



# SELECTED PROCEEDINGS

## RELIEF SUPPLY LOGISTICS IN THE GREAT EAST JAPAN EARTHQUAKE

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# RELIEF SUPPLY LOGISTICS IN THE GREAT EAST JAPAN EARTHQUAKE

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## ABSTRACT

After the Great East Japan Earthquake in March, 2011, a huge amount of relief goods were sent to the disaster area. It causes a variety of problems at every stage of logistics management. In order to prevent a recurrence of similar problems in a future disaster, we must review what happened in the logistics management, figure out the causes, and elicit lessons for the future. In this study, at first, we summarize the big picture of logistics management at the Great East Japan Earthquake. Then, we collect the records from the participants of logistics management, and do a data analysis using the collected records and derive quantitative information that is useful to elicit lessons for the future. As a result of data analysis, we show some quantitative information that is consistent with the lessons gained from the multimedia analysis and interviews.

*Keywords: emergency logistics, relief goods, the Great East Japan Earthquake*

## INTRODUCTION

The Great East Japan Earthquake in March, 2011 inflicted enormous damages in a broad area of east Japan. Especially, the coastal area of Iwate, Miyagi and Fukushima prefectures were severely damaged by the tsunami. As of March 2012, the number of missing and dead exceeds 19,000, and more than 383,000 buildings were destroyed. The number of evacuees exceeded 400,000 at the peak. Some people are still forced to live a refuge life. After the earthquake occurred on March 11, 2011, a huge amount of relief goods were sent to the disaster area from around Japan and the world. Those supplies played a very important role to save the lives of disaster victims. Due to the combined great efforts of many people and organizations engaged in the relief supply logistics, we could overcome a hard situation caused by the compound disaster of earthquake, tsunami and Fukushima nuclear accident, and avoid such a situation that many disaster victims die of cold and hunger.

However, it should be noted that a lot of problems arose at every stage of logistics management: procurement, shipping, storage, distribution and so on. Some problems were

caused by the compound of unanticipated factors, such as the severe damage to municipal buildings, the severe communication blackouts within disaster area and from outside, the extremely short gasoline supply, the release of radioactive substances and so on. In contrast, some problems having arisen in the past huge earthquakes, such as the Great Hanshin-Awaji Earthquake (in 1995) and the Chuetsu Earthquake (in 2004), were repeated this time again. These include overloads on municipal officials, sorting of unsorted relief goods mainly provided by individuals and citizen groups, a huge surplus goods and the cost of their disposal and so on. The lessons from the past experience did not prevent the recurrence of the problems. Anyway, we must review what happened this time and learn lessons for the future. Ultimately, we must consider the possibility of reorganizing relief supply logistics systems and revise all the relevant plans and guidelines.

To elicit lessons from the review, it is essential to get the whole picture of logistics management after the Great East Japan Earthquake. However, it is not an easy task. The major reasons are as follows. First, it is difficult to get a whole picture of logistics management since many people and organizations are engaged and there are many patterns of relief goods sent from providers to refugees. Second, the environment surrounding relief supply logistics differs among disaster areas and varies with time. Third, there are many causes of the problems, and some are specific to the system, and some are specific to the particular cases (*e.g.* organizations, disaster areas, period of time). Fourth, the participants of logistics management are still busy in the follow-up of the problems caused by the Great East Japan Earthquake and routine works, and the review by the each participant is postponed or not done. Memories of the participants fade away with time.

So we have already interviewed more than sixty organizations engaged in the logistics management, including municipalities and prefectures in the disaster area, central government organizations and agencies, cooperative organizations of local governments, those of private trucking companies, those of warehousing companies and so on. We have already summarized the knowledge gained from the interview, and elicit some lessons for the future. However, we must pay attention to the fact that the knowledge gained from the interviews strongly depends on the interviewees' subjective thought. It is necessary to avoid eliciting lessons only from the results of the interviews.

To cope with the limitations of the interviews, one of the effective ways is thought to back up the knowledge gained from interviews by the quantitative data. However, the record regarding relief supply logistics is not kept sufficiently. Since a huge amount and variety of relief goods was sent in the aftermath period of confusion, it was often not recorded and even if recorded it was already lost. Further, the formats of available record are not unified because each participant of the logistics management recorded the information regarding relief goods by their own way. Even if we collect the available record, the useful information in eliciting lessons cannot be gained without unifying the formats and combining them to analyze.

