strategic alliances. Wilson, Goodman and Cronin (2007) discuss shared knowledge in a group which is then stored and retrieved. Horaguchi (2008) proposes a mathematical model to show that Information system created by the alliance member of the international aviation service company falls in this category. That Japanese four major newspaper publishing companies use news delivery from Reuters is another example of Shared Knowledge although confederation is tacitly made.

Toyota production system is another example of Shared Knowledge. The evidences are shown in a language peculiar to working places of Toyota, which have been developed in the factory where workers and the production engineers interacted to attain higher productivity. Words like Kanban, Pokayoke, Andon, and Soto-dandori are created collectively to switch tacit knowledge into the common vocabulary yet peculiar to the member of Toyota production system. Here Confederate Strategy between workers and engineers creat Shared Knowledge inside of Toyota factory. The switch from tacit knowledge to explicit knowledge will be performed collectively, too.

Judging from the viewpoint that Ikegami (2003) summarized a characteristic of the Collective Knowledge, this is a case of emergence of action pattern and knowledge. It is interesting to see Mishina (2006, p.79) discusses Toyota production system by an extremely similar expression. He emphasizes that Toyota production system can not be understood even if one resolves the whole production system into a part. This corresponds to the fact that macro self-organizing system of Toyota production can dominate each micro working activity. If the confederate strategy between the workers and engineers had not existed, the working place would have been more antagonistic and the vocabulary for productivity might not have emerged. Fujimoto (1997) emphasized emergence while he analyzed Toyota auto parts business relationship. Matching knowledge that Fujimoto (2003) called “integration" means that parts suppliers contribute to create Share Knowledge.

1-5-3. Agglomeration and Local knowledge

The Agglomeration strategy is observed among companies in the same industry. The discussions on Social Capital are akin to the Agglomeration type of Collective Strategy. Since Marshal many researchers pointed out the fact that specific industry Agglomeration was formed in a certain local area. The concept of the externality explains existence of such an Agglomeration, but one can add one more reason that local knowledge is shared, and existence of knowledge shared in

identcal industry in the specific area contributes to agglomeration.

The existing literature on Industrial Clusters, such as Saxenian (1994), emphasizes geographical proximity via highways. Route 101 from San Francisco to San Jose is an example, forming “Silicon Valley.” Porter (1998), Lee, Miller, Hancock and Rowen(2000) and Kenney (2000) described what was observed in the Silicon Valley and state that the industry can accumulate and transfer knowledge through frequent movement of managers, engineers, and entrepreneurs. This creates the people network, which functions to be compatible with competing in expertise without a cooperation strategy being betrayed. I can call this Local Knowledge as it is formed by participants of agglomeration. Hayek (1945) was of course a forerunner who coined this line of concept. Horaguchi (2008) shows that a particular pattern of networking by knowledge creating companies result in a formation of cluster with excess supply of disequilibrium by a few companies. Participating in agglomeration or location strategy thus is nothing but an example of Agglomeration strategy.

1-5-4. Organic Strategy and Common Knowledge

The knowledge followed by the organic strategy is translated as “Common Knowledge". Apart from business field, vote for election is the case in which the participants are showing their Collective Knowledge. The result of the vote is understood as an expression of political power and choice of the voter, but one can reconsider it as the Collective Knowledge which reflected the citizen's intellectual standard, or Common Knowledge by voting.

Wikipedia is the site in the Internet and the anonymity is maintained about the people participating in. The participants are not limited and they are not identified as to who a provider of the knowledge is. Of course one can limit a participant by cryptographic technology such as passwords in an internet site, but there is no limit on the qualification in this example of Wikipedia. It is interesting to guess why people participate in Wikipedia. The participant may be unconscious to his or her reason to participate. Pleasure and curiosity of offering knowledge are some candidates of the motivations.

Information accumulated by Wikipedia is an example of Collective Knowledge in the twenty-first century. However, myth, traditional rituals, folklores and some religious texts are all made by thousands of people over the history. Santa Claus may be a creature made from Collective Knowledge and the stories in the Old Testament are also collectively written. Common Knowledge is the case where the participants of the Organic Strategy are not limited.

1-5-5. Conjugate Strategy and Symbiotic Knowledge

Conjugate Strategy is to create direct collaborative work among people or organizations belonging to a different type of industry. Symbiotic Knowledge is created through the Conjugate Strategy. Symbiotic Knowledge is born as a result of inter-disciplinary collaboration to create a new discovery or devices. As I surveyed in the former section, the theorists of Collective Strategy have not applied Conjugate Strategy in their empirical works.

The reason why I emphasize this point here again is that it seems that a concept of the Symbiotic Knowledge is useful to explicate business-university -government collaboration and the analysis on the outbreak of the innovation can be discussed as a case of Conjugate Strategy. Schumpeter(1926) stressed “new combination” by entrepreneurs as the starting point of innovation. Distractive innovation stressed by Schumpeter (1942) and Christensen (1997) are reinterpreted as logical consequences of creating Symbiotic Knowledge. I consider further a possibility of extending the concept of Symbiotic Knowledge to explicate the innovation process in the next section.

The function of conjugate Collective Strategy in the research and development is to give a new dimension to existing state of knowledge. If the knowledge is viable, it survives as Symbiotic Knowledge. The added new dimension is to set objectives for research and development from imaginative design stage, to get knowledge on the existence of new technology elements, to utilize skill and technology for trial, experiment, production, and the inspection, to get scientific knowledge on new treatment and its result, to know the existence of the new market. A coordinator plays an important role to conjugate the participants in the Business-University-Government Collaboration, which induces different expertise and technological skills for new product development.

Let us take creation of a composite material as an example. A researcher in a laboratory might want to obtain a composite material with aimed characteristics. If there are ten raw materials to be compounded, then the possible combinations are $\sum_{i=1}^{10} {}_{10}C_i = 1023$, or this is alternatively expressed by $2^{10} - 1 = 1023$. Subtraction of one means the case where no material is used, or ${}_{10}C_0 = 1$. Suppose three raw materials are newly added to be compounded, one can get $2^{13} - 1 = 8{,}191$.

