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# Individual-city-centered networks for cities' self-sustainability : Lesson from the Great East Japan Earthquake

Masateru HINO\*

**Abstract** Supply shortages following the Great East Japan Earthquake on March 11, 2011 posed a serious problem. Two weeks after the disaster, there were still long lines of customers in front of supermarkets even in Sendai City, the regional central city in the Tohoku region, and severe gasoline shortages caused cars to queue up outside gasoline stations. This situation resulted from damages to transportation routes and logistic facilities, particularly those located along the coast and expressways on the Pacific side of the region. Business activities in the Tohoku region have developed hierarchical networks with Tokyo at the apex, while horizontal east-west relationships between the Pacific side and the Sea of Japan side of Tohoku Region are traditionally weak. This is a fundamental issue that has perpetuated the lack of initiation of complementary relationships between two areas. In conclusion, the individual-city-centered network based on activities of various actors inside and outside in city could be proposed for supporting sustainable civic lives under an environmental change.

**Key words** : individual-city-centered network, intercity linkage, self-sustainability, the Great East Japan Earthquake, Sendai

## 1. Introduction

When a catastrophe such as a natural disaster strikes a country, structural problems that had gone unnoticed under normal circumstances appear. The tremendous earthquake that hit East Japan's Pacific Coast Area on March 11, 2011 illustrated various types of structural problems.

The shortages of the necessities for daily life that occurred after the Great East Japan Earthquake were very severe, especially in the coastal area of Tohoku Region, the north-eastern Japan. As late as two weeks after the earthquake, long lines of customers formed every day at supermarkets, even in Sendai City, the capital city in the Tohoku region (Figure 1). A severe gasoline shortage was another difficulty caused mainly by serious damage to oil facilities at the Sendai seaport. The north-south routes linking Sendai to Tokyo were also damaged, and the Tohoku Express Highway was designated as a reserved road for emergency vehicles, a move that sharply curtailed the transportation of commodities by commercial vehicles.

In addition to the delays and scarcity related to commodities after the earthquake, the lack

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Figure 1 A long row of consumers in front of supermarket on March 21, 2011, ten days after the earthquake

of viable transportation for people was a grave problem. The Tohoku bullet train line was seriously damaged and remained out of operation until two months after the earthquake, but even without train transportation, many people moved to Tokyo and western Japan during that period. The Sea of Japan side in Tohoku Region did not suffer serious damage from the earthquake, and thus the east-west national highways connecting the region's Pacific side to the Sea of Japan side were usable, allowing many people to move by long-distance buses from Sendai to Niigata and Yamagata on the Sea of Japan side. People were then able to get to Tokyo and western Japan by way of Niigata which was connected to Tokyo by the Jyoetsu bullet train line. In light of these facts, it can be said that the transportation of commodities to the Pacific side of Tohoku Region was physically possible by using west-east routes. However, this possibility was not realized.

The main reason for this lapse in post-disaster transportation of commodities is thought to have been the underdevelopment of the trading relationship between the east and west sides of Tohoku Region (including Niigata Prefecture) that normally make the mass distribution of commodities possible. The existence of trading relationship is a prerequisite for the distribution of commodities, whether under normal circumstances or after a natural or man-made disaster. The flow of commodities is markedly different from a sudden flow of people as described above. However, the establishment of a trading relationship requires the trust between entrepreneurs, and it is not likely that a trading relationship will be formed by only a telephone call or two after a disaster. If trade relationships were not formed during normal circumstances, it

may well be quite difficult to get commodities delivered to a disaster area, even by insistent requests.

Here the underdevelopment of trading relationships between the east and west sides of Tohoku Region is examined, through an analysis of the intercity linkages of the major cities in the region. The lessons learned from the post-earthquake shortages of commodities are discussed, as is the clear necessity of building up individual-city-centered networks for improving both the security and sustainability of cities.

In addition, although the term sustainability is generally understood on the concept of sustainable development clearly defined by the World Commission on Environment and Development (1987), the self-sustainability mentioned in the title means the state that the society can be maintained under an environmental change including the disaster.

## 2. Overview of Tohoku Region

The Tohoku region occupies the north-eastern part of the main island of Japan, i.e., Honshu. The region consists of six prefectures : Aomori, Iwate, Akita, Miyagi, Yamagata, and Fukushima. In some regional development plans, Niigata Prefecture is included in this region<sup>1</sup>. The Tohoku region is geographically divided into "Pacific side" and "the Sea of Japan side" by the Ohu mountain range, a backbone mountain range. Arterial traffic routes run south and north in the region. The east-west routes running across the mountain range are largely inferior to the north-south routes in terms of their transportation capacity.

