Research Article
Research on Knowledge Gap Recognition Mechanism of Virtual Industry Cluster

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Abstract: As a new organizing form, VIC gets rid of regional limit of traditional cluster, realizing virtual space agglomeration which crossing space and time. Knowledge sharing and complementary is foundation to form VIC and be one of the main goals. As preparation of the knowledge transfer, recognizing and making up for knowledge gap did not caused most scholars' attention. This study argues that, knowledge gap recognition is the premise of knowledge transfer, combined with knowledge theories, the connotation of knowledge gap were introduced. Based on the classification of strategic management of knowledge, we got knowledge gap types and designed recognition process of knowledge gap from endogenous and exogenous factors. We had respectively detail analysis on both knowledge demand and supply. This study used Bipartite Graph Theory to match knowledge gap between two sides, studied six costs which might occur during the process of make up for knowledge gap and according to the costs to choose the way to fill the gap.

Keywords: Choice fills approach, knowledge gap, recognition

INTRODUCTION OF VIC

The concept of Virtual Industry Clusters (VIC) first came from a EU 'SACFA project granted by San Paulo, 7 universities college consisting of a research network, VIC was considered to be a platform which be composed of some enterprise who have certain expertise (Molina *et al.*, 1998) and its main function was to provide and adjust members through the core competence of enterprises and to participate in the virtual enterprise operation, thus made members share market opportunities (Molina *et al.*, 2001). Most scholars agreed that VIC is an organic integration by virtual enterprise and industrial cluster. The main different characteristics from traditional clusters are:

- Across spatial, means the enterprises had get off spatial limits and realized the global interconnected
- Virtual, enterprises can overcome the time restrictions
- Organization proximity distribution of the industrial chain along the upstream and downstream firms and related enterprise, institution, organization and even government departments in virtual space were collected, realized the knowledge sharing and complementary among the cluster (Wieser, 2002).

KNOWLEDGE GAP

Knowledge gap and its types: Some scholars believe that there is technical knowledge distance between different enterprise and it is the results of enterprise pursue to output and particular technology (Griliches,
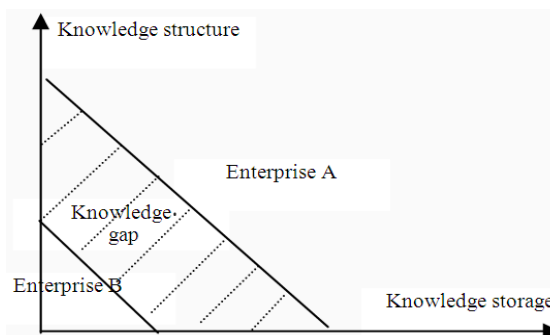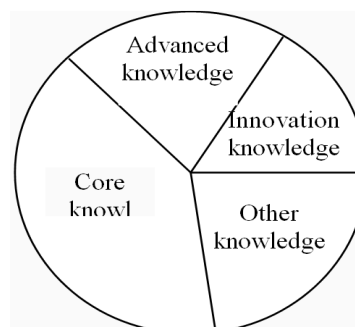

Fig. 1: Knowledge gap between enterprises

Fig. 2: Based on the enterprise strategic value perspective knowledge classification

1984), some scholars call it technical ability gap or intellectual gap (Wei, 2003; Du and Jiang, 2004). We have no one unified expression now. In this study, we call it knowledge gap, which means when enterprises in

Table 1: Knowledge gap types and causes

Knowledge gap type	Causes	Filling cost
Core knowledge gap	Enterprise lack of profession basic knowledge to implementation of multiple development strategy	Lower
Advanced knowledge gap	Enterprise knowledge resources needed to meet all the knowledge innovation or existing knowledge technology was not enough to be a competitive advantage	Medium
Innovation knowledge gap	Enterprise as the pursuit of industry absolutely leading position, innovation activities required knowledge resources shortage and produce knowledge gap	High

VIC get knowledge transfer activities, the knowledge sender (overflow) and knowledge receiver (learning) have knowledge gap between them and this gap mainly performances in the knowledge stock and knowledge structure. Knowledge gap is made by enterprise knowledge level between compared each other, which belongs to the category of the comparison, like shown in Fig. 1.

