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Knowledge Creation through International Cooperation in Agriculture†

Lily KIMINAMI* and Shinichi FURUZAWA*

Abstract

This paper intends to examine how the social environment has changed in international agricultural cooperation from the viewpoint of international food system theory. Subsequently the "knowledge creation theory", which has made significant progress in the field of economics, and the life cycle theory are integrated based on the theoretical foundation in industrial cluster theory to explore the possibilities and issues in knowledge creation (including development of human resources) in international cooperation in agriculture. It concluded that the significance of international agricultural cooperation lies in the creation of new knowledge by each researcher and institution through cooperation, and the significance of that cooperation becomes evident when agricultural issues are solved through innovation as a result of knowledge creation. Furthermore, if international cooperation in agriculture aspires to attain the situation where relevant entities such as universities and research institutions cooperate and compete globally, then an innovation induction principle in global "industrial clusters" which bear a similar relationship, or the knowledge creation framework based on the principle of cooperation supremacy, will be effective. Hence this paper would like to look at the direction of research in international agricultural cooperation as an issue of "knowledge governance" in addition to knowledge supply in knowledge creation.

JEL Classification : Q10, O30
Keywords : International Cooperation, Knowledge Creation, Agriculture

1. Introduction

Knowledge is categorised as public property in economics, and since knowledge bears both a non-exclusive and non-competitive nature, it may lapse into undersupply should it be left in the hands of the market (private companies) alone. Generally speaking, there are two possible measures to remedy such situations, namely, establishment of a system to protect intellectual property rights, and creation of knowledge by the public sector.

On the other hand, it has become clear from the impasse in international negotiations, such as at the WTO, that it is necessary to work out the conflicting interests of developed and developing countries that are based on trade-offs, not only for agricultural issues but in other areas as well. It is needless to say that the technological development in agricultural production and the subsequent rural development, and the resulting food security through increase in food production is a fundamental issue for farmers in developing countries. Considering the current circumstances of the global food system, it is necessary for small-scale farmers in developing countries to participate in the modern food system, and the fact that actual agricultural product demand comes from food-related companies in the developed countries should not be overlooked. As the entities involved in agriculture and food

* Institute of Science and Technology, Niigata University, 8050, Ikarashi 2-no-cho, Nishi-ku, Niigata City 950-2181, JAPAN E mail : Kiminami@agr.niigata-u.ac.jp

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have become more diverse and the interests increasingly complex, it is effectual in understanding the mechanism of and relationships inherent in issues concerning agriculture to analyze them from a viewpoint of the "international food system" which embraces the food flow in the face of the advancing globalization and the dynamic changes in the surrounding social environment (Kiminami [5], 2009). In order to promote the agricultural research of today, it is important to conduct research and development through international cooperation from the viewpoint of the food system in a manner that acknowledges that many of the results from upstream R&D in agriculture belong to the consumers.

Therefore, the purpose of the paper is to examine how the environment has changed in international agricultural cooperation from the viewpoint of international food system theory. Subsequently the "knowledge creation theory", which has made significant progress in the field of economics, and the life cycle theory are integrated based on the theoretical foundation in industrial cluster theory to explore the possibilities and issues in knowledge creation (including development of human resources) in international cooperation in agriculture.

2. Literature review on the issues of knowledge creation and innovation in agriculture

2.1 Existing studies on the innovation and knowledge creation in agriculture

Innovation in agriculture has a long history with special and common features comparing to the other industrial sectors. The biological nature of agricultural production means that production processes take time after resources are committed, during which outcomes are susceptible to the influence of uncontrolled factors such as weather and pests. The agricultural productivity influenced by the consequences of pests and weather vary in ways that are often difficult or costly to control or predict, not only within a season but also systematically over time and space. Climate change implies a demand for innovation with the coevolution and adaptation of pests and diseases (Pardey et al. [9], 2010). And, tacit knowledge in agriculture is diverse and affluent in the society with a high level of potential availability. Hence, the knowledge creation in agriculture has been becoming important.