Instead of adding three new materials, one can add a new dimension as from processing. For example, processing such as grinding the materials into nano-level powder, pressing the materials

with super high pressure, or breaking the material by high pressure water jet pumps can be done. This new dimension of processing is expressed by the power to the original combination. Given no-processing state is also considered, we get $(2^{10}-1)^4 = 1{,}095{,}222{,}947{,}841$ instead of $2^{13}-1 = 8{,}191$. This is about 133,710,530 times than 8,191, which widens the possibility of getting aimed property from the composite material. The researcher in the laboratory above may not be an expert of processing, so she can choose Conjugate Strategy to invite a company with competence of processing. If this type of knowledge is viable, it survives as Symbiotic Knowledge.

It is worth noting that organization retains almost the same property like composite materials. If ten people are asked to form one group, the possible combination is 1,023. If three people are added to the selection process, then there are 8,191 combinations. If one can give some sort of business education as a specialized knowledge, then new dimension is added as the power to the combination. Suppose three types of business knowledge such as venture business finance, scientific frontiers of biochemistry, or inventory management of mass-production could be taught, then the possibility of heterogeneity increases to $1{,}095{,}222{,}947{,}841$. Thus Creation of Symbiotic Knowledge is influenced by how to get inter-organizational knowledge from outside of the original members. Depending on who is participating in the inter-organization or what influence is given to the organizations, characteristics of organizational knowledge is configured. Here, once again Symbiotic Knowledge evolves through empowerment by Conjugate Strategy.

Then the problem to be solved is how to select targeted combination of inputs, in our example, composite materials or personnel groups in organization. We saw that if one adds the new dimension to search process, total combinations increase exponentially. On the contrary, one has to constrain time and cost to get result.

The basic search process is to economize time and cost. Nash equilibrium is a key to reduce search process. Horaguchi (1996) proved that search process of Nash equilibrium is cost efficient than that of Iterated Strict Dominant. More intuitive exposition is to set focal point as Shelling (1960) explicates. The famous example of the focal point is to find a meeting place in New York, which is considered as a Nash equilibrium (Shelling 1960, p.56). If two researchers of the above mentioned research laboratory coincide with the choice of four materials and one processing method, the number of combinations decrease significantly. The search process is belonging to the field of information processing, whereas creating a focal point is a product of having knowledge. Either by inspiration, by scientific data, or by tacit knowledge based on experience, one can set a basic combination of core materials. This choice significantly reduces the total number of combinations

to be experimented. Yet serendipity is deliberately expected to the researchers and a solution to the intellectual puzzle is expected through their intellectual focal point.

As for group creation in organization, the organization has its culture by the participants. Furthermore firms as organizations have their mission to serve to the markets. The firm has a power to imprint the participants according to its organizational culture. Conjugate Strategy is to add diversity to this potentially monotonic corporate organization.

The coordinator plays an important role in order to sustain Conjugate Strategy, achieving coordination and selection of the participants. By admitting a participation of new comer, other members are motivated by stimulus. A new application, a new idea, and a new trial and error are allowed to get something new. Conjugate Collective Strategy has an effect of sorting the participant. Sorting is done by decision to either allow someone to participate or not, or by the decision either of continuation of the participation or terminating the participation. This resembles process by the survival of the fittest.

2. A Case of Toyama: “Intellectual Cluster Creating Initiatives” in Japan

2-1. Logic of Symbiotic Knowledge formation by conjugate Collective Strategy

The state that knowledge is brought by heterogeneous organizations is called Conjugate Strategy. The function of conjugate Collective Strategy in the research and development process is to give a new dimension to existing state of knowledge. Under this circumstance Symbiotic Knowledge could be born, and here one could obtain a new perspective on the research and development. The added new dimension is enhancing the variety of technology choice. Conjugate Collective Strategy requires the direct relations among different organizations in the field of different businesses. Symbiotic Knowledge is formed while interdisciplinary interactions are strategically pursued by various capable participants.

The Business-University-Government Collaboration suffices such conditions for creating interdisciplinary interactions. A new invention and discovery are expected by maintaining a project of the Business-University-Government Collaboration. Each expertise contributes to create a new discovery. Symbiotic Knowledge is coming out of such Business-University-Government Collaboration by Conjugate Strategy. Then, what characteristic will there be brought about?

2-2. Conjugate collective strategy and business-university-government collaboration: Bio-chip

development process in Toyama Prefecture

In July and October 2006, the authors conducted field research regarding the Intellectual Cluster Creation Project organized by the Ministry of Education, Culture, Sports, Science and Technology of Japan and recorded the development of a bio-chip for lymphocyte analysis in Toyama Prefecture[1]. Under the Intellectual Cluster Creation Project, the Toyama Medical Bio-cluster was launched under the direction of the governor of Toyama Prefecture. This a case example of a university-launched venture (SC World, Inc.) established through cooperation by the University of Toyama Graduate School of Medicine and Pharmaceutical Science for Research and Graduate School of Science and Engineering for Research, Toyama Industrial Technology Center, local companies (Sugino Machine Ltd. and Richell Corporation) and coordinators (see Figure 1). The Intellectual Cluster Creation Project is a five-year project with a budget of 2.5 billion yen, and the Toyama Medical Bio-cluster has three science and technology coordinators.