From the view of strategic value, Michael divided enterprise knowledge into three categories: core knowledge, advanced knowledge and innovation knowledge (Michael, 1999), which is shown in Fig. 2.

Thus, the knowledge gap between enterprises can be divided into: core knowledge gap, advanced knowledge gap and innovation knowledge gap. With their knowledge strategic value of the business are different, so, the above three kinds of knowledge gap causes are different ways. Of course the cost to filling the gap, which is shown as Table 1, is different too Haider (2003).

Knowledge gap recognition process: his study designed knowledge gap recognition process. Firstly, classified knowledge gap, secondly, factors of endogenous and exogenous of knowledge demand and knowledge supply were analyzed respectively, thirdly, matched both the supply and the demand, finally, according to the cost analysis to choose filling approach of knowledge gap, just like shown in Fig. 3.
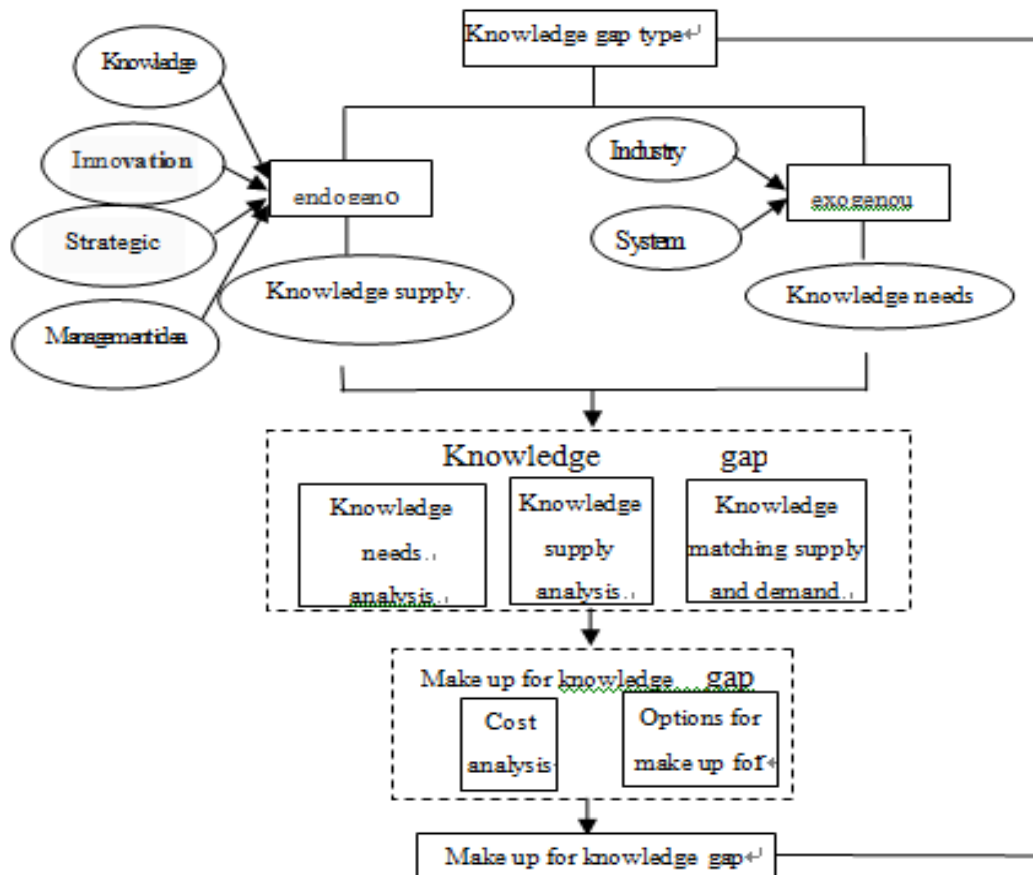

Fig. 3: Knowledge gap offset process

KNOWLEDGE GAP RECOGNITION

We will recognize the knowledge gap from supply and demand two aspects.

Generation of knowledge demand: Enterprise knowledge demand is how to arise? Enterprise always has constant pursuit to innovation and that makes some knowledge resources less to satisfy innovative activities need, it produces the enterprise knowledge demand.

The generation of knowledge demand can be divided into exogenous and endogenous factor reasons.