On the other hand, the plant breeding industry in the field of innovation in agriculture is one of the most innovative sectors in the world and has the characteristics of knowledge intensive industry. Its share of R&D in turnover is far higher than for most other industrial sectors (Dons [1], 2013). And, along with the transition of main entities of R&D from the public sectors to the private sectors, the necessity of the creation and the supply of knowledge as global public goods through the collaboration among diverse entities have been increasing.

Therefore, international cooperation in agriculture needs the establishment of the system for knowledge creation through the collaboration among diverse entities in order to adapt the coevolution of technology, natural environment and social environment. However, existing studies on the innovation in agriculture mainly focus on the economic evaluation of investment(Pardey et al. [9], 2010) and the establishment of practical research system(World Bank [13], 2006), the studies focus on the knowledge creation through international cooperation in agriculture are scarce.

2.2 Japanese experience and solution to the issues

During the Meiji era at the end of the 19th century, experiment and research in Japan was transferred from the hands of *rono* (elderly or experienced farmers) to agricultural experiment stations. With regard to this historical event, Sakiura [10] (1984) explained the reasons for this shift from the vantage of economic attribute of agricultural experiment (externality, indivisibility and uncertainty),

while recognizing the *ronos*' roles. This paper re-examines the situation according to knowledge creation theory and considers the nature of international cooperation in agriculture in present times.

Firstly, let us look at the externality. Since *rono* skills are accumulated through experience, such knowledge is strongly tacit in nature, with limited spillover effects (communication of externalized knowledge). Although the information on *rono* skills did get exchanged and there were some limited spillover effects, the knowledge transfer cost was high. It was inevitable in a way that research was transferred to public research organizations to disseminate agricultural knowledge as scientific knowledge. However, looking from the viewpoint of knowledge creation, this transfer to public research organizations may have accelerated the accumulation of formal knowledge, but at the same time reduced the tacit knowledge. The second attribute is indivisibility. As Schultz [11] (1964) pointed out, a lonely researcher with a meager facility is unable to conduct research that requires a larger number of staff and an advanced facility. Thus interaction amongst researchers was promoted by conducting experiments and research with public capital investment. From the knowledge creation perspective, it created a place for continued interaction amongst researchers and this can be construed as the process to facilitate the sharing of tacit knowledge and expression into formal knowledge. However, this may have led to lower knowledge heterogeneity as a result. The third attribute is uncertainty. Experiment and research do not always produce successes, and results are obtained after repeated trial and error. Hence public research organizations are regarded as better suited for experiment and research, given the low need to match the ability to obtain economic profit with research expenses. It is generally believed that basic research is especially suited for public research organizations as the research development tends to require a long time before results are obtained.

Based on the above, another point should be added here as the fourth, namely the speed of depletion of knowledge as capital. That is to say, it is necessary to coordinate the process from research and development to commercial viability and to accelerate knowledge creation. In addition, as the food system advances, more of the value from research and development is vested in the mid- and down-stream food industry, hence the partnership between public and private research organizations becomes key. Furthermore, considering the food industry's expansion overseas, development of intra-industry trade, and the growth in highly-developed demand for high quality and safe food, these partnerships must expand to a global scale[1].

3. Knowledge creation through international cooperation in agriculture

As seen above, international cooperation is required not just in the technological field but as a social and institutional system, and the roles played by agricultural and other economists are becoming increasingly significant. The process of knowledge creation amongst the target regions and researchers in different fields itself can also be the subject of research in agricultural economics. It fulfils a complementary role by considering the issues from a social scientific perspective along with research in the technological aspect, and such knowledge creation is seen as playing a key role in actual examples of successful international cooperation.