2-3. University of Toyama and Toyama Industrial Technology Center

The Muraguchi Laboratory, to which the research teams of Professor Atsushi Muraguchi and Associate Professor Hiroyuki Kishi of the University of Toyama Graduate School of Medicine and Pharmaceutical Science for Research belong, consists of ten members and conducts research on antibody gene analysis and lymphocyte analysis[2]. The Laboratory's research results are published in the academic journals *Journal of Immunology* and *Blood*, and the University has applied for patents concerning analysis methods. Previously, as analysis involved the use of single cells it was performed by microscopy. However, the use of cell chips makes it possible to obtain data from hundreds of thousands of cells at a time. Cell chips have 250,000 micro-wells (apertures) per square centimeter and contain one cell per micro-well. Lymphocyte analysis involves the tracking of phosphate in the cells using calcium movement as a signal. As it is possible to observe cell propagation and antibody secretion using the same method, the expression of new proteins on cell surfaces can also be observed. Research on protein expression and secretion and the function of cytokines in the brain using today's chips has also begun.

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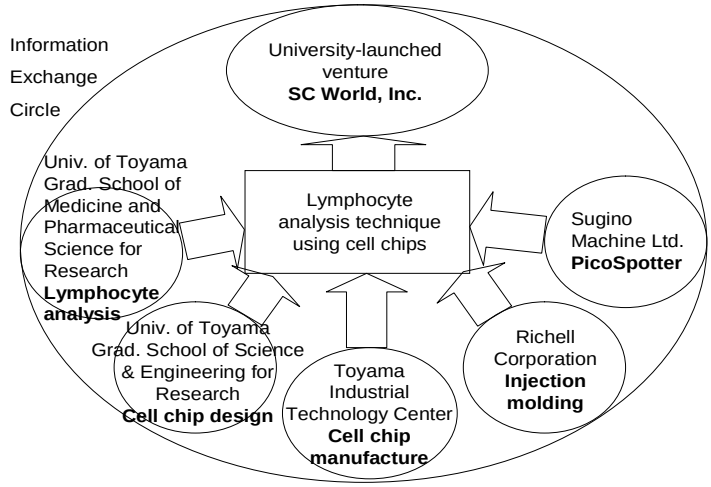
[1] The details of this interview survey are compiled in Horaguchi, Yukimoto and Li (2007).

[2] An interview was conducted on July 28, 2006, with Professor Atsushi Muraguchi, Vice President and Toyama Graduate School of Medicine and Pharmaceutical Science for Research, University of Toyama, and a Research Director of the Cluster Headquarters, and Associate Professor Hiroyuki Kishi, University of Toyama Graduate School of Medicine and Pharmaceutical Science for Research, and a Research Director of the Cluster Headquarters. The content of interview summary was checked by Associate Professor Kishi in December 2006.

In the screening of cells that react specifically with antigens associated with infectious diseases, B lymphocytes are placed in cell chips and stimulated with antibodies, and cells that have reacted are removed. Only a few cells that can produce antibodies occur among the 250,000 cells on a cell chip, and it is difficult to locate cells that occur in such a small ratio using conventional methods. The detection of antigen-specific cells can be applied in diagnosis and, if software development progresses, it can be used in the diagnosis of illnesses including tuberculosis, hepatitis, influenza, and rheumatism. As of 2006, antibodies obtained in this way have been cloned, injected into mice bearing human liver cells, and evaluated.

Coordinator Mr. Kihachiro Tohbo was formerly the director of Toyama Industrial Technology Center. Dr. Satoshi Fujiki[3] is currently the chief of the institute in Toyama Industrial Technology Center, Mechanics and Electronics Research Institute, and joint research in the cell chip project advanced due to his association with Mr. Tohbo. For this reason, both Mr. Tohbo and Dr. Fujiki assumed that cell-chip development was successfully completed in a few months.[4] Current chip research involves the third-generation of the chip.

Figure 1. Project Overview



[3] The interview was conducted on July 27, 2006, with the Chief of the Institute, Dr. Satoshi Fujiki of Toyama Industrial Technology Center, Mechanics and Electronics Research Institute and Dr. Masahiro Kadozaki of the Mechanics and Electronics Research Institute in Toyama Industrial Technology Center.

[4] This assessment is based on information from an interview conducted on July 27, 2006, with Mr. Kihachiro Tobo, the Science and Technology Coordinator of Toyama Medical Bio-Cluster, Toyama New Industry Organization. The content of interview summary was checked in November and December 2006.

2-4. Companies

Sugino Machine Ltd. and precision positioning technology

Sugino Machine Ltd.[5] manufactures drilling tools, high-pressure pumps, high-pressure cleaning equipment, automated drilling units, small machining centers and nuclear power plant maintenance equipment. The company is capitalized at about 230 million yen, has annual sales of 18,900 million yen, and employs 673 people (as of March 2006)[6]. The company employs more than 40 development personnel: the Research and Development Division has a staff of 14, and each of the six business divisions has an applied development team consisting of 5 members. The company was founded in 1936 in Osaka City as a specialty production shop for pneumatic and hydraulic tube cleaners.

Sugino Machine had previously engaged in a regional project regarding the Medical Bio-cluster Project jointly with Toyama Prefecture, and due to that relationship, received a request to participate in the Intellectual Cluster Creation Project. In accordance with the request, the company has developed the machine called “PicoSpotter” for bio-chip analysis apparatus, which is to check a reaction of lymphocyte in the microwell and some other types of analysis apparatus for PCR (Polymerase Chain Reaction).

The company received a request from Professor Eiichi Tamiya of the Japan Advanced Institute of Science and Technology and developed the “PicoSpotter” and microwell reaction apparatus jointly with Professor Tamiya. The “PicoSpotter” is also used by Professor Masayasu Suzuki of the University of Toyama. Although the exact development cost is unknown to the authors, two engineers have spent two years developing the apparatuses: one is in charge of software development and the other is a mechanical engineer. The materials cost of the “PicoSpotter” is about 10 million yen. If the cost of parts discarded at the trial-and-error stage is included, the amount is rather substantial.

