SPATIO-TEMPORAL ANALYSIS OF GASOLINE SHORTAGES IN TOHOKU REGION AFTER THE GREAT EAST JAPAN EARTHQUAKE

International Workshop on Transportation Networks under Hazardous Conditions
2, March, 2013

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Background (1)

- After 3.11, 2011, **Oil Shortage** spread over a wide area of the **Tohoku region**, and it *lasted for about a month.*

- The lack of automotive fuel
  - became a major constraints hindering **relief efforts** and **delivery of emergency supplies** in *affected areas along the coast*
  - greatly suppressed economic activities such as **commuter traffic** and **recovery efforts** in *inland areas*

  ⇒ caused **Huge Economic Losses**
Background (2)

- The root cause of the oil shortage was the event that oil refinery in Sendai and port facilities in the Tohoku region were struck by the earthquake.

- The Ministry of Economy, Trade & Industry (METI) and the oil industry have not yet released sufficient information that allow systematic understanding of the problem:
  - How the situation developed?
  - What measures were implemented?
  - Why the oil shortage lasted for a month? etc.

Many people attributed the main cause of the protracted oil shortage to “hoarding by consumers”.
Purpose of the Study

• Provide a Quantitative & Systematic View of the Oil Shortage Problem following the Earthquake.

Basic Analysis for the entire Tohoku region
  • What measures (oil transportation) were implemented?
  • What were the outcomes of those measures?
  • Why the oil shortage lasted nearly a month?

Spatio-temporal Analysis based on Quantitative Models
  • Estimate the development of “demand-supply gaps” by municipality in the Tohoku region.
Available Data for Estimating Oil Transportation

- Petroleum products: gasoline, diesel fuel, & heating oil
- Regions: 5 Prefectures in Tohoku, excluding of Fukushima (Aomori, Akita, Yamagata, Iwate & Miyagi)
Japan’s Refineries and Supply Capacities

- Many of the refineries are concentrated around **Kanto (Tokyo Bay)** and **West Japan (Seto Inland Sea)**.
- **Only one** - Sendai refinery - is located in the **Tohoku** region.
Damages to Japan’s Refineries by Tsunami

- Tohoku region lost oil refining capacity for a long time.

- Three refineries, accounting for 10% of Japan’s total crude capacity, suspended operations for a long time.

The damage to refineries was not the fundamental cause of the oil shortage in the Tohoku region.
3.11 – 3.13: all oil terminals (except Niigata) are inoperable
3.14 – 3.21: terminals on the Pacific Ocean are inoperable; only the terminals on the Japan Sea are operable.
3.21 - : the Pacific terminals gradually resume
What was the Fundamental Cause of the Oil Shortage in Tohoku after 3.11?

What Measures were Implemented?
Attributing the main cause of the oil shortage to “hoarding by consumers” is evidently wrong!!
Shipments from Refineries to Tohoku

Comparison of the volumes of oil product shipments from other regions in one month before & after the earthquake

<table>
<thead>
<tr>
<th></th>
<th>Hokaido</th>
<th>Kanto</th>
<th>Tokai</th>
<th>West Japan</th>
<th>Others</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before (10^3kl)</td>
<td>235</td>
<td>367</td>
<td>21</td>
<td>42</td>
<td>33</td>
<td>698</td>
</tr>
<tr>
<td>After (10^3kl)</td>
<td>303</td>
<td>137</td>
<td>31</td>
<td>56</td>
<td>4</td>
<td>530</td>
</tr>
<tr>
<td>Increase (10^3kl)</td>
<td>68</td>
<td>-230</td>
<td>10</td>
<td>14</td>
<td>-29</td>
<td>-168</td>
</tr>
</tbody>
</table>

**METI declared** (2011.3.17) “20 (10^3 kl) per day of oil will be supplied from West Japan”, but the actual transported volume was less than 1/10 of the declaration.
Inbound Shipments to the Ports in Tohoku

The supply to the entire Tohoku region remained insufficient until the recovery of the Pacific ports.
Why the Oil Shortage Lasted nearly a Month?
- Analysis of Demand-Supply Gap in Tohoku -
On March 24, gasoline supply recovered to the level of 98% ⇒ *Gasoline shortage resolved within two weeks***
Cumulative Latent Demand & Supply in Tohoku

- **Cumulative Curves** for Latent Demand & Supply

> Consumers gave up getting a portion of the latent demand (i.e., “Unrealized Demand” arose).
"Unrealized Demand" in Tohoku

• The volume of unrealized demand was approximately \( \frac{1}{3} \) (1 week’s worth) of the latent demand.

\[ \text{Unrealized Demand} = \text{Cumulative Demand} - \text{Cumulative Supply} \]

One week’s worth of economic activities vanished.
Aggregate “Demand-Supply Gap” in Tohoku

- Supply shortage for the first two weeks caused building up a huge backlog of demand (Pent-up Demand).

- *It took four weeks for the backlog to be cleared; this is why the oil shortage problem was protracted.*
Conclusion of the Basic Analysis

• Fundamental cause of the gasoline shortage in Tohoku was **insufficient supply due to the failure to adjust shipping volumes & patterns** in response to disaster damages.
  
  – Attributing to “hoarding by consumers” is wrong.
  
  – The amount of gasoline **transported during the two week** after the earthquake was **only 1/3** of the normal demand.
  
  – The amount brought into the Pacific region from oil terminals along the Sea of Japan was also insufficient.
  
  – This two-week supply shortage caused the level of cumulative latent demand to substantially exceed cumulative supply, **building up a backlog of demand**.
  
  – The emergence of the demand backlog that **lasted a month** resulted in **diminishing 1 week’s worth of demand**.