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A MANUFACTURING NETWORK FOR GENERATING ADDED VALUE FROM A GEOGRAPHICAL DISTANCE FOR THE NEXT GENERATION

In this study, we suggested a manufacturing network for generating added value from a geographical distance in terms of value creation from various management resources. Until today, most researchers focused on the Real Concentration of Production Base, which provides certain manufacturing benefits in these domains. However, "the Virtual Concentration of Production Bases" is realized by overcoming large physical distances and time differences between production bases, and creates greater added value for products. We attempted the simulation of the manufacturing network of creating the added value after having shown the new framework of network analysis in the manufacturing system.

1. INTRODUCTION

With increasing uncertainty in the management world, it has become essential for companies to adapt to environmental changes. We consider two ways for environmental adaptation, i.e., paying attention to visible management resources like financial and production resources, and invisible management resources like information and knowledge. Management resources such as the latter strongly affect innovation. We refer to such resources as "intangible management resources."

Intangible management resources can create added value for production, because companies are free from physical limitations such as space and time by using information technology. Some successful attempts have been reported. On the contrary, we focus on the physical side in this study. In general, physical factors of management such as the geographical distances between production bases create certain difficulties; for example, increase in transportation costs and loss of communication. However, it will be advantageous for production industries if they can create added value by overcoming these physical difficulties.

Many researchers have paid attention to the creation of a network structure to overcome physical difficulties. However, most researchers have focused on small and homogeneous networks such as an industrial complex in these domains. If widely

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heterogeneous networks are created to overcome the disadvantages of greater geographical distance, these networks may create greater value for products in manufacturing industries. An industry that possesses such a network can adapt to the complexity of the management environment in the next generation.

Accordingly, we suggest a framework of networks from the viewpoint of management resources using a new concept of regional industrial agglomeration called the "Virtual Concentration of Production Bases" as a value-added production network. In this network, companies should generate higher value from heterogeneous management resources.

2. THE PARADIGM SHIFT OF PRODUCTION STRUCTURE TO CREATE ADDED VALUE

It has been believed that industrial agglomeration is one of the sources of competitiveness for companies. Companies achieve benefits from distribution by intensive production, efficiency in information flows, and joint purchase. An industrial agglomeration is known as a production structure that produces much profit. The mutual exchange of management resources such as technologies, manufacturing components, and information is necessary for companies' production activities. If the distance between companies is small and companies accumulate in a limited area, transaction costs become low and the quality of the information is increased.

Worldwide interest in local agglomeration by clustering is high. Porter [1], professor of business administration at the Harvard business school, defined a cluster as an organization which belongs to a particular management field, and is a geographically co-located group consisting of a company and the organizations to which it is mutually related to. A characteristic of such a cluster is subsidiarity that serve as ties between members of the group.

An example of using clusters as a national policy can be found in Finland. The country offers a first-class innovation and business environment and helps entrepreneurs to access innovation networks by identifying potential business and R&D partners. The Finnish Funding Agency for Technology and Innovation (TEKES) is the most important public funding organization for financing research, development, and innovation in Finland [2]. They promote wide-ranging innovation activities in research communities as well as in the industrial and service sectors. The areas of expertise include forestry, chemicals, metal industries, information and communication technology (ICT), new materials, environmental technologies, functional food, and biotechnology and diagnostics. As a result of active clusters including global partnership, TEKES promotes the development of industry and services by means of cross-industrial networks. In addition, the collaboration between the business sector and academia runs exceptionally smoothly for not only small and medium-sized enterprises but also researchers and end-users.

We believe that clustering helps to renew industries, increase added value and productivity, improve the quality of working life, boost exports, and generate employment and well-being. We argue that the possibility of networks create added value thus surpassing the demerits of large geographical distances.

3. THE THEORETICAL BACKGROUND OF A VALUE-ADDED PRODUCTION NETWORK

It is difficult for companies to change complicated internal structures for the purpose of environmental adaptation, because companies' management resources are constrained, and therefore it is impossible for a single company to adapt to the environmental change of the management world.