The objectives of this study are the following: 1) to summarize the big picture of logistics management at the Great East Japan Earthquake; 2) to collect the records from the

participants of logistics management and to unify the formats of each record to make it possible to combine them, and 3) to do a data analysis using the collected records and derive quantitative information that is useful to elicit lessons for the future.

The structure of paper is as follows. In Section 2, we summarize the big picture of the logistics management at the Great East Japan Earthquake. In Section 3, we explain the records collected and how to unify their formats. In Section 4, we show a part of results of quantitative analysis. Section 5 summarizes the paper.

## **THE BIG PICTURE OF LOGISTICS MANAGEMENT AT THE GREAT EAST JAPAN EARTHQUAKE**

### **Definition of Terms**

Before going into the explanation of the big picture, we define some terms. First, “relief goods” are defined as “foods or daily necessities that are supplied to disaster victims”. They are subdivided into three types of goods: stored goods, procured goods, donated goods. Stored goods are goods that are stocked by municipalities or by citizen in preparation for disasters. They are mainly necessities (e.g. foods, drinking water, blanket). Procured goods are goods that are procured by municipalities and supplied to disaster victims. They are provided by the request of municipalities. Providers are compensated in some cases, whereas in the other cases not compensated. Donated goods are goods that are donated by the providers of goods. They are supplied to disaster victims directly from providers or indirectly through municipalities. Second, we define “logistics management” as the collective term of all activities of logistics, such as, procurement, transportation, picking, sorting, storing, shipping, distribution, surveying the needs of disaster victims and so on.

### **Major Participants of Logistics Management**

Let us briefly explain the role of major participants of logistics management and the problems regarding their activities.

#### *Municipality*

Municipalities are requested by the law (Basic Act on Disaster Control Measures, 1961) to implement necessary measures for disaster prevention (including both disaster mitigation and preparedness) and emergency response. One of the measures for disaster prevention is to store stored goods, and one of the measures for emergency response is to supply foods and necessities to disaster victims. At the Great East Japan Earthquake, the amount of stored goods was too small to fulfill the demands of disaster victims in most municipalities. There are mainly two reasons. First, the number of disaster victims greatly exceeded the predicted numbers. Second, municipalities are not financially supported for storing stored goods, and though they are requested by the law, they are not subject to punishment if they

do not. Therefore, the municipalities had to ask for the supports from the prefecture, they are locating in.

At the Great East Japan Earthquake, Disaster Relief Act (1947) was applied to most heavily damaged municipalities were applied. In this case, the prefecture was primarily responsible for the supply of relief goods to disaster victims, and expenditures for the implementation were shared by the central government and the prefecture. However, it does not mean that all the works necessary were done by the prefecture. The municipalities still had to do the following works regarding relief goods logistics: assessment of the needs of disaster victims, management of the depots of relief goods set up after the earthquake occurred, distribution of relief goods to the disaster victims, requirement of the donated goods that are not supported by the prefecture in the law, replying to the offer of donated goods, and so on. In addition, the infrastructure for the above works was severely constrained, i.e., low availability of communication tools and office equipments, limited space and facility of depots, lack of equipments generally used in the commercial depots and necessary for the efficient management (note: in the most municipalities, school gymnasium or communication centers were used as the depots), low availability of cars and trucks, shortage of gasoline, and so on. Further, since the municipalities were responsible for many other jobs than the relief goods logistics, they lacked the manpower, and they lacked the knowhow for the management of relief goods logistics too. Under such a situation with constrained infrastructure and manpower, a lot, and variety of relief goods was transported to the depots or municipal offices even at night, and some of them were not unsorted and sent from the goods provider (in many cases, individuals or civil groups) unilaterally. These caused the overloads on the municipal officials.

