Enhancing Self-organizing Capabilities of the City for Disaster Prevention - Continuous creation of knowledge for disaster prevention and parallel distributed decision making in emergency -

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A self-organizing or "holographic" system is characterized by 1) "whole in the parts" structure, 2) internal "redundancy," 3) "requisite variety," 4) "minimum critical specification," and 5) "learning-to-learn" capability. It has excellent capability of continuous learning and knowledge creation as well as information processing, and is also called as "auto-poietic," or "self-reproducing" system. A region's capability to prepare for disasters can be enhanced by building this self-organizing capability into its socioeconomic system as it enables continuous learning and creation of knowledge for disaster prevention in ordinary times and efficient parallel distributed information processing and decision making in emergencies. A self-organizing model for regional disaster prevention associated with major basic policies will be constructed and presented. In the model, importance of "tacit" knowledge on a region that are embedded in and continuously reproduced through day-to-day routine activities of various regional agents will be stressed. Some lessons from the case of Hanshin-Awaji Great Earthquake that hit Kobe in 1995 will be carefully examined from this perspective, and limitations of traditional measures for disaster prevention will be explored. It will also reexamine traditional roles of public agencies, individual citizens, and business firms in the field of disaster prevention, and the need to form new "knowledge-based partnership" among these agents for disaster prevention will be proposed.

1. Introduction

Rapid aging of society now requires Japanese cities to enhance the disaster preventive functions greatly so as to maintain security and safety of citizen's life under the condition of decreasing "physical power" of youth that is the largest social resource for disaster prevention. This paper explores the possibility of and practical measures for enhancing disaster preventive functions of cities by building the "self-organizing" capability into its socioeconomic system. A self-organizing or "holographic" system is characterized by 1)"whole in the parts" structure, 2) internal redundancy, 3) requisite variety of the subsystems, 4) minimum critical specification of subsystems, and 5)"learning-to-learn" capability (Morgan, 1997). The five characteristics are at the same time "enabling" or "facilitating" conditions necessary to create and sustain the self-organizing system. Recent studies in social sciences call the self-organizing system as "auto-poietic" or "self-reproducing" system since it has excellent capabilities of continuous learning and "knowledge creation" (Nonaka & Takeuchi, 1995) as well as information processing and decision making, which are indispensable for any system to adapt to rapidly changing environment.

According to this theoretical framework, an urban socioeconomic system that has high self-organizing capability is considered to be highly proof to various disasters such as great fires, floods, and earthquakes for majorly two reasons. First, in ordinary times the system can continuously learn and even create new knowledge for disaster prevention that is well adjusted to the system's unique characteristics. Second, in emergencies the system can efficiently process information so that appropriate decisions are made swiftly in a parallel distributed manner. In order for a city to reinforce

the self-organizing capability of its socioeconomic system, it should carefully reexamine the existing disaster prevention policies and measures to check if the five “enabling” conditions for self-organizing are appropriately realized in its socioeconomic system.

In the following sections, we will first analyze some valuable experiences in Hanshin-Awaji Great Earthquake that hit Kobe in 1995 from this perspective, and develop a self-organizing model for disaster prevention associated with major practical measures that will contribute to realize the “enabling” conditions.

2. Lessons from Hanshin-Awaji Great Earthquake

Let us begin with a brief explanation of five “enabling” conditions for self-organizing.

1) The principle of "whole in the parts" or “Chinese-box” structure means every part of a self-organizing system needs to have all the knowledge that entire system has. In other words, all the knowledge that a self-organizing system has should be completely shared by all of its parts.

2) The principle of internal “redundancy” means every function that a self-organizing system needs to operate must be shared by multiple parts of it. In other words, every part of a self-organizing system should be designed to have some extra functions that are not necessary to perform the immediate task of each part.

3) The principle of “requisite variety” means the variety of internal elements of a self-organizing system needs to just match to the variety of elements of external environment. In other words, a self-organizing system needs to have various internal elements that are just required by the external environment.

4) The principle of “minimum critical specification” means behaviors of each part of a self-organizing system should not be specified more than just absolutely necessary. In other words, in order to make a system self-organize, it should delegate enough authority and power to subsystems to allow them to behave as autonomous as possible except minimum critical points.

5) The principle of “learning-to-learn” capability means a self-organizing system needs to be able to question and correct, if necessary, the basic assumptions on which the system is designed to operate.