However, from the recent network theory, there is a route that adapts to the complexity of external environment while performing a "rewiring" depending on an environmental change flexibility to reciprocally exchange resources with an external organization, which has random rewiring possibilities to connect to a "small-world network."

According to the small-world network model, in the social network of the world, one person turns out to be linked to another person by approximately six connections. Soon after meeting a stranger, we are surprised to discover that we have a mutual friend, or that we are connected through a short chain of acquaintances. Duncan Watts [3] uses this intriguing phenomenon, colloquially called "six degrees of separation," as a prelude to a more general exploration, and this fascinating exploration is applicable to a wide variety of fields, including physics, mathematics, sociology, economics, and biology.

In addition, Duncan and Strogatz [4] explored simple models of networks that can be tuned through this middle ground: regular networks "re-wired" to introduce increasing amounts of disorder. They found that these systems can be highly clustered like regular lattices, yet have small characteristic path lengths, and are similar to random graphs. They call them "small-world networks." They found that a small world network reduces the distances within the network dramatically by using re-wiring links.

In social network theory, social relationships are viewed in terms of nodes and ties. Usually nodes and ties mean graph theory consisting of some nodes and edges in mathematics and computer science. In this study, nodes are the individual actors within the networks, and ties are the relationships between the actors. There can be many kinds of ties between the nodes. Granovetter [5] argued that "weak ties (acquaintances) are less likely to be involved within the social network than strong ties (close friends and family)." By not going further in the strong ties, but focusing on the weak ties, Granovetter highlights the importance of acquaintances in social networks. He argues that the only thing that can connect two social networks with strong ties is a weak tie. These strong ties networks would not, in fact, be connected to one another at all if weak ties did not exist. It follows that individuals with only a few weak links are at a disadvantage, compared to individuals with multiple weak links. Another interesting observation that Granovetter makes in his work is that the increasing specialization of individuals creates the necessity for weak ties, because all the other specialist information and knowledge are present in large social networks predominantly consisting of weak ties.

Granovetter's proposition is that a person can easily obtain useful information through a weak connection with a person who is in a different environment and has a different sense of values. As well as the person in a close social relationship, it is sometimes necessary to exchange information with a person who is not close, such as people in different

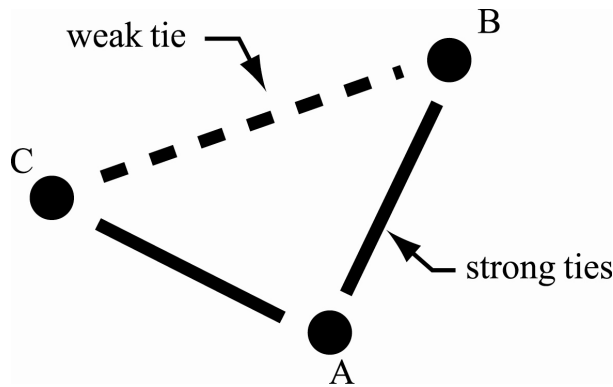occupations and who are geographically farther.

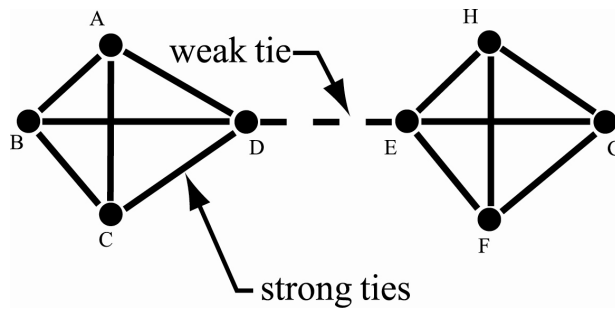Fig. 1. Sample of relationships (strong ties/weak tie)

Fig. 2. Weak tie connecting two networks

Burt's "Structural Holes" [6] is a milestone in the continuing development of structural sociology. Burt's central theory is that structural holes in business networks are very important. He described that a structural hole is a gap between two individuals with complementary resources or information. When the two are connected through a third individual as entrepreneur, the gap is filled. Competitive advantage is a matter of access to structural holes in relation to market transactions. If you link to two people who are not linked, you can manage their network structure.