Exogenous factors include industry and system factors. Industry factors means industry environment change and competitiveness, etc. System factors include the government policy or the industry such as the change of the rules. Furthermore, all exogenous factors demand can be boiled down to market opportunity. Endogenous factors are usually refers to the enterprise internal demand factors, generally include: the enterprise itself knowledge resource deposit and enterprise strategic direction, management concept, enterprise innovation ability and other factors.

Usually, the exogenous factors to the generation of new knowledge needs and endogenous factor, which can help the enterprises to identify as new knowledge demand by the knowledge gap produced. So on; make recognition and judgment to the knowledge gap based on knowledge shortage. And, endogenous factor can also help enterprises promote knowledge learning and innovation and other activities. Both exogenous and endogenous factors changes could produce knowledge enterprise needs.

Knowledge needs analysis: In this study, VIC's knowledge transfer between enterprises is defined as

Table 2: Acquisition of knowledge demand

KE	Knowledge needs
K_1	Y_1, Y_2
K_2	Y_1, Y_3, Y_4
K_3	Y_5
K_i	Y_l
K_m	Y_{M-1}, Y_M

the knowledge resources sharing among enterprises. This kind of sharing derives from knowledge supply to demand. Knowledge demand derives from knowledge gap created by key events during enterprises faced. Key events (KE) is mostly involving knowledge level, category factors such as the time span, also including the knowledge structure and learning ability of the learning party.

KE generate knowledge demand and each KE will produce one or several knowledge demand, KE set is K $= \{k_i\}(i = 1, 2, …m)$, each KE derives knowledge demand Y_l, shown in Table 2, knowledge demand set is $Y = \{Y_l\}(l = 1, 2, … M)$, KE and knowledge demand is not exactly corresponding, so $l = 1, 2, …M$.

Knowledge supply of enterprise can be descript from knowledge type, knowledge level, knowledge strategic value, overflow level of the knowledge spillovers, its set is $X = \{X_j\}(j = 1,2,…N)$. Most of knowledge is tacit knowledge and must be exist and transfer by attaching some carriers, like employees, team, equipments, spillovers media, organizational culture, etc. Knowledge supply set $\{X_j\}$ is in the above many knowledge carriers. Using enterprise internal knowledge map can help us to find enterprise knowledge supply set $\{X_j\}$. Its essence is one-to-one relationship between various kinds of knowledge and the attached carriers in enterprise business flow. Hypothesis enterprise knowledge has four types
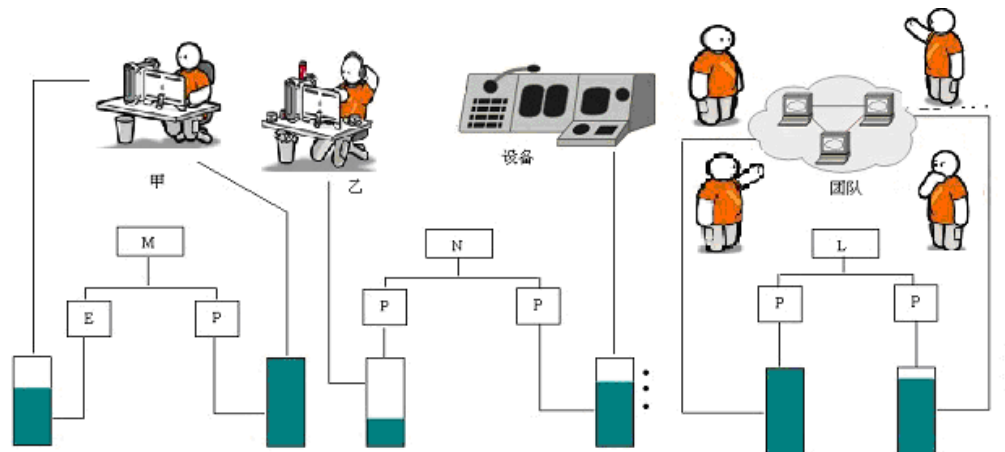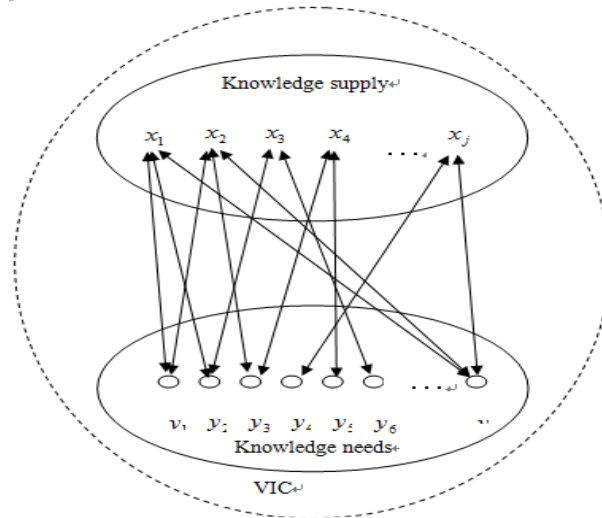