Sendai is the capital city of the Tohoku region with a population of approximately one million (Figure 2). The region's prefectural capital cities are Aomori, Morioka, Akita, Yamagata and Koriyama<sup>2</sup>, and the region's large industrial cities include Iwaki and Hachinohe ; these cities' populations range from roughly 200,000 to 300,000 people. Thus, there is a large disparity between population of Sendai and those of the other cities in the region. Figure 2 also shows a northern part of Niigata Prefecture. Niigata City is the prefectural capital and the largest city on the Sea of Japan side. Its population was approx. 812,000 people in 2010, making it the next-largest city in the Tohoku area after Sendai. Niigata City was designated as a designated city in 2007.

Figure 3 shows the network of long-distance bus lines between the major cities in Tohoku Region with the thickness of each line representing the number of buses operating on a regular basis. The bus lines operating between Sendai and other major cities comprise the largest segment of the bus network. The other prefectural cities are also connected by smaller bus lines. The long-distance bus network shows clearly that the urban system of the Tohoku region is characterized by a structure in which Sendai is the central hub.

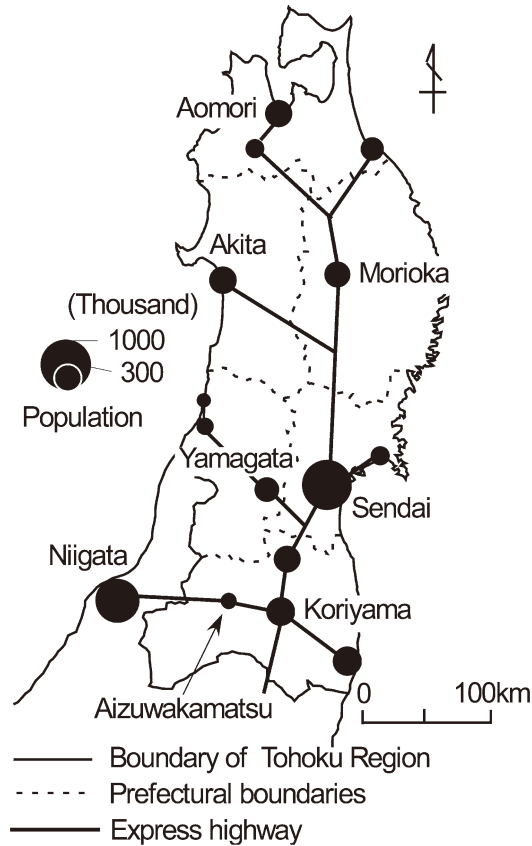


Figure 2 Major cities in Tohoku Region

### 3. Examination of Intercity Linkages

As noted above, the distribution of commodities requires an established trading relationship. Regarding the supply shortage after the March 2011 earthquake, the general manager of a large corporation that operates chain of convenience stores said the following in newspaper interview :

“Six logistic bases were located in the Tohoku region. All of them were situated along the No. 4 National Highway and the Tohoku Express Highway running from south to north in the region. Most of these bases were damaged in the earthquake. Our company had not established a supply route connecting the stores on the Pacific side of the region and the food production sites on the Sea of Japan side. This is one of the reasons why our company could not deliver daily life necessities just after the earthquake.” (Asahi Shinbun, March 29, 2011)

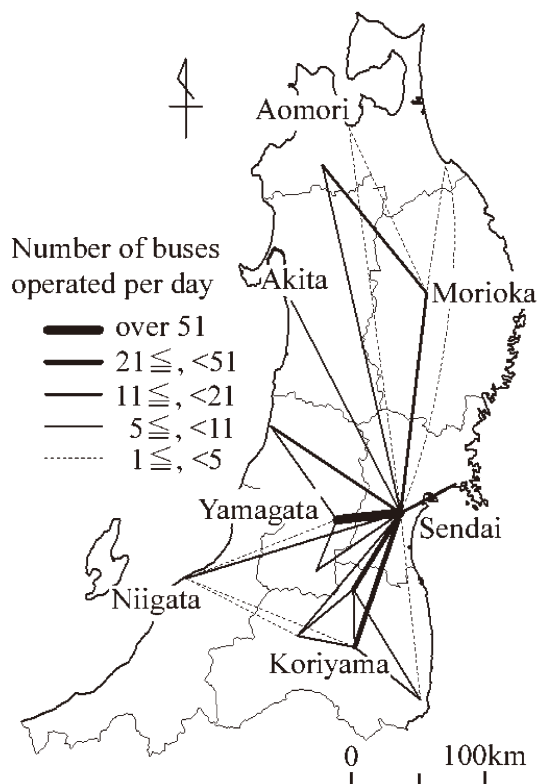


Figure 3 Spatial patterns of connections between major cities by express bus operations in Tohoku Region  
 Source : Kotsushinbunsha (2011) : Kosoku Basu Jikokuhyo (Express Bus Time Table), Vol. 42