The important thing is that people have to find the structural holes, because the structural hole has strategic value, and it is important to promote the interaction of management resources by quickly finding the structural hole and building a bridge.

Recent network theory intends for a wide area network. However, a difference exists between theory and practice. In addition, a way of thinking is required to build a new manufacturing concept based on the future production environment from not only the social science perspective but also the domain of production systems engineering.

This is related to a new concept of regional industrial agglomeration named the "Virtual Concentration of Production Bases." Until today, most researchers focused on the Real Concentration of Production Base, which provides certain manufacturing benefits in these domains. However, this conventional concept cannot be applied to the complex

environment of industrial companies in the next generation. On the contrary, the virtual concentration of production bases is realized by overcoming large physical distances and time differences between production bases, and creates greater added value for products [7].

In this study, we discuss the required conditions for organizing valuable production structures of a company or a group of cooperating companies that create added value from a geographical distance.

4. THE CONCEPT OF VIRTUAL CONCENTRATION OF PRODUCTION BASES

4.1. DEFINITION OF VIRTUAL CONCENTRATION IN PRODUCTION

Under a production network in the next generation, a production network, which is not limited to the immediate local area, is geographically more effective than the industrial accumulation, which is limited to that area, if we consider future management environment. In the case of cooperation with a company in a distant location, it is considered that added value occurs even if they produced the same products that are made in a geographically limited and small area. This indicates that they can benefit from the local manufacturing culture and climate by cooperating with local companies. If the virtual concentration is proved to lead to added value surpassing the disadvantages derived from distance, active bridging, namely network construction, begins.

In general, industrial agglomeration is recognized to be a cause to bring about competitiveness. If companies gather in a small and local area, transaction costs are reduced. The transportation cost becomes the most important element of business expense. To maintain a local industrial unity, local agglomeration has been formed for these reasons.

On the other hand, recently, the shift of production bases to un-concentrated areas is observed in some manufacturing industries. We pick up three examples of manufacturing companies that found the possibility to construct the new network, which we investigated in this study.

Case Ⅰ—TOYOTA Motor Corporation

TOYOTA Motor Corporation launched an expansion positively in the Tohoku district as the third market foothold next to Chubu and Kyushu Districts. The aim of this movement was to disperse the risk of geographical concentration such as workforce acquisition or the earthquake disaster.

Similar to TOYOTA, Isuzu Motor Ltd. and Aisin Seiki Co., Ltd. have already moved into the island of Hokkaido. In general, it is believed, there is less industrial agglomeration in Hokkaido; however, an increase in associated companies is being planned in Hokkaido in the near future. Local agglomeration begins from the viewpoint of getting access to an abundant workforce and a huge vacant industrial space. In addition, export to North America or gaining power by acquiring export foothold in Russia and China is expected.

Case Ⅱ—MORI SEIKI CO., LTD., Machine Tool Company

Mori Seiki is a machine tool company in Japan [8]. Machine tools are referred to as

"mother machines," because of their role: machines, which make machines and many industrial products such as automobiles, trains, and mobile phones that we take for granted in our daily lives are manufactured by machine tools. Mori Seiki has delivered over 180,000 machines worldwide.

Mori Seiki has built three manufacturing bases: the Iga Plant, the Nara Plant, and the Chiba Plant. In addition, the Mori Seiki Group has delivered a total of 175,000 units worldwide and they have formed a business and capital alliance with Gildemeister in Germany and Shen Yang Machine Tool (Group) Co., Ltd., in China. This alliance enables them to offer the most extensive product range in the machine tool industry by cooperation and sharing the expertise of the company. Under this alliance, Gildemeister is in charge of design and development, and Shen Yang is in charge of production, and Mori Seiki is in charge of sales and service.

Furthermore, the Digital Technology Laboratory (DTL) in California (U.S.) provides research and development services for Mori Seiki as one of their subsidiaries. The engineers of DTL feedback analysis results using the difference in time with Japan. Firstly, engineers in Japanese division design data and send it through the use of information technology during daytime in Japan. Secondary, engineers of DTL laboratory analyze the design data during night in Japan. Mori Seiki is recognizing the efficiency that this system is equal to design the data in 2 shifts with noon and night in Japan, and the system contributes to a considerable shortening of the development period.