### *Prefecture*

Prefectures are requested by the law (Basic Act on Disaster Control Measures, 1961) to support municipalities in disaster prevention and emergency response. As for the storing of stored goods, instead of storing a large amount of goods, before March 2011, they had concluded agreements with retail and wholesale companies to provide goods preferentially if disaster occurred. At the Great East Japan Earthquake, since the commercial logistics system was heavily damaged and the number of disaster victims greatly exceeded the predicted number, the prefectures cannot procure sufficient foods and necessities from both companies with and without agreements. In addition to the retail and wholesale companies, the prefectures had concluded an agreement of mutual assistance in a disaster with all other prefectures in Japan before March 2011. Since the scale of damages exceeded the ex-ante prediction, this agreement also did not work as expected too. Therefore, the prefectures had to support disaster victims asking for the supports from the central government organizations and agencies.

The prefectures had concluded agreements with the cooperative organization of trucking companies or that of warehouse companies, and were supported by those companies. However, the amount of relief goods handled at the depots of prefectures was much larger, and it was necessary for the prefectures to take care of all the municipalities and to

coordinate with more agencies than the municipalities. As a result, as for the prefectures' works regarding relief goods logistics, similar problems to municipalities took place caused by the constrained infrastructure and manpower.

### *Central Government*

At the Great East Japan Earthquake, the central government conducted mainly two operations regarding the logistics of relief goods. First, a huge volume of relief goods was procured by the organizations and agencies of the central government for about a month after the earthquake. The government secured necessary budget for the procurement and some governmental organizations and agencies procured relief goods from companies under their jurisdiction with compensation or accepted their offer of donation of goods. A large part of procured goods were transported by the truck companies with that the government had concluded an agreement of emergency response or by the Self-Defence Force planes. It was the first time for the central government to conduct such kind of large logistics operation of relief goods. Though many minor troubles arose, caused by the communication disruption, shortage of gasoline, lack of experience of such kind of operation and so on, the central government contributed a lot in compensating for the lack of relief goods kept by the prefectures and municipalities.

Second, the Self-Defence Force conducted an operation that sent a huge volume of donated goods from the private companies and local governments outside the disaster area using their transportation capacity. Under this operation, those who wanted to donate goods only had to bring them to the nearest base of Self-Defence Force. To prevent the confusion caused by the small-lot and consolidated packages, the donation of goods by individuals and civil groups were excluded from the plan of operation. However, some local governments accepted the offers of donation by individuals or civil groups, and collected goods were brought into the base of Self-Defence Force, and sent to the prefectures in disaster area. Therefore, though this operation contributed in overcoming the low transportation capacity due to the shortage of gasoline, it became the cause of other problems for the prefectures and municipalities in the disaster area.

### **Flows of Relief Goods and Information Transaction**

Figure 1 shows the flow of relief goods and information. The left side of Figure shows the physical flow of relief goods. The right side of figure shows the information flow and transaction. We can see that the information regarding demands of relief goods (request of goods) and that regarding supplies of goods (assessment of needs, acceptance of request or offer of donation) were exchanged in each pair of players: shelter, municipality, prefecture, central government and good provider. However, it does not mean that supply and demand matches well in the whole system. Because, if the municipality or prefecture requested donated goods on its webpage, many good providers offered donation without coordinating among them, and in some cases only the donated goods were sent from the good providers without contact with the municipality or the prefecture. In addition, goods providers had

limited information and did not know the real-time situation of all the municipalities and prefectures. As a result, the demand exceeded the supply in a portion of municipalities, and vice versa in another portion of municipalities. In other words, the occurred mismatch of demand and supply were not well-adjusted among municipalities. It should be noted that the insufficient matching capacity is one of the most notable characteristics of the relief goods logistics system.