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[1] One of the purposes in encouraging farmers' participation in screening and promoting NERICA rice is to direct experiments and research while utilizing the strengths of *rono* skills, i.e., tacit knowledge. Another purpose is human resource development through improvement of farmers' management skills. Concerning the above, the negative aspect stemming from the social and economic circumstances in Japan, in which hardly any technological development has been made after the *ronos* became parasitic landlords, must not be overlooked.

Therefore this paper integrates the knowledge creation theory (Nonaka and Takeuchi [7], 1995 ; Fujita [2], 2007) and the industrial life cycle theory (Vernon [12], 1966) using the concept of "proximity" to explain the knowledge creation mechanism in international agricultural cooperation. Before setting out to explain the model, here is the explanation of the different kinds of knowledge. There are two kinds of knowledge, namely tacit knowledge (Kta) and formal knowledge (Kfo). Tacit knowledge is a term also used in knowledge management theory and it refers to knowledge based on experience or hunch/gut feeling, which is difficult to explain in words. Formal knowledge, on the other hand, is knowledge that can be explained or expressed in sentences, diagrams, or mathematical formulae. The assumption of the model is as follows.

i. There are two stakeholders or stakeholder i and stakeholder j.

ii. Structure of knowledge between stakeholders is different.

iii. Scale of Knowledge (SK) and structure of knowledge changes according to the lifecycle.

iv. Knowledge growth can be approximate as the growth of SK, and can be shown by the function at time t.

v. Structural change of knowledge in individual, organization, regional nations according to the lifecycle can be described as Fig. 1.

vi. Knowledge Growth Potential (KGP) of stakeholder becomes the product of knowledge scale (SK) and the ratio of tacit knowledge (TKR) (Fig. 2).

Here, The model of knowledge creation based on the interaction between stakeholders can be set as follows.

vii. There are two kinds of knowledge of common wisdom (Cij) and peculiar wisdom (Dij, Dji) between two stakeholders.

viii. Common wisdoms (Cij) in this case are all explicit knowledge. Peculiar wisdom is divided into tacit knowledge (Dij^{ta}, Dji^{ta}) and explicit knowledge (Dij^{fo}, Dji^{fo}) further (Fig. 3).

ix. Knowledge can be created through the interaction between stakeholders. Thus, in the following, the possibility of creation of knowledge through the interaction between stakeholders is formulated as "Knowledge Creation Potential".

x. The network proximity (NP) between stakeholders shows synthesis of a geographic proximity (G1), an institutional proximity (G2), a technological proximity (G3), an organizational proximity (G4), a social accessibility (G5) and cultural proximity(G6), etc. And, the level (NP) of the network proximity takes values that are larger than 0 and smaller than 1. Because when NP takes the value of 0(1), the cooperation is not formed (or is dead).