Case Ⅲ—Noodle Company X

As an example of a successful company creating higher added value from distance, we focus on a food manufacturing company, "X," in Hokkaido (Japan). The company produces noodles, which can be made only in Hokkaido and ships them to the bases in four main regions (i.e., Tohoku, Kanto, Chubu, and Kansai). The pre-processed noodles, which are still not commercial products, are transported to four bases in a completely sealed hygienic state from the main factory in Hokkaido. These bases complete the last process depending on an order situation, and transport them to logistics centers of each store. By using this network, they can add the expiration date in those bases.

If the expiration date is added when products are produced in the main factory of Hokkaido, transportation takes time and products reach their expiration date. But the company can avoid transportation risks by setting up regional bases. They perform the final processing stages in the base, and the expiration date is decided there. Therefore, this system can lengthen the expiration date than that of products directly transported from the main factory in Hokkaido. It may be said that an added value called the expiration date is created so that the difference of the metric space is big in this case.

A geographical strategy introduced by a company to reduce transaction costs and increase profits becomes necessary. Nevertheless, a geographical strategy that paid attention to visible management resources such as the workforce and the industrial site cannot become the production system for the next generation. This is because intangible management resources, e.g., culture or knowledge is not recognized as important resources. In other words, local agglomeration as the construction of "the production system, which considers the difference in the manufacturing culture " is important.

As the concept of a new network of manufacturing structure based on the prediction

of a future production environment, we get a suggestion from the Virtual Concentration of Production Bases by Ito [9]. He defined the concept of Virtual Concentration of Production Bases by demonstrating that companies develop production activity on a system scale (a local scale/a continent scale/a global scale/one country scale) to have one manufacturer grouped closely. This concept is based on a production environment prediction of 2020, and it is shown as a concept to overcome the conditions of physical limitations in the so-called "Real Concentration of Production Bases," such as industrial complexes. The generation processes of the virtual agglomeration are classified into two types; one is built by the self-growth of a single company, the other is built by grouping or a merger.

We have summarized the comparison between the Virtual Concentration of Production Bases and the Real Concentration of Production Bases as shown in Table 1.

Table 1. Characteristic of real concentration and virtual concentration

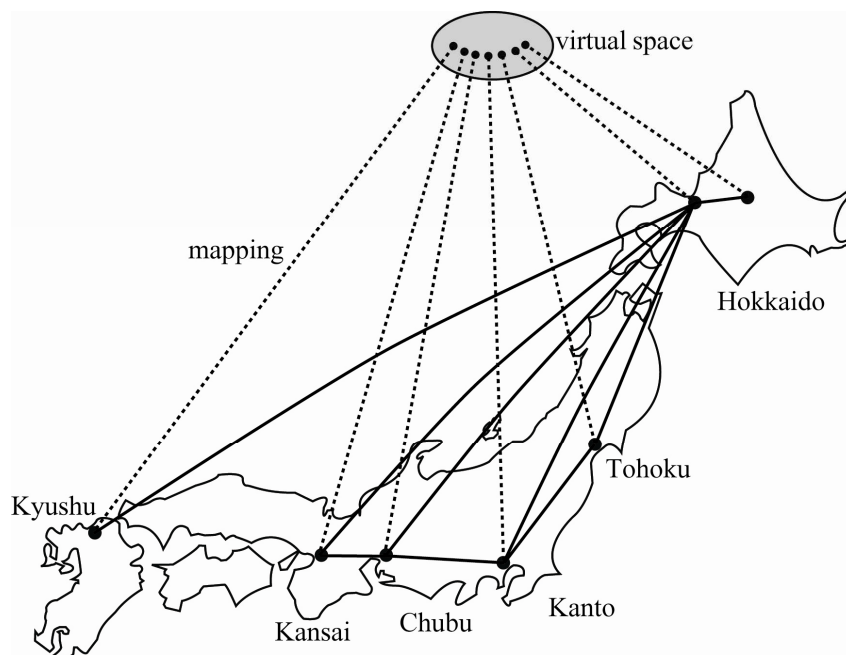| Real concentration	Production Bases	Virtual concentration
Promotion of efficiency	Purpose	Creation of Added value
Quantitative	Management Resources	Qualitative
Geographical space	Concentration Space	Virtual space
Transaction cost saving	Advantages	Added value