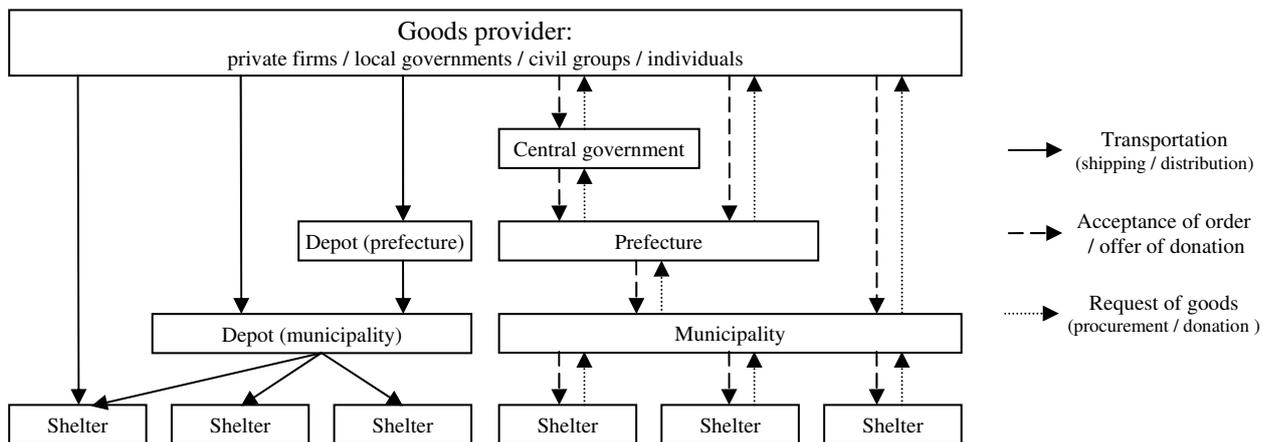


Figure 1 Flows of Relief Goods and Information

## QUANTITATIVE ANALYSIS

### Collected Records

Now, let us classify the participants of logistics management into three categories, that is, supply side participants (goods provider), intermediate side participants (central government, prefecture and municipality) and demand side participants (disaster victims at shelters). We collect the data recorded by the intermediate side participants, specifically, the following data: i) the data on the relief goods taken to the depot of municipalities, ii) the data on the relief goods taken to the depot of prefectures, , iii) the data on the relief goods taken from the depot of prefectures, iv) the data on the relief goods procured by the central government.

We did not collect other data recorded by the intermediate side participants, such as, the data on the request of goods by the municipality and the prefecture. They are not reliable even if we can collect them. Because the requests and offers of relief goods were orally communicated in many cases, only a part of them was recorded. For the same reason, we did not collect the data recorded by the demand side participants. The data recorded by the supply side participants was not collected, too. Because the number of goods providers is enormous and we do not have a list of who provided relief goods, it is impossible to collect a reliable data.

The contents of collected data are summarized in Table 2. From the collected data, we can know some useful information, such as the actual state of the depots at the municipality and prefecture. However, each data has a limitation to elicit more useful information in discussing the future disaster prevention policy. For instance, we can see either the sender or the provider of goods from the data i), and we cannot know the share of relief goods procured by the central government. It is necessary to combine multiple data for eliciting more useful information.

Table 1 Collected Records

Data	Contents
i) Relief goods taken to the depots of municipality	Type of goods, arrival date, quantity, sender or provider
ii) Relief goods taken to the depots of municipality	Type of goods, arrival date, quantity, sender or provider
iii) Relief goods taken from the depots of prefecture	Type of goods, shipping date, destination, quantity
iv) Relief goods procured by the central government	Type of goods, shipping date, destination, quantity, provider

### Unification of Formats

We need unify the formats of collected data. Because, the collected data have the following problems. First, it contains many missing values. Second, units of the same goods are different. For instance, the quantity of rice is sometimes measured by “kg” and in other cases by “number of box”. Following the rule shown in Table 3, we unified the units of quantity. Third, classifications of goods are different.

Table 2. Conversion Table

Type of goods	Standardized unit	Conversion rule
Rice	kg	“a box of ~” = 20 kg, “single serving”= 0.15 kg
Bread	serving	“a box of ~” = 50 servings, “a bag of ~”= a half serving
Pot Noodle	pack	“a box of ~” = 50 packs
Blankets	piece	“a box of ~” = 10 pieces
Clothes	number of times	count the times of receiving clothes

### Results and Discussion

In the following, we show the results on the share analysis of the specific relief goods provided by each types of goods provider (specifically, central government, prefecture, other

municipality, civil group, individual). Here, we pick up the case of Kamaishi city and Ofunato city. Both cities were heavily damaged by the tsunami. The populations of both cities were each about 40,000 in March 2011, and the number of people died and missing reached slightly more than 1,000 and 400 respectively. The data recorded in both cities has little missing values, and the results are relatively reliable compared with other municipalities.