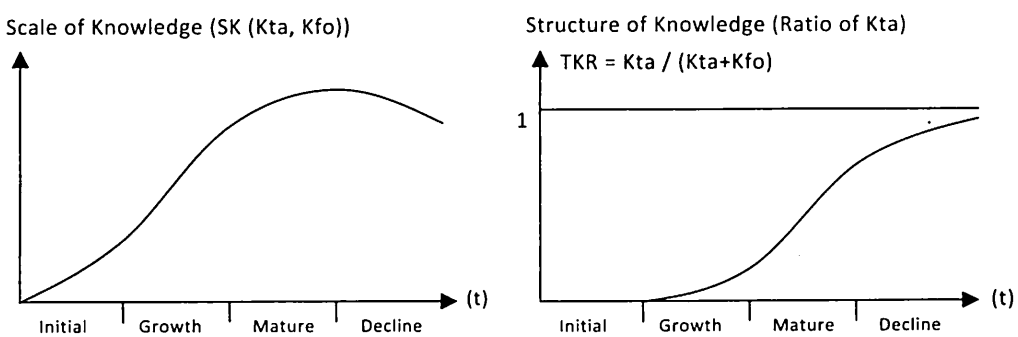

Fig. 1. Scale and Structure of Knowledge and Lifecycle

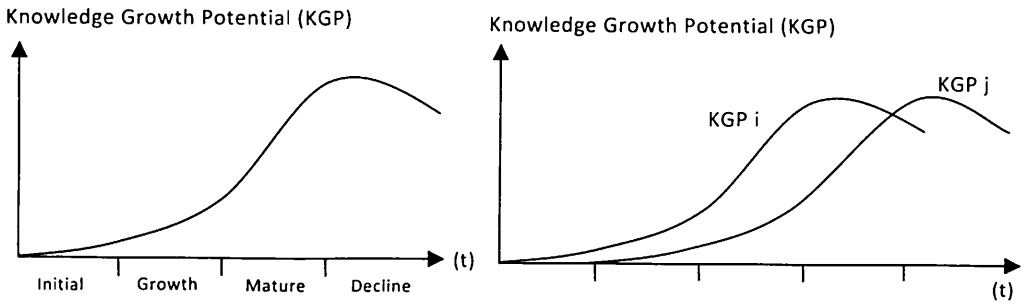

Fig. 2. Knowledge Growth Potential (Stakeholder i and j)

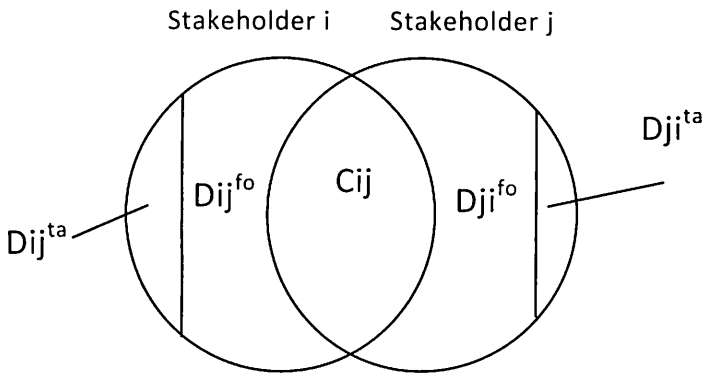

Fig. 3. Relationship among Stakeholders in Knowledge Creation

$$NP = np\,(G1, G2, G3, G4, G5, G6 \cdots Gr)$$
$$0 < NP < 1$$

xi. And, Knowledge Creation Potential can be shown by the function of "Knowledge Growth Potential (KGP) of each stakeholder", "rate of peculiar wisdom of stakeholder (heterogeneity of knowledge : (Dij+Dji)/(Cij+Dij+Dji)), and "Network Proximity (NP) between stakeholders".

xii. Function of Knowledge Creation Potential (KCP) is defined by the following formulation.

$$KCPij=(1-NP)\times(KGPi\times KGPj)^{(NP/1-NP)}\times\{(Dij+Dji)/(Cij+Dij+Dji)\}$$

The derivative of KGPi, KGPj, and Z can be written respectively as follows as (Cij+Dij+Dji) =Z.

$$d\,KCPij / d\,KGPi = NP \times KGPi^{(2NP-1)/(1-NP)}\,KGPj^{(NP/1-NP)} \times Z \quad > 0$$
$$d\,KCPij / d\,KGPj = NP \times KGPj^{(2NP-1)/(1-NP)}\,KGPi^{(NP/1-NP)} \times Z \quad > 0$$
$$d\,KCPij / d\,Z \quad = (1-NP) \times (KGPi \times KGPj)^{(NP/1-NP)} \quad > 0$$

xiii. That is, if "product of the Knowledge Growth Potential between stakeholders" is large, "Knowledge Creation Potential" grows. Moreover, if "rate of peculiar wisdom between stakeholders (heterogeneity of knowledge)" is large, "Knowledge Creation Potential" grows, too (Jacobs [4], 1969).