With the five conditions above in mind, let us turn to the re-examination of the experiences of Hanshin-Awaji Great Earthquake.

2.1 Insufficient Knowledge Sharing among Local Agents

2.1.1 Underutilized Residents’ Resources

For over half a century since the end of World War II, most Japanese cities have been lucky enough to be exempt from large-scale disasters. Majority of Japanese citizens under their 50s have little hands-on knowledge on fire-fighting, immediate rescue, and first aid, which citizens in other countries may learn in public services. While considerable investments have been made to reinforce firehouses and hospitals, such outsourcing has made citizens very weak and passive to disasters; they have lost initiatives and hands-on knowledge to fight against disasters by themselves. The critical knowledge on fighting against disasters has come to be monopolized by special public agencies.

Just after the occurrence of Hanshin-Awaji Great Earthquake, numerous small fires broke out in the devastated area. There were very few districts where residents collaborated together to extinguish them at the initial stages. Mano district in Nagata-ku, Kobe was one of such exceptions where residents desperately tuckled to the fires by “bucket relay,” which was common practice among Japanese during the World War II. In most other districts, however, majority of residents was simply stunned, staring at fires only waiting for somebody to appear to rescue them as usual. Similar cases were reported in the fields of immediate rescue of the injured from rubble and medical first aid to them.

Rapid urbanization in Japan and changing lifestyles of Japanese have weakened traditional local communities and made residents difficult to share knowledge on the districts they live in and on communal life, which are critical to smooth recovery from the disaster. Just after the occurrence of

Hanshin-Awaji Great Earthquake, many residents at newly-developed districts fell into extreme anxiety that prohibit them to engage in fire-fighting, immediate rescue, and first aid. In the recovery process, many unexpected conflicts among residents made the operation of the refuge places all the more difficult. At some refuge places in their initial phases, conflicts among residents around the distribution methods of relief goods were so heated that relief foods became bad and were thrown away.

2.1.2 Underutilized Corporate Resources

Under typical disaster prevention schemes held by most Japanese cities, local firms are, in the first place, regarded and treated as "victims" of the disaster to be rescued. After the disaster, under these schemes and principles of "self-help," they are supposed to concentrate on restoring their facilities and equipment, and on resuming business activities as soon as possible. However, in the recovery process from Hanshin-Awaji Great Earthquake, it became clear that direct physical damage to the local firms differed greatly firm by firm. There were many firms that were slightly damaged or intact even located at the center of the afflicted district. It became also clear that for most local firms it took longer than expected to resume business activities completely as usual. This was because even though they finish restoration of their own facilities and equipment, they had to wait for a) recovery of utilities and transportation, b) recovery of business partners such as suppliers and vendors, c) recovery of employees' home life.

In ordinary times, business firms never employ all their resources to the full extent. There always are various lowly-utilized corporate resources ranging from recreational facilities such as gymnasiums to vacant land spaces that are often generated as a result of business restructuring. Even though these lowly-utilized resources will be partly used for the firm's own recovery from disasters, they will not be used up. Further, as explained above, most firms located at the afflicted districts need to wait for recoveries of utilities, transportation, business partners, and employees' home life to resume full operation.

During the period of recovery from Hanshin-Awaji Great Earthquake, some local firms wisely recognized the above situation, and voluntarily let the city government or local residents use corporate resources that have low priority for their own recovery. They realized that such voluntary actions would facilitate recovery of the city that, in turn, will shorten the idle time for them. Mitsuboshi Belt Corporation in Kobe, for example, opened the company gymnasium to the local residents as a temporary refuge place. However, these were rather exceptional cases. In most other districts, majorly because the city government and residents knew very little about the corporate resources of the local firms, they were seldom utilized for the public use. Based on this lessons, some Japanese cities have started building database on the corporate resources of local firms to make proper agreements with them so that in emergencies city governments or local residents can appropriately use their lower-prioritized resources for the benefits of public.

2.2 Limitations of Over-Specification

It has been widely reported and criticized that just after the Hanshin-Awaji Great Earthquake prefectural and city governments were very slow in making decisions and taking actions. It took, for example, hours for Hyogo prefectural government to make a critical decision to request local base of the Self-Defense Force to dispatch rescue troops. This was due to the strict legal procedural request that the rescue request to the Self-Defense Force must be done by the governor himself at the office. While the governor's arrival to the office was delayed due to the traffic jam, because no action plan for the absence of governor was stipulated, the prefectural government had to waste invaluable time for immediate actions.