According to the results of a survey on the business operations of super-markets in Aizuwakamatsu City being located in the inland area of Tohoku Region (Saito *et al.*, 2012), the supermarket were able to continue business operation for several days after the earthquake because they had incurred only minor damage. However, it became impossible for these supermarkets to re-stock their supplies because they had received their stock chiefly from Koriyama and Sendai on the other side of Ohu mountain range, and they were obliged to greatly shorten their hours of operation. At that time, several of Aizuwakamatsu supermarkets tried to develop new suppliers, but the management of only one supermarket looked for a new supplier in Niigata Prefecture—although Niigata Prefecture is near Aizuwakamatsu.

#### 4. Characteristics of Urban Linkages of Main Cities in Tohoku Region

Next, the spatial pattern of intercity relationships in the Tohoku region was examined in

light of the locations of branch offices of multi-location companies. For example, when many companies that are headquartered in City A operate branch offices in City B, the relationship between City A and B is considered strong. Data on the number of employees in branch establishments by industry and by location of the head office are available only for prefectural capitals and other cities with populations over 300,000 from the Japanese Establishment Census. With these data, it is possible to estimate the number of employees in branch offices for major cities in the Tohoku region. Only the branch establishments belonging to the following industries were treated as branch offices : wholesaling, construction, finance and insurance, real estate, transportation and communication, and producer services. Over 60% of the branch establishments in these industries are in the form of offices (Hino, 1996).

Figure 4 shows the main intercity linkages based on the location of branch offices. The base of each arrow shows the location of company's headquarters, and the arrow's tip indicates the location of branch office. The thickness corresponds to the number of employees in the branch offices. In Figure 4, only intercity linkages in which the number of employees in

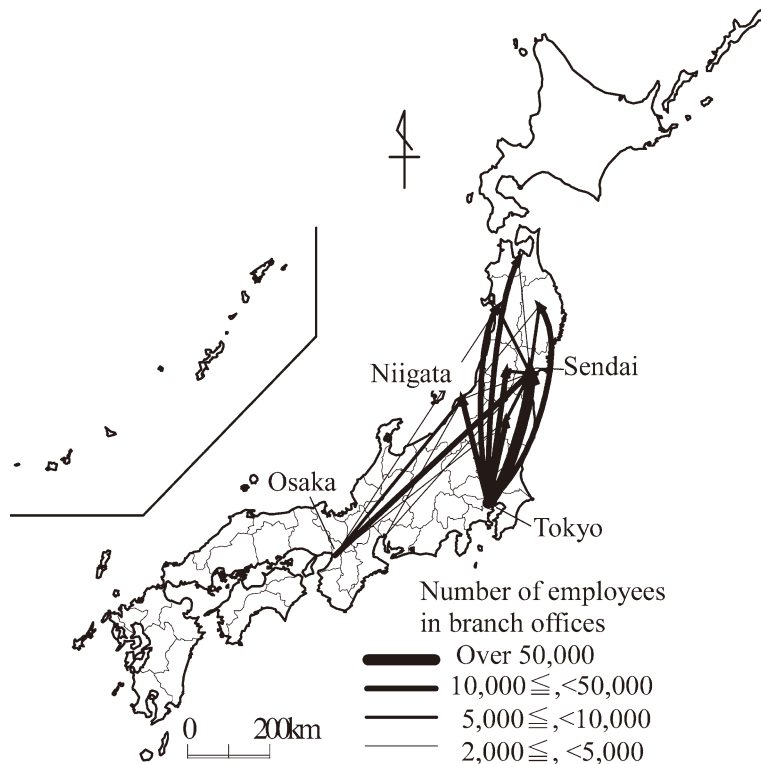


Figure 4 Spatial pattern of main intercity linkages based on strength of connection between headquarters and branch offices in 2006

Source : The Japanese Establishment Census in 2006

branch offices was over 2,000 are drawn.