With respect to the connection between the apparatuses and Sugino Machine’s technologies, as the “PicoSpotter” requires accurate positioning, it is closely connected with technologies relating to small machining centers. Nozzle technologies account for half of the development effort. The

[5] The interview was conducted at the Sugino Machine Ltd. Hayatsuki Plant on July 27, 2006, with General Manager and Operating Officer of Research and Development Division, Mr. Ryoji Muratsubaki. The description of interview content was checked in December 2006 by Sugino Machine Ltd.

[6] This information was obtained in November 2006 from the following Sugino Machine Ltd. website URL: http://www.sugino.com/menu/menu_index/profile/idx_profile.html

company has adopted a method involving suction by artificial ruby nozzles and has conducted research in fluid technologies for many years. The “PicoSpotter” mechanism involves suction using capillary action. The narrower the capillary tube, the greater the suction with capillary action. Control is exercised to prevent excessive suction due to pressure and to ensure that an appropriate quantity of liquid can be dripped. Nozzles are cleaned using ultrasonic waves. The company has adopted a similar structure for “Cellporter,” an automated cell recovery apparatus. The mechanism for dropping cells one by one is the same principle as that used in coin-counting machines. One issue has been improving the dispensing rate: it proved difficult to exceed 50%. There are issues with the surface condition of the chips themselves, and the company has devised a surface treatment method. Currently, injection rates of about 60% to 70% have been achieved.

The “Cellporter” was developed in 2005. Although the technologies were nearly perfected in 2005, work to complete the product and to respond to new needs has extended into 2006. Although prior to the Intellectual Cluster Creation Project the company had nearly no exchanges with professors at universities in Toyama Prefecture, since participating in the project, it has developed networks. However, it has not reached the level of commercialization or the generation of profits.

Richell Corporation and development of resin cell chip[7]

Richell Corporation was founded in 1956 as a manufacturer of children’s eating utensils from urea resin. The molding technique at the time was not injection molding, but compression molding. Richell acquired from NHK the copyright to the popular TV program BOO-FOO-WOO and enjoyed a hit product by printing images from the program on children’s eating utensils. The company succeeded in expanding its sales channels nationwide and subsequently came to sell nursing care products, pet products, and other products through home centers and garden centers. Although sales of housewares previously exceeded 15 billion yen, they have fallen to about 8 billion yen. The company also manufactures mobile phone casings and has sales of about 4 billion yen from this business. Total sales in fiscal 2006 were about 12 billion yen.

In 2006, Richell manufactures housewares at three factories — the headquarters factory (Mizuhashi Factory), the Osawano Factory, and the Dongguan Factory in China — and also uses OEM manufacturing (overseas). The company manufactures about 1,000 items and has a domestic

[7] The interview was conducted on October 26, 2006, with Mr. Mitsuru Miyamoto, General Manager, Microchip Business Development Office, Richell Corporation. The interview content was checked in December 2006 by Richell Corporation.

manufacturing rate of 55%. Richell manufactures mobile telephone casings at the Kamiichi Factory in Toyama Prefecture. The company built the factory as a mold manufacturing plant in 1993 and produces nearly all the molds used for casing manufacture in-house. The company sources nearly all the molds used for housewares manufacture from external suppliers.

On the basis of microchip production technology proven through participation in the Intellectual Cluster Creation Project, the company aims to establish a microchip business involving precision molding. The company has the technology to manufacturer precision molds (precision of 1/100 of a millimeter or less) to support the business and has machine tools that make possible high-precision processing.

Dispatch of researchers to the Industrial Technology Center

What prompted Richell's involvement in Toyama Medical Bio-cluster was the dispatch of researchers to Toyama Prefecture's Industrial Technology Center. The company had not participated at all in the Regional Concentration Project prior to the Intellectual Cluster Creation Project or other projects, had nearly no ties with universities, and lacked even the experience of involvement with Ministry of Economy, Trade and Industry- or Ministry of Education, Culture, Sports, Science and Technology-subsidized projects. To develop new food containers similar to Tupperware that are suitable for refrigeration, freezing, and microwave range warming, the company engaged in research and development of materials that offer high transparency and heat resistance (130°C or higher). As part of that effort, the company at first dispatched one engineer to Toyama Prefecture's Industrial Technology Center and began joint research with Center engineers.

The materials research for new household products failed. The reason was that although Richell achieved the transparency and heat resistance it sought, the surface of the resulting material had numerous minute blemishes that made commercialization difficult. The cause of the blemishes was minute irregularities (blemishes) on the surface of the molds that were transferred as is to the products during molding. However, this experience of failure was turned to advantage in the Toyama Medical Bio-cluster project. Although the project had been developing a silicon microchip for cell arrangement, the use of silicon entailed several problems, including high cost due to breakability of the expensive needles used for cell collection when they came into contact with the silicon chips, the fact that separated blood does not flow readily, and difficulty in collecting lymphocytes. Consequently, Mr. Tobo of Toyama Industrial Technology Center, who was serving as a coordinator, offered guidance to the researcher dispatched from Richell: "Is precision molding using resin

possible?" It occurred to the researcher that it might be possible to take advantage of the characteristic minute irregularities on the surface of resin material, and the researcher conducted a successful experiment. Using resin, which offers high transparency and heat resistance, Richell was able to create micron-sized apertures on the surface of chips and comparatively smoothly inject cells into the apertures.

Richell and other companies participate in the Intellectual Cluster Creation Project at their own expense. Richell installed a clean room with a level of less than 3,000 in the Kamiichi Factory. As the Kamiichi Factory manufacturers mobile phone casings, the entire factory is a clean room. Nevertheless, the company invested about 30 million yen to install a high-level clean room. A patent was obtained for a resin composition that has excellent transfer properties. Richell, Toyama Prefecture, and University of Toyama jointly own the patent, with respective ownership ratios of 65%, 30%, and 5%. Richell has entered into a license agreement with the Prefecture and the University and manufactures and sells the resin composition. Under the agreement, the company pays dividends to the Prefecture and the University at fixed allocation ratios in accordance with annual sales. Last year, sales occurred, and the company paid the Prefecture a dividend of merely 344 yen. As the University of Toyama holds a patent concerning the injection of cells to the chip and cell collection, Richell cannot sell the cell chip to customers other than University of Toyama. As of 2006, the patent has been transferred to SC World.