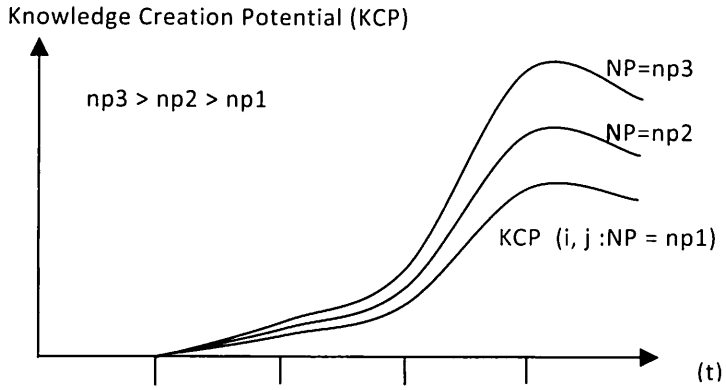

Figure 4. Knowledge Creation Potential through the cooperation between stakeholders

As seen above, knowledge creation potential is considered to be the knowledge growth potential by each stakeholder, network proximity, and the increasing function of knowledge heterogeneity. Given this perspective one can argue that the value of knowledge creation potential changes in response to individual life cycle, degree of knowledge heterogeneity, and function form which determines the network proximity (Fig. 4). It is also considered that the larger this knowledge creation potential is, the more it is possible to achieve knowledge creation through international cooperation in agriculture.

Knowledge creation potential depends on the form of functions in the model, but it is also influenced by the characteristics of the determinant of knowledge creation. Examination in accordance with the model shows that the industrial life cycle is generally considered to be long for agriculture, though the recent view holds that there are many sectors where the life cycle is short. In terms of international cooperation it is considered that the gap in the life cycle among stakeholders is relatively large, knowledge heterogeneity is high, and the network proximity is low in many cases. Therefore, it is highly likely to find a form of cooperation where knowledge creation potential is high by combining these determinants, and this suggests that international cooperation in agriculture is effective as knowledge creation through cooperation between stakeholders.

Meanwhile, an issue relating to diversity of a group and individual ability lies at the core of the issue over "cooperation". In other words, which of the two, individual ability or diversity of the group, is more significant in knowledge creation (Page [8], 2007). In international cooperation involving developed and developing countries, the strategy for profit through group diversity (tacit knowledge can be viewed as this) while improving individual abilities is considered desirable. In the case between developed countries, it is ideal to pair experienced researchers with younger researchers, such as graduate students whose individual ability is already high but whose apparent ability in terms of career as a researcher is yet to be proved. Moreover, if the partnering is between those with different backgrounds culturally and socially, further knowledge creation may be possible. From the viewpoint of organizational management, it is necessary to specify obstructive factors to such activities, as well as to establish a structure to enhance the effectiveness of the activities.

4. Position of and issues in human resource development for international cooperation in agriculture

4.1 Position of human resource development

Human resource development imparts experience and knowledge (shows the tacit knowledge that is expressed in formal knowledge and teaches the method of its transfer) to students (regardless of whether they are from developing or developed countries), and enables those on the educating side to transform formal knowledge to tacit knowledge. It should be viewed as the process to link their knowledge with one's own and transfer it to tacit knowledge. Care should be taken to identify one's own tacit knowledge and formal knowledge as well as firmly acknowledging the commonality and heterogeneity between oneself and others.

For instance, if we use the SECI model (Nonaka and Takeuchi [7], 1995) to explain human resource development, the process can be divided into four steps : *combination*, *internalization*, *socialization*, and *externalization*. First, the educators in the field of education establish links amongst existing formal knowledge and systematize it through classroom lectures (*combination*). The knowledge acquired through lectures is then internalized by implementing it (*internalization*). Internalization is the embodiment of systematic knowledge through experiences. The tacit knowledge in this case is akin to the abilities acquired through case method (ability to adapt to changes in environment and apply acquired skills ; ability to make appropriate decisions ; etc). When it reaches the stage of collaborative research, tacit knowledge is transferred between individuals working on shared issues (*socialization*), thus creating new formal knowledge through research (*externalization*).