Fig. 3. Concept of Virtual Concentration of Production Bases

According to the Virtual Concentration concept, we attempt to derive a production network structure that a geographical distance produces high added value. We consider the production structure, in which each production base is physically distant from the other, but is very close in the mapped virtual space. We call this virtual space the "added-value creation space." Therefore, we attempt to show the degree of virtual local concentration by a functional analysis in the following section.

4.2. A FRAMEWORK OF THE VIRTUAL CONCENTRATION OF PRODUCTION IN THE NEXT GENERATION

Management resources as a source of companies' competitiveness are the elements, which are indispensable for the company to adapt itself to a change of the management environment, and also become elements, which create competitive advantage and produce added value at the same time when we build a network structure. It is necessary to add not only tangible resources, e.g., money and sites, but also highly qualitative management resources such as the management system or the production culture of the organization.

The most influential framework of sustained competitive advantage is the resource-based view suggested by Barney [10]. In his article, management resources include not only traditional and tangible resources such as a firm's financial capital (e.g., equity capital, debt capital, retained earnings, and leverage potential) and physical capital (e.g., the machines and buildings it owns), but also intangible resources such as a firm's human capital (e.g., the training, experience, judgment, intelligence, relationships, and insights of individual managers and workers in a firm) and organizational capital (e.g., attributes of collections of individuals associated with a firm, including a firm's culture, its formal reporting structure, its reputation in the market place, and so on).

Such resources add flexibility for decision-making and strategic development. Therefore, we propose a framework for network construction in the production system from the viewpoint of interaction of management resources in the next generation.

(A) Span of networks

If an industry is accumulated in a limited area space, the business expense reduces and the quality of information rises, as we discussed earlier. The geographical distance becomes a bottleneck in cooperation. However, there is a possibility that organizations may use various management resources in a complementary manner if the shift from a limited space network to the wide space network is possible. Moreover, it is thought that new added value is created from there. A production network in the next generation is different from a locational strategy on the point that it employs not only quantitative resources but also qualitative resources in the business network. This network is not only expected to acquire quantitative resources such as plentiful labor and vast industrial sites, but also develop export bases to North America or Russia and China, and therefore boost employment and reduce geographical diversification of risks such as earthquakes, making the best use of the advantage of the large area space network.

(B) Structure of networks

A closed network in the limited space is generally thought that a risk is few and stable

such as a conventional industrial accumulation. However, the company is unable to receive any stimulation from the outside environment in such a closed network structure. Therefore, new information and meanings never emerge easily.

On the other hand, there is the possibility of building new relationships in an open network structure. As Burt suggested, the important points here are finding the structural holes, constructing bridges at random, and adopting rewiring. We can expect an incremental organizational change by rewiring. A dynamic change can be brought about by adopting an open network. Moreover, a closed network promotes the transfer of knowledge and experience. It is more feasible to optimize the network structure not by creating a dynamic revolution of links but by rewiring incrementally.

(C) Effect expected from network

In the next-generation network, we can expect a change in emphasis from efficiency and rationality to the creation of added value. The excessive pursuit of rationality promotes homogeneity, and therefore makes environmental adaptation difficult. Conversely, it is thought that companies extend the sustainability of the organization by using heterogeneity because heterogeneity relatively reduces complexity. While a market globalizes and the needs of the customer diversify, companies that expanded overseas received the benefits of the local market and created added value by accumulating information and know-how of foreign business. It not only means increasing sales and the development of a new market but also getting the overseas market's feedback to evaluate our product and service. In other words, management resources that can create added value from manufacturing culture or climate come to be handled in the network of the next generation.