Poor coordination and communication among different ministries and among national, prefectural and city governments also delayed governmental decisions and actions. In Japan, fire-fighting activities are under the control of the Ministry of Home Affairs and Fire Defense Agency. Disaster relief

activities are controlled the Ministry of Welfare. Urgent actions against disasters are under the authority of National Land Agency and the prefectural government. Restoration of lifelines and making and enforcement of rehabilitation plans are under the jurisdiction of the city government. It is often the case that while National Land Agency and the prefectural government know little about the actual condition of the area, the city government and ward offices, which knows the area very well, lacks sufficient fund and legal authority to enforce meaningful decisions and actions for the smooth recovery.

2.3 The lack of redundancy in communication channels, lifelines and transportation systems

For a considerable period after Hanshin-Awaji Great Earthquake, use of telephones in the afflicted area was extremely constrained. This was due to a) physical destruction of lines, 2) extreme traffic flow (50 times of usual) through limited lines, and 3) continuous use of limited lines by some firms. Back-up systems to support the damaged lines were insufficient. Most lifelines (electricity, water supply, and gas) stopped immediately after the earthquake and their restorations took longer than expected since each of them was designed and constructed as a single system. Restoration of water supply system in Kobe took especially long because the only system drawing of water supply system was lost in the destruction of the city's water service department office. Delayed restoration of roads and railway systems, which were also designed and constructed as a single system, caused intense traffic congestion that again slowed down the speed of recovery.

3. Self-Organizing Processes in Action

Despite the insufficient structural support as described above, self-organizing process took place at some districts in the afflicted area of Hanshin-Awaji Great Earthquake. Let us examine the cases of Mano district in Nagata-ku, Kobe and the Bank of Japan Kobe Branch.

3.1 Self-Organizing Process in Mano District

Mano district at Nagata-ku, Kobe has been repeatedly reported as an excellent case of "self-help" activities by residents. In contrast to some other districts in Nagata-ku that were completely devastated by great fire, Mano residents miraculously extinguished all the fire by "bucket relay" and other means before fire engines came. Majority of residents knew very well the locations of fire hydrants, emergency boxes, buckets, hoses, water pumps, and other tools for fire fighting.

After the period of emergency, the ward office of Nagata-ku was designated as the distribution center of relief foods and goods. The ward office soon turned to be the place of confusion and uproars that was especially dangerous for elderly people. Mano residents have decided to receive the relief foods and goods collectively from the ward office so as to secure their perfect distribution to all residents.

These successful self-organizing activities in Mano district can be attributed to the fact that most Mano residents knew very well about their neighbors and neighborhood. The shared knowledge on the district enabled them to realize rapidly what they could and should do for the community, and enabled effective collaborations in the emergency. Knowledge sharing among residents in Mano is considered to be one of the results of famous community activities in Mano that have been very active since the anti-pollution movement in 1970s. In the process of these activities, Mano residents have accumulated a common knowledge base on the community and have developed the methods and methodologies for the collective action.

3.2 Self-Organizing Process in the Bank of Japan Kobe Branch

While we have found at Mano a successful self-organizing in the residential area, we can see at the city center of Kobe another successful self-organizing in the business and commercial area. It has been widely praised that effective urgent actions by the Bank of Japan (BOJ) Kobe Branch saved the afflicted area from regional financial crisis that most economists worried to happen after the disaster. After Hanshin-Awaji Great Earthquake, BOJ Kobe Branch continued its operation, even in the very

day of the disaster, without any closing day. This was possible because most employees lived in company-owned houses located very near to the office, physical damage to the building and facilities were small, and a special telephone hotline remained intact.

On the day of the earthquake, BOJ Kobe Branch first quickly issued the temporary notification of emergency financing to all the financial institution in its jurisdiction. Since the power supply stopped, these notifications were all hand-written. To obtain authorization of the notification, they directly communicated with the Ministry of Finance (MOF) in Tokyo using the hotline because they could not reach to the Kinki financial affairs office that has jurisdiction over them due to telephone congestion. In order to meet the cash demand of the residents and firms in the afflicted area, BOJ Kobe Branch then invited major retail banks in its jurisdiction to setup temporary paying tellers at BOJ Kobe Branch office. They supported banks to resume bill dealings also at BOJ Kobe Branch office in one week under strict guard by police.