However, the more items there are that must be learned at school through textbooks, the less time there is to learn from experiences. Formal knowledge is converted to tacit knowledge by, for example, following up a textbook lesson on rice crop diseases with an excursion to a farming village to spot diseases in the rice growing in paddies. A relationship of trade-off exists between the time needed for such activities and classroom learning time ; however, as tacit knowledge and formal knowledge are complementary to each other in terms of knowledge creation, the key is to maintain a good balance between the two.

4.2 Issues in human resource development

As discussed above, new tacit knowledge is created by expressing and sharing tacit knowledge held by individuals, industries, and regions/countries in international agricultural cooperation, hence face-to-face communication is essential. Information does not truly become one's knowledge or wisdom unless the information (tacit knowledge) is assimilated through that individual's cognitive filter, and this point should be stressed in agricultural training.

On the other hand, more time is required to be spent on activities to "know" as the scientific technology advances and the gap between the parties may expand. This situation can be described using the demand and supply curve of knowledge creation (Fig. 5). While the knowledge economy increased the demand of advanced knowledge (DD → D'D'), the widespread use of IT and globalization has reduced the transfer cost of formal knowledge, yet the time spent on activities to "know" continues to rise with the advancement of scientific technology and segmentalization of studies, resulting in a one-sided advancement in accumulation of formal knowledge. In other words, the transfer of formal knowledge induces further transfer of formal knowledge and more formal knowledge is transferred.

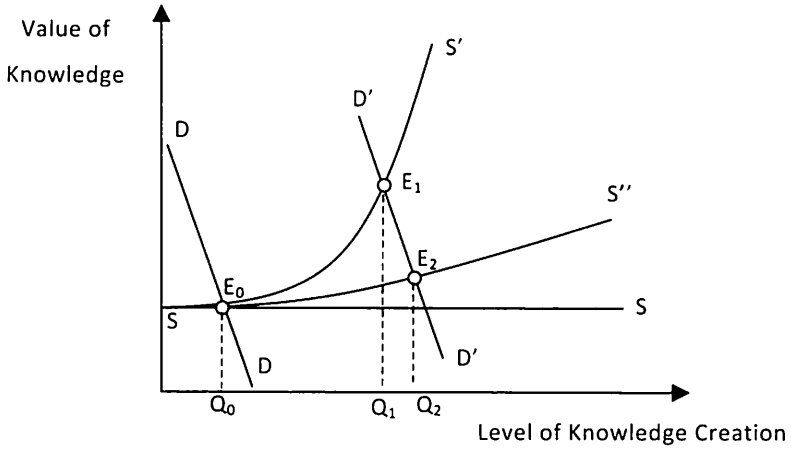

Figure 5. Demand and Supply Curve of Knowledge Creation

As a result, the proximity increases ; heterogeneity, which is a source of knowledge creation, is reduced, making it harder to create knowledge (SS → SS' ; $E_0 \rightarrow E_1$)[2].

There is also an inevitable aspect that the advancement of technology leads to the loss of opportunities to obtain tacit knowledge itself. Norman Borlaug, who is also called "the father of the Green Revolution", said during discussions with the world's wheat experts in Nairobi, Kenya in September 2005 to prevent the infestation of highly-virulent black wheat rust (ug99) which emerged in Africa in 1999, "Nobody's seen an epidemic for 50 years, nobody in this room except myself," and "Maybe we got too complacent (Lacey [6], 2005 ; Hesser [3], 2009)." With the issue of black rust in wheat solved, tacit knowledge is lost as its threat is forgotten due to the absence of the problem.