Based on the framework of the network discussed here, we simulate the most suitable productive agglomeration network to create added value in the following Chapter.

5. SIMULATION MODEL OF THE PRODUCTION NETWORK USING MANAGEMENT RESOURCES

We discuss an appropriate next-generation production network in the sense of the value-added creation. In this section, we assume that the industrial location such as factories indicate nodes and the flow of management resources indicate the links.

The network suggested here expresses the flow of management resources such as distribution and information as a link and the factory that a company and a group have as a node.

In addition, we can model this structure of cooperation as a growth process of networks with time because those networks grow up like a traditional industrial accumulation. In other words, the nodes of bases or sub-networks are connected in structure in the present stage and grow up to the next stage. When we consider this problem as an issue of optimization, the problem shifts to identifying an objective function indicating the degree of preferability of the network. We can demand the most suitable network by maximizing this objective function if we can build this objective function[11].

We discuss a method for finding the most suitable agglomeration structure here. This

problem is considered as an optimization problem. To solve the optimization problem, an objective function f_{vc}, which indicates the degree of virtual concentration, has to be defined. The virtual concentration structure cs ($\in \mathbf{CS}$) has a type of network structure in which the factories of a certain company or a company group correspond to nodes and a link represents logistics or information flow. The $\mathbf{CS}$ is a set of feasible agglomeration structures. In addition, this network assumes that it gradually grows up over time like a conventional local agglomeration and enlarges it. In other words, a node or sub-network is connected to the current network structure cs_t and then modified to cs_{t+1} in the next time step.

The issue of optimization becomes a problem of identifying the objective function f_{vc} representing the degree of the suitability of a virtual concentration structure. Thus, the most suitable agglomeration structure cs^*($\in \mathbf{CS}$) maximizing objective function f_{vc} is defined as follows:

$$cs_{t+1}^{*} = \arg \max_{cs_{t+1}}[f_{vc}(cs_{t+1}) - f_{vc}(cs_{t})] \tag{1}$$

In this study, the following three significant values of virtual concentration structure cs are settled as evaluation items of objective function f_{vc}.

  1) Distance in geographical space…$D(cs)$
  2) Distance in time space…$T(cs)$
  3) Complexity of management resources…$MR(cs)$

Therefore, the objective function is expressed as the next equation.

$$f_{vc}(D(cs), T(cs), MR(cs)) \tag{2}$$

Virtual concentration creates added value by discovering the most suitable agglomeration structure cs^*. As a result of virtual concentration, the best agglomeration structure cs^* shows superior added value compared to the real concentration, which relies on simple geographical convenience strategy and conventional reality.

In addition, deciding the progressive growth process of each company is accordingly more practical than finding suitable networks at one time if they consider cooperation assuming a difference of the geographical distance as growth of the networks. The network where the objective function becomes the maximum is desirable as cooperation in the next step from the node that can be added. By this objective function, various management resources become a driving factor for creating added value. Added value is created by connecting the nodes that can supplement management resources that they do not have in a production network at some point.

We present a model that the authors simplified on the basis of this supposition. We define the management resources vector for the quantity of the characteristics of a certain network and assume that we can create high added value so as to have various management

resources. We express the factor of each management resource with the values of 0 and 1. The number of figures expresses the node that can be combined with a production network in the same bit string. At this time, we find out the next combination candidate by size of hamming distance.
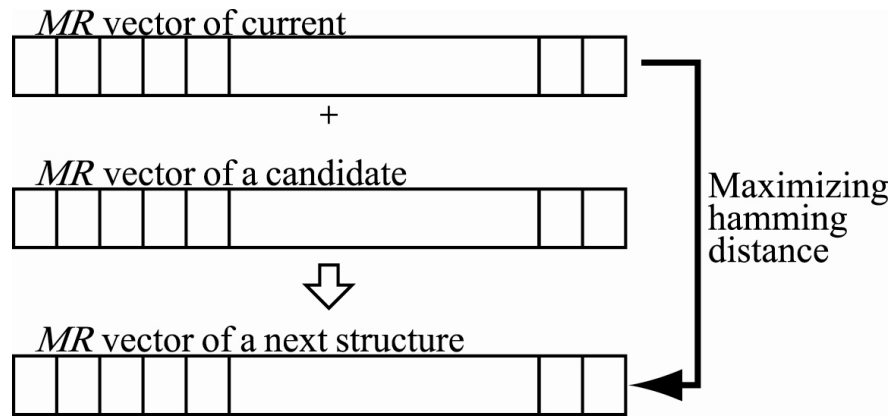

Fig. 4. Optimization method by management resources vector of concentration structure

The variety of management resources is created by the hamming distance, and added values are created from there.