The micro fuel cell field is mentioned as a promising area of application for resin microchips. Fuel cell efficiency can be further improved by arranging narrow flow channels to ensure the natural flow of liquid (methanol) and layering the flow channels. The layering technology has already been patented. There are two types of fuel cells (PEFC, which use hydrogen, and DMFC, which use methanol), and the resin microchip can be applied to the latter type. A request has already been received from another university-launched venture, and Richell has manufactured a chip that has six layers of flow channels glued together.

2-5. Venture Business Launched from the Cluster

Mr. Munehiro Sueoka[8], President and CEO of SC World, Inc., was formerly General Manager of the Corporate Planning Department of Intec Inc. He has sales experience of about 20 years and has also engaged in product planning and systems development. Mr. Sueoka also has

[8] The interview was conducted on July 27, 2006, with Mr. Sueoka. The interview content was checked in December 2006 by Mr. Sueoka.

experience in the listing of INTEC Web and Genome Informatics Corporation (hereinafter “IW&G”), the first bio-venture to be listed on the Mothers section of the Tokyo Stock Exchange. Mr. Sueoka, who hails from Toyama Prefecture, was requested by the chairman of Intec Inc. and the governor of Toyama Prefecture to launch the venture, an “offer he couldn’t refuse.” In 2005, he and a group of involved professors voluntarily started SC World, Inc. The company has obtained three basic patents concerning cell chips and has obtained the rights to a series of systems. Professor Muraguchi of University of Toyama serves as the company’s chairman, and Mr. Sueoka, who had been president of IW&G, was named president.

In July 2005, SC World, Inc. was able to recruit its first clinical trial leader. The company received a Ministry of Economy, Trade and Industry start-up subsidy of about 45 million yen, rented a room at Toyama Medical and Pharmaceutical University, and in October 2005 opened a laboratory. The company was able to begin experiments at the laboratory around December 2005. It engaged in work to create direct antibodies using cell chips. A prototype of an integrated cell screening system was completed in March 2006. Currently, the company is working to collect antibodies. The company hired a sales representative in April 2006, displayed a panel exhibition at the BIO 2006 event in the U.S., and exchanged information with about 20 countries. In May 2006, the company exhibited at the International Bio Expo in Japan. It was standing room only at a presentation by SC World. Companies that left business cards are contacting the venture company. The company believes that it is viewed in the U.S. as a company that can skip existing rights in the antibody business, obtain new patents concerning antibodies, and succeed as a late entrant in the antibody business.

SC World, Inc. has not yet recorded sales from the antibody business. The market reaction is that the equipment price of 15 million yen is high. The company must reduce the price to less than 10 million yen. The company has two sales representatives, three including Mr. Sueoka himself. The company’s activities are system sales, development of the antigen and clinical trial businesses, and antibody acquisition. In June 2005, the company increased its share capital by 150 million yen after a capital injection from a partner. Further, in December 2005, the company obtained a capital injection of 200 million yen from multiple venture capital investors. The company receives OEM supply from Hitachi Software Engineering Co., Ltd., which it has commissioned to produce equipment software, and is an exclusive agent for the software in a manner of speaking. SC World, Inc. plans to move into the University of Toyama’s incubation facilities in April 2007.

3. Poisson Regression on Questionnaire Survey

3-1. Research Outline and Variables

I conducted a questionnaire survey to the coordinators of "Intellectual Cluster Creating Initiatives" in Japan. The total number of appointed cluster was eighteen. Among 18 regional clusters, 16 coordinators have responded to the questionnaire survey. This questionnaire is designed to know how effectively coordinators "conjugate" the competence of participants in a local cluster. Professors, doctoral students, researchers in laboratories or companies, entrepreneur for high-tech start ups, a governor and local government officers must be conjugated in an effective manor. One of the examples, the case of Toyama, is shown in the former section.

The author asked eighteen questions as shown in Appendix Table 1. Original questionnaire was made in Japanese and was translated in English for this paper. All of the questions were answered in free format by the coordinators in each region. By reading the answer the author gave either 1 or 0, if the answer is positive or negative, respectively.

Given there are a significant number of potential ideas for projects, one can see the realized projects are the outcome of small fraction of potential ideas. This fits to the model of Poisson distribution where probability of realization is small with the combination of a large number of potential ideas. Here, I would like to state some hypothesis driven by the theory of Conjugate strategy with Symbiotic Knowledge.

Hypothesis 1. Coordinators play a critical role to make University-Business alliances work to create Symbiotic Knowledge, which will lead to actual business plans.

Hypothesis 2. If Coordination by Conjugate strategy is successful, a larger number of University-Business projects will be undertaken by business forms.

Hypothesis 3. Conjugate strategy is workable under the conditions in which base economy is larger.

In order to check the appropriateness of the hypothesis, I employ the following variables as dependent, independent and control variables.

Dependent Variable:

BusA: The number of projects, which were already undertaken as an enterprise at the moment of questionnaire survey.

Bus5: The number of projects, which would be expected to set up an enterprise within less than 5 year from the moment of questionnaire survey.

Independent Variable:

Wide; yes=1, no=0. If the cluster has induced the company beyond the radius of "1 hour by car including 80km per an hour of speed way use," the answer is yes. In other words, if the geographical definition of “the cluster” includes participation from wider area with some distances, then the cluster is approaching to the wider area.

Call; yes=1, no=0. If the coordinator of the cluster invite researchers and coordinators from other clusters, the answer is yes. Otherwise the answer is no.

Out; yes=1, no=0. If the coordinator goes outside of his cluster to see how to organize the cluster, then the answer is yes.