The results are shown in Figure 2 and Figure 3. Each figure consists of five bar graphs and one line graph. The former shows the temporal change in the quantity of five types of relief goods (rice, bread, pot noodles, blankets and clothes) taken to the depots. The horizontal axes of the graphs are the number of weeks since the earthquake occurred. The vertical axes are the quantity of relief goods taken to the depots of municipality. We can see how much of the relief goods were provided by each types of goods provider. From two figures, we can see that the share of goods procured by prefecture is high for the foods (rice, bread and pot noodles). Especially, almost all breads were procured by the prefectures. The line graph shows the temporal change of the number of disaster victims in the shelters. It is shown for the reference to compare with the bar graphs.

The quantity of rice taken to the municipality peaked at three weeks since the earthquake occurred. It is thought that they could not cook rice just after the earthquake occurred due to the unavailability of essential utilities and the demand for rice increased as the essential utilities became available. In contrast, the quantity of bread taken to the municipality peaked at the first week. We can see that the demand for bread was very high since they can eat even if no essential utility is available. The quantity taken to at first week was around 65,000 for Kamaishi city and around 160,000 for Ofunato city. At that time, the number of disaster victims in the shelters was around 8,000 in both municipalities. Under this situation, we can expect that each disaster victim received two or three servings of bread per day. In the second week, the quantity of bread taken to the municipality largely decreased. It is thought that the demand for bread decreased as the quantity of other foods increased.

The quantity of pot noodles taken to the municipality peaked at the first week and the seventh week. We can see that it was not temporally stable. It is unlikely that the demand for pot noodles suddenly increased around the seventh week, and it is thought that the pot noodles were not taken to the municipality according to the demand for it and that the prefecture sent pot noodles to go through its depot.

The quantity of blanket taken to peaked at the first week. In the second week, the quantity largely decreased and few blankets were provided by the prefecture after the second week. This implies that the municipalities did not request blankets to the prefecture and the demands for the blanket were fulfilled at the second week. We can see that most of the blankets taken to the municipalities were donated by the firms or municipalities outside of the disaster area, and these unnecessary donations caused the problem of surplus goods.

In the case of clothes, we can see that the quantity taken to the municipality at the first period is very small, and it peaked at the second or third week. The share of goods donated by civil groups or individuals was high compared with the other goods. The clothes donated by non-

*Relief Supply Logistics in the Great East Japan Earthquake*  
 FUKUMOTO, Junya; MIYASHITA, Yuko

firm providers were second-hand clothes. Since most people prefer the new (non-used) clothes, there were no demands for the second-hand clothes except the period just after the earthquake occurred. Therefore, most of clothes taken to the municipality after the second week only caused the problem of surplus goods.