Fig. 5 shows the result that simulated the growth process of the network on the basis of the above.

The points show a base candidate that can become a node of the network, and the point coupled to it by a link expresses a base included in a network. We set the total number of the base candidates with 88 nodes by this simulation. The first figure in the left   expresses the initial state (t = 0) of the network, and the base with the initial state assumes 3 nodes. By this simulation, we decided to express management resources in a bit string of 100 bits, and if it is 1 bit, we assume that resources exist. We set 0 and 1 as management-resource information of each base for random simulation.

We express the variety of each base by setting 1 from 2 bits at the minimum, up to 15 bits. The network grows by adding one best base to an initial value, and the organization expands by repeating this growth. The variety of management resources of the entire network is represented as the logical sum of each base. The various degrees of management resources are expressed in the number of figures that 1 rises of 100 columns of bit string. In other words, it indicates that networks can create added value when a bit is formed at different positions. However, we reduce the added value depending on the distance of a link to express the negative factor of physical distance.

Furthermore, Fig. 6 shows the value-added change in the growth process of the network shown in Fig. 5.

In Fig. 6, the cross axis shows a growth step of the network structure and the vertical axis indicates the added value. At the initial stage of growth, the added value rises linearly because there is a lot of efficient candidate to make links. However, the added value traces the decline gently after having arrived at the peak.
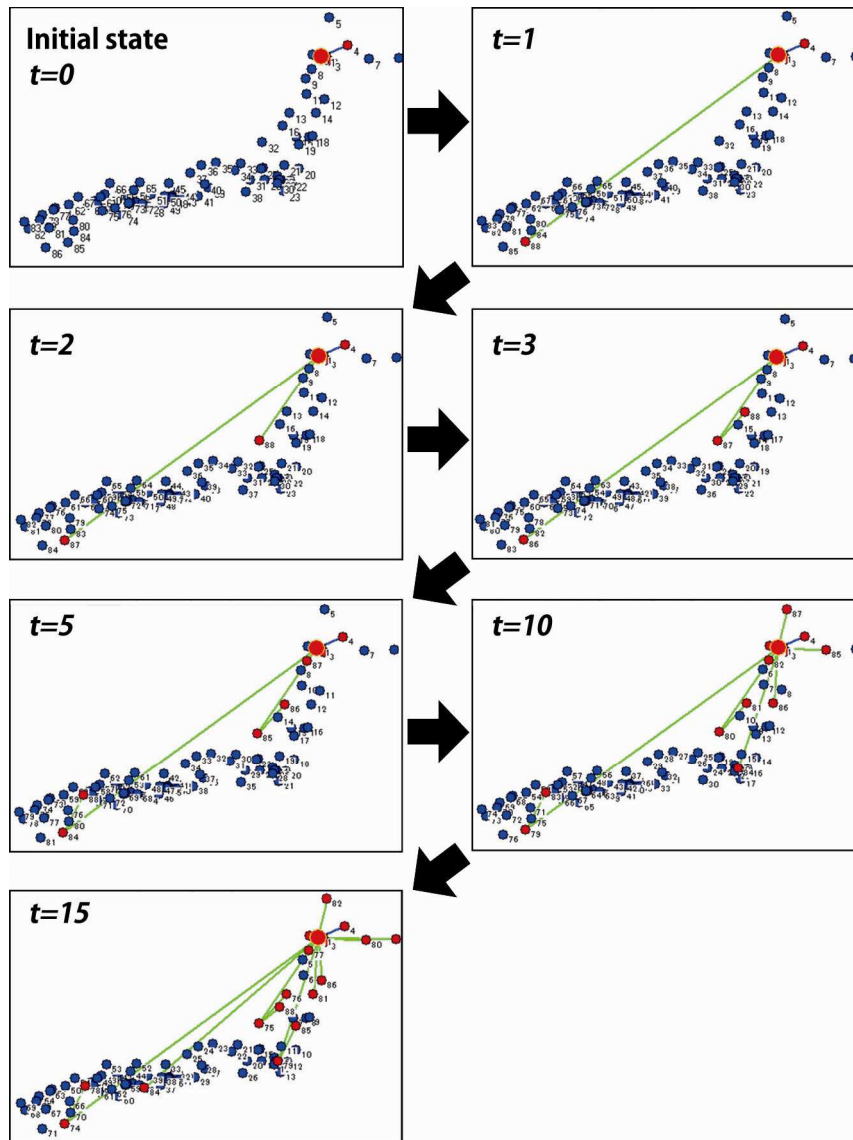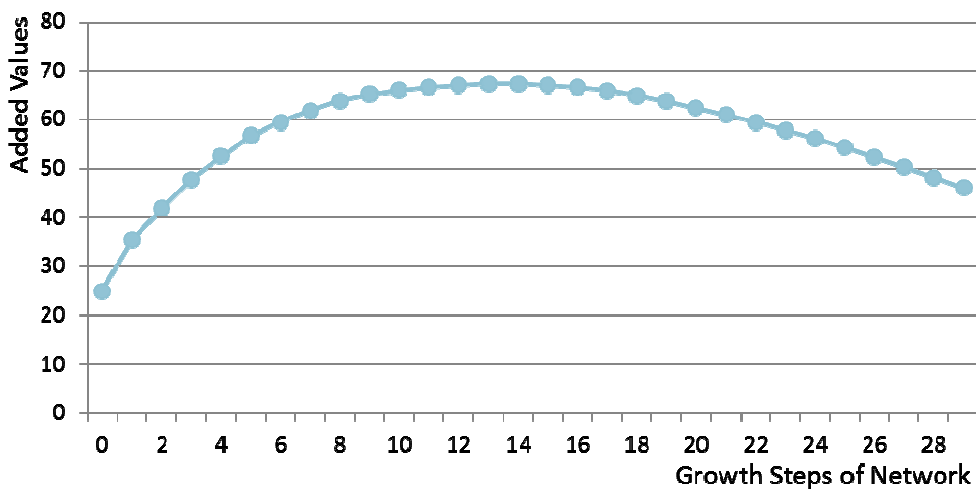
Fig. 5. Growth process of the network

Fig. 6. Added values through network growth