Exi: yes=1, no=0. If the cluster coordinator held an exhibition to induce a new membership at the site of cluster, then the answer is yes.

Agg: yes=1, no=0. If the coordinator acknowledges that the cluster had a historical continuity from the traditional industrial agglomeration to the “Intellectual Cluster Creating Initiatives” then the answer is yes.

Inc: yes=1, no=0. The answer is yes if there are incubation managers.

Sat: yes=1, no=0. The answer is yes if the coordinator satisfies with the status quo of the incubation facilities in his district.

Prac: yes=1, no=0. If the patents owned by the cluster are considered as practical enough to be industrialized, the answer is yes.

Fund: yes=1, no=0. If the research done by the cluster is considered as so-called “fundamental researches” the answer is yes.

Cord: yes=1, no=0. If the coordinator agrees that there exists a problem of coordination due to having three parties, such as University professors, corporate researchers and public officers, the answer is yes.

Bug: yes=1, no=0. If the coordinator considers there are some losses in budget because of annual budget system, the answer is yes.

Ven; yes=1, no=0. It the coordinator observed the cases in which Ph.D. student became a

representative of university based start-up because of the advisory professor of the student was the member of "Cluster Initiative", the answer is yes.

For: yes=1, no=0. If the organization in cluster has any initiative to accept foreign students to the laboratories, the answer is yes.

The following variables are gathered by printed materials for "Cluster Initiative".

Pop: The number of total population by participating local governments. If the population is larger, the number of project will be larger in number.

Uni: The number of participating universities. If the number of participating universities is larger, the number of project will be larger in number.

Year: The year in which "Cluster Initiative" has been taking place in each region. It varies from 3 years to 5 years. The longer the number of project may be larger in number.

These variables would reflect the sheer effect of size. The size of the cities may significantly affect the performance of projects. This effect could be observed to single out the effort of coordination, which in turn shows networking skills for conjugating.

3-2. Results

When BusA, or the number of project which have already been undertaken as an enterprise, was taken as dependent variable, no independent variables were statistically significant except for Population of participating areas. Running up period for the "Intellectual Cluster Creating Initiatives" may be significantly different in each area and its preparation for business might affect the number of project within five years.

Poisson regression was performed for the dependent variable of Bus5 and dependent variables of Wide, Call, Out, Exi, Agg, Inc, Sat, Prac, Fund, Cord, Bug, Ven, For, and control variables of Pop, Uni, and Year. The variable "For" was dropped because of high collinearity.

Interesting results are obtained through the result of "Call" and "Out." The two variables have negative coefficient with more than one percent of statistically significant level. If coordinators invite outside researchers after the "Cluster Initiatives" was launched, the probability of having project of business perspectives is low. If coordinators visit outside

of his cluster, the new project is not likely to be postponed. This suggests that the coordinator must have dense personal network before he is appointed as the coordinator.

The number of organized university (Uni) and the years of the "Cluster Initiatives" project (Year) are also showing the negative sign, which means the number of organized universities is not decisive effect on the proliferation of projects and the years of "Cluster" operation do not relate to the number of projects as the author asked the questionnaire.

Table 4. Poisson regression for the Questionnaire Survey

Bus	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
Wide	-1.635962	.9045719	-1.81	0.071	-3.408891	.1369659
Call	-1.842763**	.5601328	-3.29	0.001	-2.940603	-.7449225
Out	-2.996145**	.7385951	-4.06	0.000	-4.443765	-1.548525
Exi	-.4760456	.4226983	-1.13	0.260	-1.304519	.3524278
Agg	1.665521**	.6360508	2.62	0.009	.4188844	2.912158
Inc	.7971039	.4658868	1.71	0.087	-.1160174	1.710225
Sat	2.052094**	.4848901	4.23	0.000	1.101727	3.002461
Prac	1.667146*	.7365967	2.26	0.024	.2234432	3.110849
Fund	.0317821	.4328245	0.07	0.941	-.8165383	.8801025
Cord	-1.26837*	.6466512	-1.96	0.050	-2.535783	-.0009565
Bug	.7694866	.4959993	1.55	0.121	-.2026541	1.741627
Ven	-.5306217	.3766186	-1.41	0.159	-1.268781	.2075371
Pop	.000737*	.0003611	2.04	0.041	.0000292	.0014448
Uni	-.4826261**	.1508763	-3.20	0.001	-.7783382	-.186914
Year	-1.829666**	.5893387	-3.10	0.002	-2.984748	-.6745833
Cons	13.0171	3.188632	4.08	0.000	6.76749	19.2667

Number of observations: 16.

LR chi2(15) = 51.00

Prob > chi2 = 0.0000

Log likelihood = -34.261842

Pseudo R2 = 0.4267

Conclusion

The concepts collective strategy and collective knowledge hold promise as a theory of innovation generation.[9] In cases where an alliance strategy or an integration strategy has been adopted as a collective strategy in a single industry, as the product types that are the manufacturing target are clearly limited, frequently sustained innovation, such as the improvement or addition of new functions, occurs. In cases of conjugate collective strategy and the resulting symbiotic knowledge, applications for the manufactured products are varied and in many cases unexpected uses

[9] The paradigm theory of Kuhn (1962) is interpreted in a way that the paradigm is a type of collective knowledge shared by a group of researchers. When a paradigm shift is made, the scientists in fringe firstly respond to the problem inherited in the older paradigm.

are discovered. This holds the potential for destructive innovation.

The participants in the conjugate collective strategies in one of the case examples discussed above performed the following functions. The University expressed its requirements as a customer for lymphocyte analysis and analysis apparatuses; Richell Corporation engaged in precision mold manufacture, injection molding, and new resin material development; Industrial Technology Center produced a prototype of a cell chip using the new resin material; and Sugino Machine Ltd. provided machining equipment positioning technology and fluid nozzle technology. The devices that resulted from this were the PicoSpotter and Cellporter, which became products for sale by the venture company SC World, Inc.