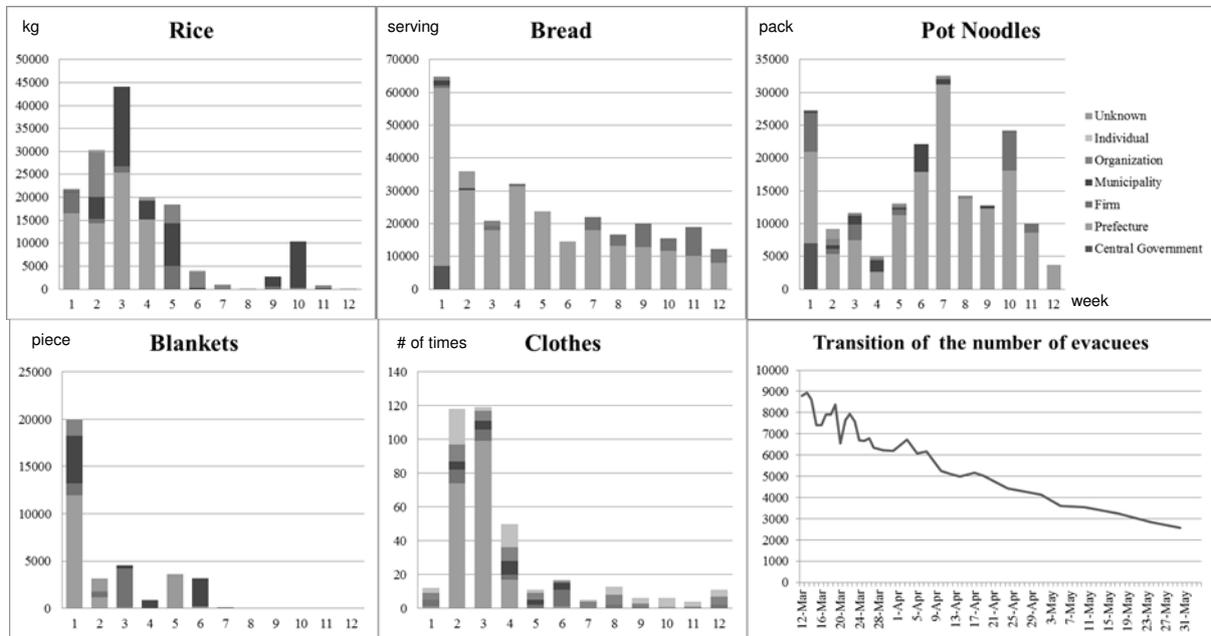


Figure 2. Relief goods taken to Kmaishi city

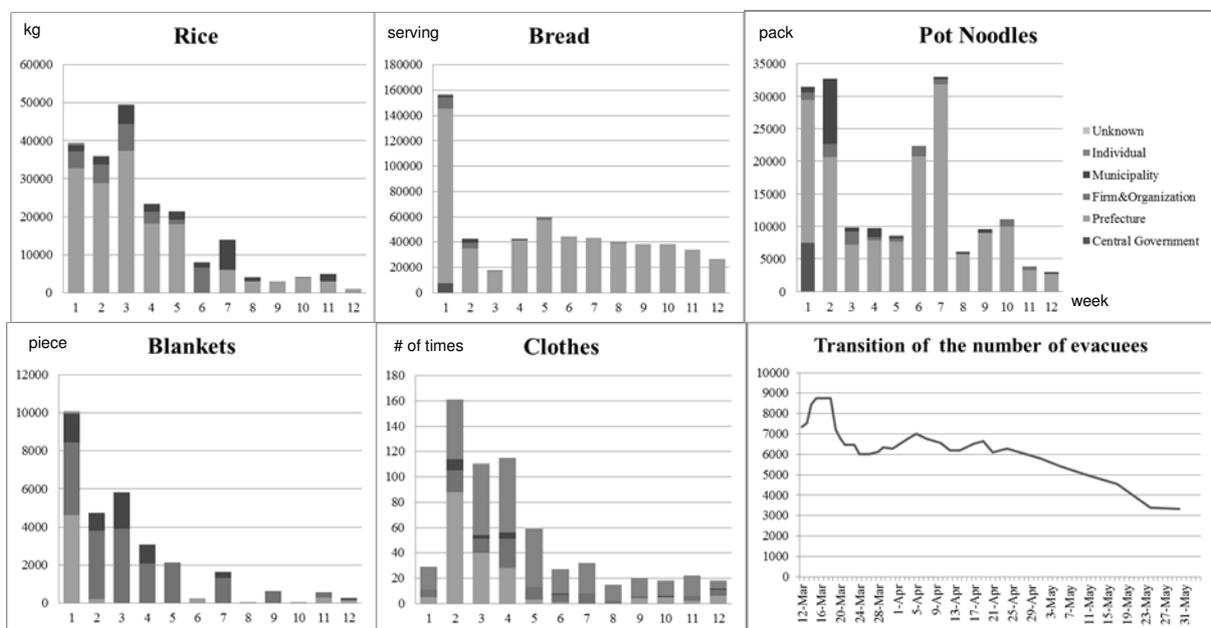


Figure 3. Relief goods taken to Ofunato city

## **CONCLUSION**

In this study, at first, we summarized the big picture of logistics management at the Great East Japan Earthquake. Then, we collected the records from the participants of logistics management and unified the formats of each record to make it possible to combine them. Since it was impossible to collect the records of goods providers, we mainly collected the records of inflow and outflow at the depots. Then, we did a data analysis using the collected records and derived quantitative information. As a result of data analysis, we show some quantitative information that is consistent with the lessons gained from the multimedia analysis and interviews.

## **ACKNOWLEDGEMENTS**

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