Fig. 4: Knowledge supply analysis

Fig. 5: Knowledge needs and knowledge supply matching

knowledge: M. N, O, P and can also subdivision. Including personal, team, equipment, enterprise culture and others are knowledge carriers. We can structure enterprise knowledge map, shown in Fig. 4.

Knowledge matching: We have already had knowledge demand and supply analysis. This study applied Bipartite Graph Theory to matching both sides.

Set the total number of knowledge supply and demand within the. VIC as point set. The contact between the two sides called edge set. Then the supply and demand of knowledge matching available within VIC can be expressed as: G = (V,E). By matching definition, there are many kinds of matching relation inside VIC. All matching form the matching set. Split point set V into X and Y and V = X∪Y, X∩Y = φ, between X and Y is edge X_jY_l, constitute edge set E' ,so E' = (E' = $X_j Y_1$, ($X_j∈ X, Y_l ∈ Y$)), graph M = (X, Y, E') composed b X, Y and E'. This study wants to get optimal matching for the graph.

- **Establish matching model:** From above analysis, we can know G = (V, E) is a full weighted binary chart, its mapping definitions for: L：V(G)→R, each edge in G, e = {X_j, Y_1} all meets the following inequality:

$$l(x_j)+l(y_l)\geq \omega(x_j,y_l) \qquad (1)$$

ω (x_j, y_l) is weights of e, l is feasible top calibration of G:

$$E_l = \left\{\{X_j,Y_l\}\middle|\{X_j,Y_l\}\in E(G), l(X_j)+l(Y_l)\in \omega(X_j,Y_l)\right\} \qquad (2)$$

Among them, G_l is generation son graph which for edge to E_l. So we can call G_l is equal son graph to l, if G_l has a perfect match M, then M is also optimal matching to G (Yin and Kaiya, 2003). This study constructing model as shown in Fig. 5.

- **Model solving:** By continuously revised feasible vertex label, we can get optimal matching of the model. There are many ways to solving the model, in this study we use Kuhn-Munches algorithm, described below:

Step 1: Any given a feasible vertex, then make sure l is equal son graph to G_l, find match collocation M in G_l.
Step 2: Judge whether A saturated B, if it was, *M* is optimal matching; solving process is over otherwise use the Hungarian algorithm

Hungarian algorithm described below:

Step 1: Choose any matching of G:
Step 2: If M fixed all of point, M is the optimal matching for asked Otherwise, take an unsaturated point M in X_j as μ,make S = { μ }.
Step 3: If N(s) = J, said it is no match in G to saturated all X_j vertices, stop looking, any take a point as Y in N (s)-J.
Step 4: If Y is saturated to M, take hypothesis that y μ ∈M, use S∪{ μ} instead of S,J∪{y} instead of J, turn to step3. Otherwise, take P as an augmented path from μ to y in M, use M = M⊕P instead M, turn to step2.

FILLING KNOWLEDGE GAP

After above analysis, let us look at if we want to fill the knowledge gap, what cost we need to spend on. We will use cost-profit function in the analysis process.

Cost analysis: Directly goals of enterprise are usually getting economic interest. When they meet the market opportunities, the vast majority of cases will choose their own revenue maximization way of transaction, of course is no exception in the filling process. Knowledge spillovers need to measure profits to decide whether to carry on the knowledge transfer and knowledge learners will measure the learning cost to decide whether or not to go on.