In all of the major cities at the ends of arrows drawn in Figure 4, it was confirmed that 5,000 employees or more worked at branch offices of Tokyo headquartered companies. In Sendai, the number of employees of Tokyo companies' branch offices was approximately 116,000 persons. In Niigata, approximate 43,000 employees worked at branch offices of Tokyo-based companies. Even in Koriyama, Morioka and Akita, over 10,000 employees were confirmed to be working at branch offices of Tokyo-based companies. These figures indicate that the major cities in Tohoku Region are strongly connected to Tokyo. Additionally, Sendai had 11,000 employees in branch offices of companies headquartered in Osaka, the capital city of Kansai Region (the western Japan) with the second highest centrality after Tokyo. This finding indicates that there is some agglomeration of headquarters of large companies in Osaka.

Figure 5 shows the intercity linkages of major cities in Tohoku Region alone based on the location of branch offices of local companies. According to this figure, a large portion of these linkages are those formed by the location of branch offices of Sendai headquartered companies. The spatial pattern was similar to the network of long-distance buses among major cities described above (Figure 3). However, the number of employees in branch offices of Sendai

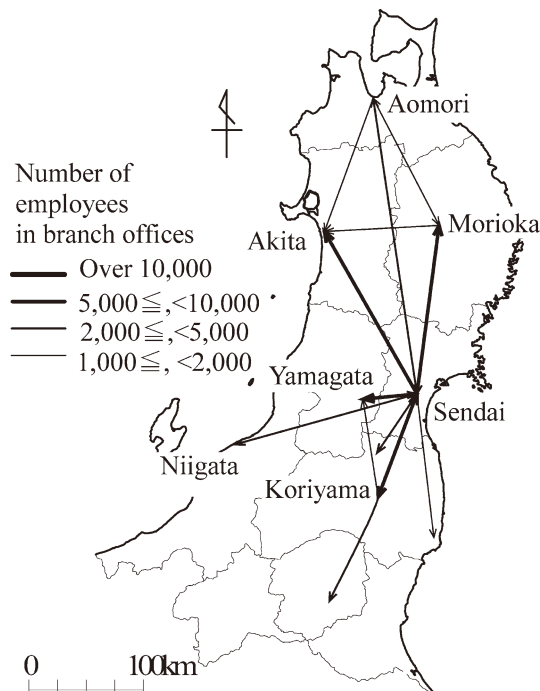


Figure 5 Spatial patterns of main intercity linkages based on strength of connection between headquarters and branch offices of local companies

Source : The Japanese Establishment Census in 2006



companies was remarkably small compared to that of employees in branch offices of Tokyo companies ; it did not reach 5,000 employees. Therefore, the mutual relationship between major cities based on the location of branch offices of local companies can be said to be weak in the Tohoku region.

Figure 6 illustrates the hierarchical aspect of branch offices, based on previous studies (Hino, 1996). The height of the bar at each city in the figure corresponds to the number of branch offices located in that city. The arrows of various thicknesses indicate the number of branches in a hierarchical relation. For example, a large portion of the branch offices located in Sendai was directly supervised by headquarters located in Tokyo chiefly, whereas many of the branch offices located in other major cities were under the jurisdiction of Sendai branch offices. That is, the jurisdictional area of Sendai offices generally covers the entire Tohoku region, whereas the jurisdictional area of other major cities was mainly limited to within the prefecture where the cities are located.

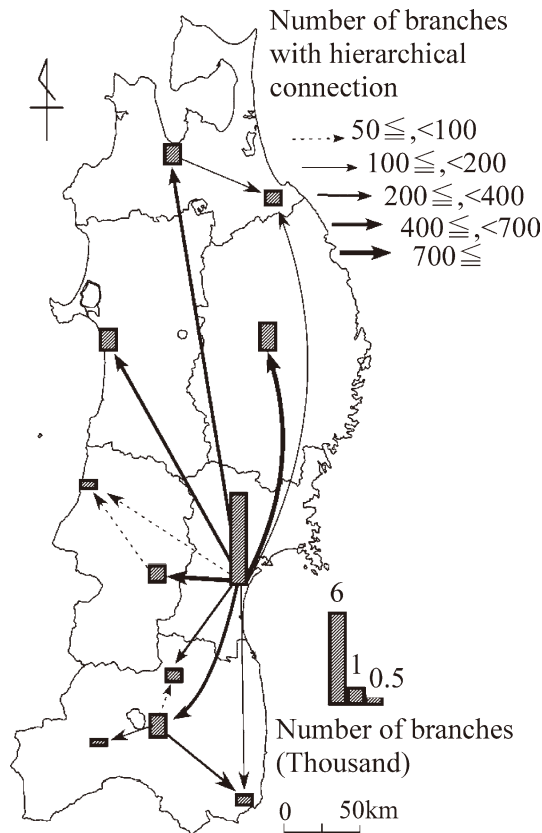


Figure 6 Spatial patterns of hierarchical connection of branch offices in the Tohoku region  
Source : M. Hino (1996)