As a realistic idea, it is important for companies to build cooperation in the sense of added value. However, increasing links may have excessively opposite effects. Thus, rewiring, Burt insists [6], carries significant implications.

6. CONCLUSION

In this study, we suggested a manufacturing network for generating added value from a geographical distance in terms of value creation from various management resources. The geographical differences between production bases surpass the transaction cost, and we gain an opportunity derived from the next-generation production network, which created the added value theoretically. We attempted the simulation of the manufacturing network of creating the added value after having shown the new framework of network analysis in the manufacturing system.

This study clarified that companies can complicate their internal structure by producing a network, which does not consider the limitations that assume geographic differences, and they can adapt themselves to the complexity of the management environment by using added value brought for a management organization. These are different from conventional industry accumulation, the so-called real concentration of production bases.

For this purpose, we consider the organization of the virtual concentration of production bases as a way of optimizing the strategy of the manufacturing industry, and define an objective function that represents the degree of virtual concentration. On the basis of results of computer simulations and case studies in a business world, the usefulness of this approach is verified.

However, the simulation results proved that added value did not rise endlessly by only increasing the links. Thus, it will be necessary to let the company's internal structure become more complicated in order to relatively lower the variety of outside management resources. On the other hand, it must be performed at the same time to plan networking to let the internal structure become complicated. In this manner, companies will create added value from virtual concentration as a next-generation production network.

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