The production function can be expressed as: $Q = f(x_1, x_2, \ldots, x_n)$, $(x_1, x_2, \ldots, x_n)$ can be understood as production factors, especially the knowledge elements. If market price of the spillover knowledge is P, then knowledge transfer benefit is $R = P \times f(x_1, x_2, \ldots, x_n)$.

The cost to fill knowledge gap includes:

- **Knowledge searching cost C_1:** It is usually difficult to get knowledge source and price for innovation activities required. So it needs to be active in the market to search for. Obviously, for the present popularization of the network technology and the diversity of information, this cost is lower than before.
- **Knowledge losing cost C_2:** In the knowledge transfer process, not 100% is success. Because of the willingness and ability of spillovers are likely to cause the loss of knowledge transfer, produce loss cost. Learning ability and willingness of learners will lead to the same result.
- **Knowledge learning cost C_3:** For knowledge learners, knowledge (especially tacit knowledge) absorption is not only rely on their own knowledge stock but also need to put in some cost like time, person material and financial resources, we call it knowledge learning cost.
- **Knowledge transaction cost C_4:** Due to the influence of opportunism, learners are not sure about if the opposite exaggerate the value and level of knowledge and knowledge spillovers worry about reselling or abusing knowledge by opposite. These factors will make both parties of knowledge transaction high cost, include: negotiation, contract signing, the performance of the contract and the supervisory cost, etc. Sometimes, exorbitant transaction cost will be obstacles to knowledge transfer. In VIC, both parties trade in "Virtual"

space and may have never met, so trust plays a very big role.

- **Technical cost C_5:** Knowledge transfer must rely on certain media, the language is the foundation of communication between individuals. In addition, modern communication technology makes the wide application of the transmission of knowledge wider and more rapidly. The main influence factors are communication technology of level, advanced equipments and technology.

Besides the cost factors, the price of knowledge is also by the time factor influence. In a certain time scales, there are three ways to fill their knowledge gap for most enterprises (i.e., knowledge transfer way): autonomous learning, knowledge transaction and establish cooperation. In the next, we have analysis on the three ways one by one.

- **Autonomous learning:** Belong to enterprise internal knowledge transfer way. They fill knowledge gap by autonomous learning. In this case, the enterprise don't need knowledge transfer, but only rely on internal departments and search for required knowledge resources between team, which C_1 is very low. And because of communication and cooperation smoothly among internal teams, C_2 is low. Entirely depend on their own, enterprise requires a lot of human, material and financial resources to the innovation activities and therefore, C_3 is high. Due to no knowledge transactions, C_4 will be zero. And because the knowledge in the enterprise internal for exchange and sharing, technical factors on the influence will also be very limited, which C_5 will be very low. But just depend on their own strength, it will take a long time relatively, unless the enterprise can accomplish anticipated target in short time by its own strength, there are few enterprises to choose this way.
- **Knowledge transaction:** Because of the particularity of knowledge transaction, this study analyzed it separately. In the market, through technology trading or merger and acquisitions, enterprises purchase knowledge directly. Because it is hard to measure the existence and value of knowledge, in this way C_4 will be very high. In addition, knowledge spillover and learning ability, gap in knowledge stock and structure in knowledge transfer activities among different organizational that all will get C_1 and C_2 high. C_3 Depends on the level of knowledge transfer and the ability of

Table 3: Knowledge transfer cost and time factor list

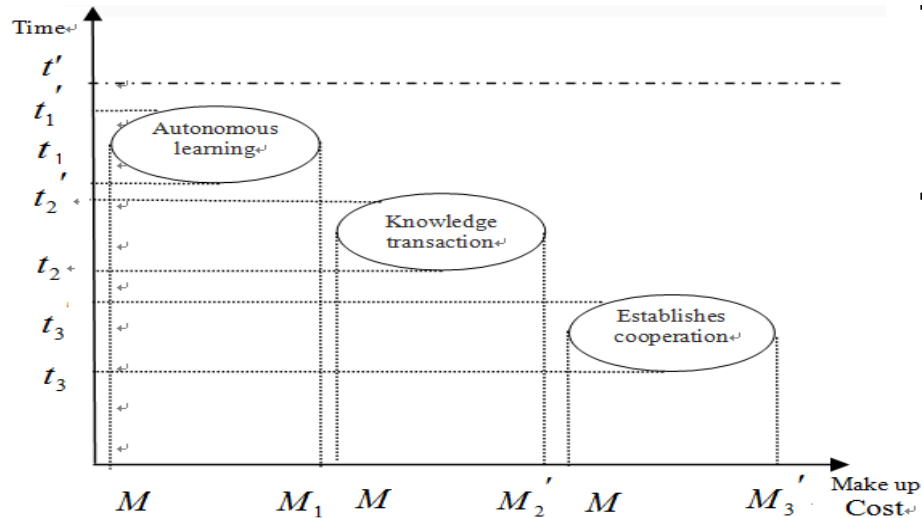| Knowledge transfer ways	C_1	C_2	C_3	C_4	C_5	t
Autonomous learning	Very low	Low	High	None	Low	Long
Knowledge transaction	High	High	Uncertainly	High	Uncertainly	Uncertainly
Establishes the cooperation	Low	Low	Lower	Higher	Low	Short