Based on the above findings, since the distribution channels of nation-wide companies with offices in Tohoku were organized by Sendai-centered linkages supported by the main Tokyo-Sendai and Osaka-Sendai connections, the flow of commodities could be expected to be significantly disturbed if Sendai was to be damaged in a natural disaster. Moreover, the trend of nation-wide companies' branch office placement in each city changed from an increase to a decrease starting in the 1990s (Hino, 2009). This reversal was due to structural changes of Japanese society which included long-term economic stagnation, an increase in the overseas investments of large companies with a reduction of domestic investment, the development of information technology, the aging of Japanese population and the country's low fertility rate. These structural changes had already prompted calls for other types of intercity linkages (such as horizontal linkages) to maintain the vitality of cities, before the 2011 earthquake.

## 5. Intercity Linkages and the Actors Forming Them

### 5.1 Types of Intercity Linkages Needed

Figure 7 shows four types of potential intercity linkages for a regional city such as Sendai

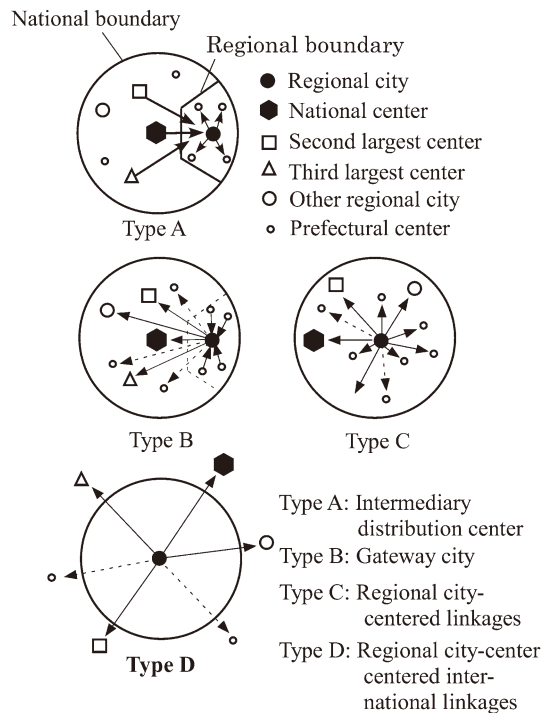


Figure 7 Types of intercity linkages in a regional city  
Source : Hino(2009)

(Hino, 2009). A prefectural center could substitute for a regional city if the spatial framework is changed from national to regional. Type A presents the intercity linkages which a regional city forms as an intermediary distribution center. An example of a Type A intercity linkage is the hierarchical Sendai-centered networks formed based on the location of branch offices by nation-wide companies, as described above. Such networks tend to strengthen the regionalization of urban networks in addition to hierarchical city linkages. However, it has been recognized that this type of intercity linkages has stopped growing in Japan, due to the decreases in the agglomeration of large companies' branch offices in regional cities.

Type B shows the pattern in which a regional city plays the role of a gateway for other cities within the region. For example, when local companies establish their branch offices in the regional city in order to extend their selling activities to the whole country, this type of linkage is formed. In the Tohoku region, this type of intercity linkage is underdeveloped, as described in the previous section.

Type C is significantly different from Types A and B. In Type C, a regional city occupies the center of intercity linkages; that is, the type is comprised of regional city-centered linkages. In Sendai, nation-wide companies are present, although they are few in number. These nation-wide companies form this type of linkage. In addition, the Miyagi Prefectural Union of Consumers Cooperative headquartered in Sendai is a member of the Japanese Union of Consumers Cooperative, and thus, after the earthquake, the latter delivered necessities and dispatched a good deal of support to the former. With this support, the Miyagi Prefectural Consumers Cooperative was able to sell commodities to many citizens immediately after the earthquake. Such a linkage is classified as Type C.

In addition, civic groups that exchange information with other cities through cultural activities and sports are not small in number in Japan. For example, a jazz festival is held in September every year in Sendai, operated by citizen volunteers' organization. In recent times, some 700,000 people have attended the festival each year, and many musicians participate. The audience members and musicians are often residents of other regions. This activity is categorized as a Type C intercity linkage.