The process of lymphocyte analysis apparatus development through business-university-government collaboration examined in this research cannot be explained by the tacit knowledge and existing theory of knowledge management. Through recognition of the creation of symbiotic knowledge by means of conjugate collective strategy, the path to new product development can be explained. Symbiotic knowledge is the imparting of new dimensions of knowledge by different organizations and companies. These new dimensions include, for instance, 1) the setting of research and development objectives and targets; 2) knowledge concerning the existence of elemental technologies at the concept and design stage; 3) the use of techniques and technologies from different industrial sectors in prototyping, manufacture, and inspection; 4) scientific knowledge concerning new materials and new manufacturing methods; and 5) knowledge concerning the existence of uses and markets for products for development. In business-university-government collaboration, companies, universities, and coordinators combine different specialized knowledge, technologies, and techniques to engage in new product development.

In conjugate collective strategy, the selection of who to invite as participants plays a decisively important role in knowledge creation. The limits of symbiotic knowledge creation are decided by who is included in the organization. In that sense, the role performed by the coordinators is a major one. New applications, new ideas, and the resolution of problems that could not be previously solved come about through knowledge contributed by a participant. There are two means of increasing participant diversity for the sake of conjugate collective strategy: the first is selection by participant recruiting, and the second is selection by continuation of the participation process. This resembles a survival of the fittest process. Symbiotic knowledge is knowledge generated by project participants through this type of survival of the fittest process.

There are problems with conjugate collective strategy. Firstly, as it involves interaction among different organizations, objectives vary from participant to participant. Because participant benefits are multilayered, free riders tend to occur. In business-university-government collaboration, objectives coexist: for instance, the receipt or payment of subsidies, research results, glory, social status, and monetary income from new product development. Because benefits are multilayered, slack within the organization may arise and participants who feed off subsidy money may appear. Secondly, distribution of results is ambiguous, and the imposition of burdens is prone to occur. Until clear results are obtained all participants share the burden equally, and when results are obtained it is difficult to decide the rules for dividing them among the participants.

There are the problems in Conjugate Collective Strategy and this makes a limit of Symbiotic Knowledge.

First, objective function is apt to become obscured because participants are joined from different kind organizations. Each participant has different purpose so the time horizon tends to be shorter than other collective strategies. Project base collaboration is typically chosen for the collaboration. The project is dissolved if it attains the set purpose.

Second, a free-lance rider may also join the Conjugate Strategic organization.
It is not because of participant's mal intension but because ambiguity of the objective function. No one may suggest what to do but the participant has to find what is to be done by oneself. For example, the objective function of Business-University-Govern-
ment collaboration is sometimes broad and is having long time horizon. As a consequent, burden to sustain the collaboration is not shared evenly.

The concepts of Collective Strategy and Collective Knowledge have been developed independently. Astley and Fombrun (1983) describe corporate strategy from biological corollary of symbiotic states. The concept of Collective Strategy was applied in various fields such as fishery cooperation, strategic alliances, and de facto standard in an industry. Until "the wisdom of crowd" (Surowiecki (2004, 2005)) came to be reviewed under the development of the Internet, collective behavior of people were considered as a source of stupidity. This stupidity of the crowd was often emphasized in the argument of group think, psychology of crowds, and prisoners' dilemma.

Since the concept of Collective Knowledge is one of meta-concepts, we can reinterpret existing theory of knowledge into the category of Collective Knowledge. Nonaka and Takeuchi (1996) focus on transfer of tacit knowledge to the explicit knowledge in a company. This means that they are dealing with Shared Knowledge under Confederate type of Collective Strategy in a

company. The participants to share tacit knowledge are confined to the company members. This is the reason why their examples of knowledge creation are taken from examples of product development such as a home baking machine and a new car design rather than distractive innovation.

The concept of “paradigm” by Kuhn (1962) falls into our category of Shared Knowledge since “paradigm” as a definition is confined to a certain school of thought. If the “paradigm” prevails among researchers, it becomes Local Knowledge as long as Agglomerate type Collective Strategy is applied in one field of research. Then we see the prevalence from Local Knowledge to Common Knowledge as the “paradigm” has been accepted by society. The paradigm shift is derived by Commensalistic interdependence, whereby believers of the new paradigm attach their findings to the one, which is still minor in population, without harming the guru of the new paradigm.

The “emergence” described by Polanyi (1966) has a macro effect of determining the structure of Collective Knowledge. Once Collective Knowledge emerges itself, it then binds the pattern of thinking by people. Collective Strategy induces Collective Knowledge but the Collective Knowledge, which emerges after interaction of participants, set limits of finding solutions.

Symbiotic Knowledge, created through the application of Conjugate Strategy, is promising as a theory of the innovation. Schumpeter (1926) pointed out a big-bang process of innovation as “die neuen Kombinationen (the new combination)” but he never showed an anatomy of combined knowledge. Symbiotic Knowledge emerges when the core process of making new discovery and invention are pursued through which new dimension of knowledge is giving exponential power. Diversity, Independence, Decentralization and Coordination shall be pursued when Conjugate strategy is chosen. Symbiotic Knowledge created through Conjugate Strategy is worth noticing since the former is the core of distractive innovation whereas Shared Knowledge is boiled down to gradual innovation. As many countries in the world adopt a promotion policy of innovation, they advocate business-university-government alliances. Multinational companies are creating business-university collaboration for their new product development. These are all examples of Symbiotic Knowledge.

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Questionnaire Survey to Intellectual Cluster Creating Initiative Coordinators

Haruo Horaguchi: Hosei University

Date: June 16, 2006.
Deliver: Mail+E-mail to 18 Coordinators at the Intellectual Cluster Creating Initiatives.
Respondents: 16 Coordinators at the Intellectual Cluster Creating Initiatives.
Method: All of the answers were written.