5. Conclusion

Based on the above examinations, the industrial life cycle is generally considered to be long for agriculture, though the recent view holds that there are many sectors where the life cycle is short. In terms of international cooperation it is considered that the gap in the life cycle among stakeholders is relatively large, knowledge heterogeneity is high, and the network proximity is low in many cases. Therefore, the significance of international agricultural cooperation lies in the creation of new knowledge by each researcher and institution through cooperation, and the significance of that cooperation becomes evident when agricultural issues are solved through innovation as a result of knowledge creation. Furthermore, if international cooperation in agriculture aspires to attain the situation where relevant entities such as universities and research institutions cooperate and compete globally, then an innovation induction principle in global "industrial clusters" which bear a similar relationship, or the knowledge creation framework based on the principle of international cooperation supremacy, will be effective. Moreover, industry-academia-government collaboration will expand to industry-academia-government-public collaboration where the public (residents) and NGOs also join in, and the question would be the matter of how "knowledge" should be created within the framework. Hence this paper would like to look at the direction of research in international agricultural cooperation as an issue of

[2] To foster the activity of knowledge creation, increase of heterogeneity (diversity) and cooperation among stakeholders are necessary (SS' → SS'' ; $E_1 \rightarrow E_2$).

"knowledge governance" in addition to knowledge supply in knowledge creation.

From a macroscopic perspective, the three pillars of principle, strategy, and method are the most important in international cooperation in agriculture. Unless all three aspects are addressed, network cost alone may accumulate, and it is impossible to interact with all stakeholders equally, hence strategy is needed. This is one of the purposes in establishing international agricultural cooperation as an area of academic study. Three questions should be asked going forward: first, what does international cooperation at the national, regional, organizational, and individual levels entail; second, how should international cooperation be embraced in national principle, regional culture, and individual belief and lifestyle; and third, what significance should international cooperation have in relation to corporate management policy[3].

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References

[1] Dons, J.J.M., (Hans) "Intellectual Property Rights Systems and Innovation in the Plant Breeding Industry," *EuroChoices*, Vol. 12, No. 1, 2013, pp. 36-41.

[2] Fujita, M., "Towards the New Economic Geography in the Brain Power Society," *Regional Science and Urban Economics*, Vol. 37, 2007, pp. 482-490.

[3] Hesser, L., *The Man Who Fed The World*, Durban House Press, 2009.

[4] Jacobs, J., *The Economies of Cities*, NY: Vintage, 1969.

[5] Kiminami, L., *International Food System*, Agriculture and Forestry Statistics Publishing, 2009 (in Japanese).

[6] Lacey, M., "New Strain of Wheat Rust Appears in Africa," *New York Times*, September 9 2005.

[7] Nonaka, I. and Takeuchi, H., *The Knowledge-Creating Company: How Japanese Companies Create the Dynamics of Innovations*, Oxford University Press, 1995.

[8] Page, S.E., *The Difference: How the Power of the Diversity Creates Better Groups, Firms, Schools, and Societies*, Princeton University Press, 2007.

[9] Pardey, P.G., Alston, J.M. and Ruttan, V.W., "The Economics of Innovation and Technical Change in Agriculture," *Handbook of Economics of Innovation*, Vol. 2, 2010, pp. 939-984.

[10] Sakiura, S., *Economic Analysis of Rice Breeding Research (Ine Hinshu Kairyo No Keizai Bunseki)*, Tokyo: Yokendo Publishing, 1984, pp. 1-30 (in Japanese).

[11] Shultz, T.W., *Transforming Traditional Agriculture*, Yale University Press, 1964.

[12] Vernon, R., "International Investment Trade in the Product Cycle," *Quarterly Journal of Economics*, Vol. 80, No. 2, 1966, pp. 190-207.

[13] World Bank, *Enhancing Agricultural Innovation: How to Go beyond the Strengthening of Research Systems*, World Bank, 2006.

[3] Socially responsible enterprises that produced results through international cooperation should be recognized not only for successfully shifting their management policy and producing socioeconomic benefits, but also for achieving innovation through creation of new knowledge that reconciles sound corporate management with international cooperation.