Fig. 6: Knowledge gap remedy way choice

knowledge learners to determine. If knowledge gap is small, C_3 will be low, otherwise will high. On the other hand, if knowledge is purchase directly,t (the time to fill knowledge gap) will short, or conversely. Such as different medium and establishment choice of communication will lead C_5 to change.

- **Establish cooperation:** The premise of knowledge transfer activities in VIC members is to establish cooperation and cooperation relationship based on trust. VIC information platform will help enterprises to choose partners, establish cooperation such as virtual enterprise. It will internalize the external knowledge transaction, so C_1 will be lower. Generally speaking, access, exit and credit evaluation system of VIC make members to build trust in a short time and all above ensuring smooth progress of the knowledge transfer, so C_2 is low. Due to the trust and cooperation relationship, C_3 is also lower. But to C_4, because of opportunism, it will be high. Most of enterprises cooperation rely on computer network, so C_5 will be low. It is worth noting that, this way usually spends shorter time than autonomous learning, which shown in Table 3.

Choice of make up ways: In this study, we construct selection model from time and cost dimensions, as shown in Fig. 6.

t'= Time threshold:

- t > t' means enterprise can not withstand the time to fill knowledge gap, so they will do nothing.
- Only when t > t' enterprise chooses the way to fill knowledge gap based on analysis of the cost.
- When $t_1 < t < t_1'$ and cost scale is in $M_1 < M < M_1'$, this means the enterprise can accept a long time but lower cost way to fill knowledge gap. Usually, this kind of enterprise relatively has rich knowledge resources and strong ability to learn themselves, so most of them choose the way of autonomous learning by internal knowledge transfer.
- When $t_2 < t < t_2'$ and cost scale is in $M_2 < M < M_2'$, this means the enterprise can accept moderate time scale and cost to fill knowledge gap. If enterprise do not has enough knowledge stock to do innovation activities and want to fill gap in a short time, they may be willing to pay higher cost and get knowledge transaction. Due to the opportunism, they must be careful to select subjects for the deal.
- When $t_3 < t < t_3'$, and cost in $M_3 < M < M_3'$, this means the enterprises want to fill gap in a short time, but they will not afford very high cost. Therefore, establishing the cooperation for innovation is their preferred way. This will not only help to sharing and complementary knowledge resources, but also reduce the risk of innovation.

The scale of t and M mainly rely on subjective estimate of enterprise itself, it may be different because of different enterprises. When scale of t or M is overlapping, means that they can also choose two or more ways to finish the filling process.

CONCLUSION

Combined with VIC characteristics, this study discussed the initial stage of knowledge transfer-recognition and choice filling way for knowledge gap and the results are as follows:

- Based on Knowledge Management Theory, knowledge gap is divided into three types, respectively is: core knowledge gap, advanced knowledge gap and innovation knowledge gap.
- This study designed recognition process of knowledge gap from endogenous and exogenous factors and had respectively detail analysis on both knowledge dimand and supply. In addition, this study used Bipartite Graph Theory to match knowledge gap between two sides.
- After recognized knowledge gap, in this study, how to choose the way to fill knowledge gap was studied. The cost of filling was analyzed and had 5 costs: Knowledge searching cost, Knowledge losing cost, Knowledge learning cost, Knowledge transaction cost and Technical cost. In this study, we construct selection model from time and cost dimensions and discussed enterprise's choice strategy on how to fill knowledge gap.

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