Type D is an expansion of Type C linkage to an international scale. Sister cities' relationships are typical of this type of intercity linkage. Sendai has nine sister cities across the world. In addition, Tohoku University has academic exchange agreements with 138 universities in foreign countries. In fact, many types of organizations have relationships with foreign partners; e.g., the Korean Consulate in Sendai, forming a relationship between Sendai and some Korean cities.

It can be said that if Tohoku Region attempts to strengthen the east-west connections within the region, Sendai should develop Type B, C, and D intercity linkages. At the same time, it is necessary to do so to maintain the vitality of cities in the region, in light of the reduction of Type A intercity linkage.

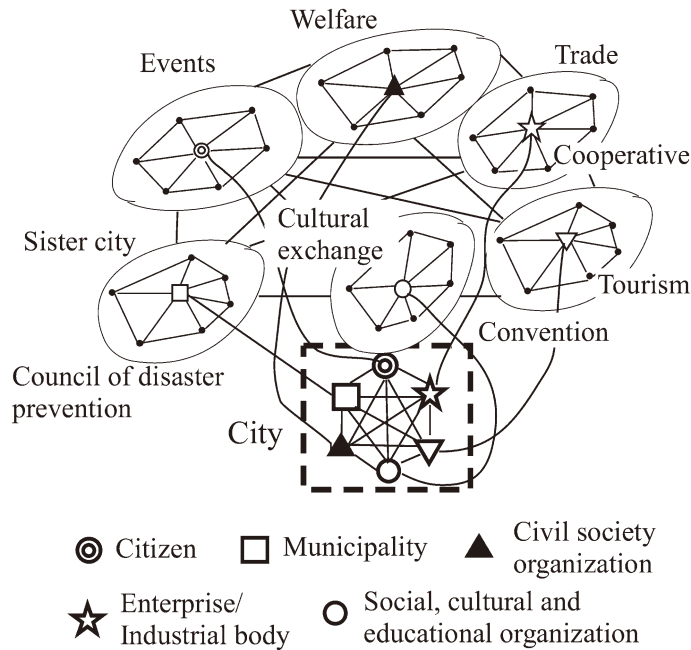


Figure 8 Image of actor-centered networks

## 5.2 Actors forming Type B, C and D Intercity Linkages

Figure 8 illustrates the networks formed by various actors in a city. Six types of actors are identified : 1) citizens, 2) municipal and other administrative organization, 3) civil society organizations, 4) company and trade associations, 5) social, cultural and educational organizations, and 6) visitors and tourists. All of these actors form interrelationships in a city, and the intercity linkage formed by one type of actor affects other types of actors through an inter-relationship.

Each individual actor makes intercity linkages through his/her activities. For example, both sister-city relationships and university academic exchanges have the potential to improve economic exchanges between cities. In addition, it is possible for citizens' various exchange activities to lead to agreements regarding disaster prevention and relief between cities. Visitors also have the potential to make various intercity linkages. After the 2011 earthquake, many visitor-volunteers and NGOs helped cities' post-disaster relief and recover efforts, and many are planning to continue their efforts to support the damaged cities for some time to come. Apparently many these volunteers have felt a sense of kinship with the damaged cities based on their relationships with local people built via various types of organizations.

## 6. Conclusion

Pred (1990) examined intercity linkages in order to explain the spatial variations of urban growth. He hypothesized that innovations to promote urban growth must diffuse through intercity linkages. Certainly, intercity linkages are channels for transmission of information and knowledge. At the same time, they play the role of improving the security of cities as mentioned above. When a great disaster occurs, relief and recovery support is given by both individuals and various organizations based on social capital. This support is brought through existing intercity linkages.

Therefore, it is necessary to recognize the actors forming intercity linkages and to know the activities by which they form such linkages. With this point in mind, it is necessary to promote intercity linkages by arranging the physical and socio-economic environments that meet these actors' needs. In the context of the Tohoku region, the east-west linkages between cities can be strengthened through such endeavors, although this may take years to accomplish adequately.

### Notes

- 1) For example, the Regional Plan of Tohoku Region authorized in 2009 on National Land Formation Plan Law.
- 2) In Fukushima Prefecture, Fukushima City is the political and administrative capital. However, Koriyama is superior to Fukushima in terms of economic centrality and population. So, Koriyama was evaluated as the central city of the prefecture here.

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