These quick and effective decisions and actions by BOJ Kobe Branch can be seen as another good example of self-organizing in emergency. Redundant telephone lines and delegation of appropriate authority to the Branch by MOF supported the self-organizing process to occur. As a branch of national bank, BOJ Kobe Branch has redundant resources that are just necessary and enough for private banks to setup temporary tellers and bill-dealing office at the Branch. All branch staff possessed sufficient knowledge and expertise on operations of private banks and could supported their operations very well. The Branch Manager Endo also recollected that in making decisions in emergency he could learn a lot from the records of urgent financial measures by MOF at the time of a past great earthquake that hit north-east Japan in 1994.

4. Creating a Knowledge-Creating City for Disaster Prevention

Examples of basic policies to realize the five “enabling” conditions for self-organizing at a city level are summarized in Table 1. If these measures are sufficiently taken in respective time period, crisis management in times of emergency will be far easier since all agents in the city’s socioeconomic system, i.e. residents, local firms, and public agencies, will spontaneously collaborate together to fight against extreme uncertainty.

Enhancing self-organizing capability of a city enables continuous creation of various new knowledge in the process of dense interactions by local agents for disaster prevention. Japanese management scholars Nonaka & Takeuchi (1995) distinguish two types of knowledge; “tacit” knowledge that cannot be tell easily and “explicit” knowledge that is already expressed in languages, figures, formulas and designs. According to their management theory of organizational knowledge creation, new knowledge is created through repeated interaction between two types of knowledge. These interactions are triggered and realized especially in the process of intense dialogue among organizational members that is facilitated in the self-organizing organization .

In the context of disaster prevention at city level, such process of knowledge creation starts with local "tacit" knowledge that are embedded in and continuously reproduced through day-to-day routine of social agents. By realizing five conditions for self-organizing, these tacit knowledge can be transformed into new explicit knowledge that will contribute to construct “localized,” region-specific measures for effective disaster prevention. In order for this process to take place, it is indispensable to create various “ba” or fields and opportunities for communications and dialogue among all the agents in the city (residents, local firms, public agencies and municipal government) to develop grounded measures for disaster prevention and realistic roles they can take. Yokohama city government, for example, has recently announced a new disaster prevention program that aims at establishing such a "knowledge-based partnership" to create new knowledge and new division of labor among local agents for the disaster prevention.

TABLE 1. 3-Phased Model of Improving Self-Organizing Capabilities of City for Disaster Prevention

Time Phase / Functions	Prevention Period	Just-happened and Temporary-doings Period	Reconstruction Period
"Whole-in-the Parts" Structure	Sharing knowledge on the district and local agents among public agencies, residents, and local firms. (building "common knowledge base of district") Standardizing disaster prevention knowledge, facilities, equipment, and residents' organization for self-help. Continuous acquisition of the latest disaster prevention technologies from world-wide sources.	Sharing all information and knowledge on the disaster among public agencies, residents, and local firms through multiple media.	Multi-purpose use of disaster prevention resources to reduce the cost of preservation and maintenance.
Redundancy	Building redundancy into local communication channels, lifelines, and transportation systems.	Concentrating all energy and resources to the most critical problem until it is completely settled.	
Requisite Variety	Fine-textured zoning and resource preparation to make the district self-sufficient for disaster prevention. Promoting of mixed living of the young and the elderly, new-comers and old-comers. Listing all resources (including corporate resources) in the district that can be utilized for disaster prevention.	Requesting the most critical resource for the immediate relief and restoration.	
Minimum Critical Specification	Replacing "must do" style action-restricting manuals with "should not" style action-enabling guides. Fostering local organizations of residents and local firms that can exercise appropriate temporal authority and power in emergencies.	Temporal suspension of the request principle and other administrative regulations that may restrict flexible decisions and actions of agents. Delegation of authority to local organizations.	
Learning-to-Learn Capability	Continuous examination of the disaster prevention plans, planning procedures, and basic assumptions. Organizing liaison conferences for disaster prevention to promote knowledge sharing and creation through communication among various local agents. Articulating old-comers and elderly residents' wisdom for disaster prevention.	Applicating of various resources to the immediate relief and restoration.	Re-examination of the disaster prevention plans, planning procedures, and basic assumptions. Expansion and enrichment of liaison conferences for disaster prevention.