① Among research and development projects elaborated in your district, how many projects will there be a possibility of establishing business? Please tell us the theme of projects. In this question, the annual income and expenditure may record a deficit when it is defined "a possibility of establishing business."

Please also tell us the projects with various time horizons to be independent businesses such as; less than 5 years, less than 10 years, or more than ten years. If you think that there is no feasible project, please answer it as it is.

①–a. After intellectual cluster Creating Initiative was started; the project that has already undertaken as an enterprise:
BusA

①–b. The project that is expected to set up an enterprise within less than 5 year:
BusB

①–c. The project that is expected to set up an enterprise within less than 10 years

①–d. The project that is expected to set up an enterprise for more than ten years:

② Ministry of Education, Culture, Sports, Science and Technology advocates the formation of "the cluster" as a policy, but the geographical definition of "the cluster" may include participation from wider area with some distances. In your cluster, is there the cooperation with the local company beyond the radius of "1 hour by car including 80km per an hour of speed way use?" Please tell us the company names if possible.

Wide; yes=1, no=0

③ This is a question to the person who answered there were the examples mentioned above. Do you do anything for the exchange of information for the companies joining your cluster? Or, do you do anything to induce a new membership so that you can increase companies for further cooperation in your cluster?
Call: They invite scholars and business person to their cluster.
Out: The coordinators go outside of their cluster to look around the other clusters' practices.
Exi: The coordinators held an exhibition.

④ This is a question to the person who answered that there is the example ③mentioned above. Please tell us if the company participates in the joint research project as a Division, or if it participates as a research and development center? Or will the company be one of the medium and small-sized businesses, which does not have Division? If there is an example of cooperation with a company from remote area, please tell us the actual situation of the cooperation.

⑤ Please tell us if your cluster has a historical continuity with the traditional industrial agglomeration led by small and medium-sized businesses in the existing industry. Please also tell us some cases if there are some companies which became involved in the "Intellectual Cluster Creating Initiatives" recently.
Agg: They answered "yes," there has been an agglomeration.

⑥ How do you asses the ability of "a person" who is in charge of incubation facilities or of MOT(management of technology)? Are there any "incubation managers"? If any, please tell us his/her experience and careers as "incubation managers."
Inc:1=There is an incubation manager in the cluster.
0=No, there is not.

⑦Are you satisfied with the status quo of the incubation facilities in your district?
Sat:1="Yes," the coordinator is satisfied with the level of performance.
0="No," the coordinator is not satisfied.

⑧ What kind of organizational form do you take to sustain industry-university-public co-operation, especially as a part of the public official? Do you take a form of a company with equity or a form of foundation? Who consists of the organization? Are there coming from private companies, local government, or some other background?

⑨Are there a business person or an entrepreneur who spun-out from an existing high-tech industry to join the "Intellectual Cluster Creating Initiatives"?

⑩How the universities commit to create new industry? How do you assess the practices done by the universities such as lecture series of venture business, MOT, or the management of the intellectual property rights? Are they satisfactory as a coordinator?

⑪ Will the patent that the university researcher of your cluster owns have possibility of the industrialization? Are there any cases where a patent and/or the technology is held even if possibility of the industrialization is extremely low? Is it proper to evaluate the performance of "Cluster" by the number of Patents? Please tell us your opinion.
Prac: 1=It is considered as "Practical".
0=No, it is not practical.

⑫ Would you agree with the opinion that the importance of so-called "fundamental researches" is dismissed by the Intellectual Cluster Creating Initiatives policy? Do you think that the importance of inspection, certification, or analysis is fully appreciated?
Fund: 1=Yes, the importance of "fundamental Researches" are fully appreciated.
0=No, it is not.

⑬ How do you assess the following opinion? "One of the biggest impediments for the coordination for the coordinator is the organization of semi-public nature. The office of the Knowledge Intensive Cluster is organized by officials of temporary transferred, or the dispatch employee from the local government." Would you agree with this opinion? Please tell us your opinion if any.
Cord: 1="Yes," there is a problem.

0="No," there is not.

⑭ Are there any losses in your annual budget in which you are assumed to consume all of the amount within a year?

Bug:1="Yes," there is a loss in budget.

0="No," there is no losses.

⑮ When I assumed that creation of university-led venture businesses are one condition of providing subsidy to your area, are there any case that a person of graduate school, or Ph.D. program becomes a representative due to the will of a professor so that they can link the name to the company to their research projects? Do you have any inspection system to check these cases will not happen?

Ven: 1="No," there is not such a venture business with low motivations.

0="Yes," there is such a problem.

⑯ The method of the intermediate evaluation by Ministry of Education, Culture, Sports, Science and Technology(MEXT) seems to be based on the report from the person himself/herself concerned with the research project. Do you think this is a proper method to evaluate the actual situation of the research project?

⑰ Because a large amount of research fund by Ministry of Education, Culture, Sports, Science and Technology (MEXT) such as COE, Intellectual Cluster Creating Initiatives, were concentrated in certain universities, some scholars are said to have too much research funds within a several year. Do you recognize this as a problem? If so, do you have any preemptive step to avoid such a situation?

⑱ In comparison with Silicon Valley, or in European countries, less foreign students seem to be accepted in laboratories of Japanese universities. Do you think that your district or your organization has done anything to accept the foreign students from the foreign countries?

For: 1="Yes," they are positively accepting foreign students.

0="No," they are rather passive.

Control Variables:

Pop: The total number of populations by participating municipals.

Uni: The number of participating universities.

Cor: The total number of Participating Companies.

Date of Visit:

Hokkaido

法政大学イノベーション・マネジメント研究センター
The Research Institute for Innovation Management, HOSEI UNIVERSITY

〒102-8160 東京都千代田区富士見 2-17-1
TEL: 03(3264)9420　FAX: 03(3264)4690
URL: http://www.hosei.ac.jp/fujimi/riim/
E-mail: cbir@adm.hosei.ac.jp