Disaster Management and JIT of Automobile Supply Chain

Toko Sasaki
Department of Information Systems
Niigata University of International and Information Studies
Introduction -1

Population: 2.3 million
Major Industry:
- Rice-related
- Metal processing

Is known as:
- High-quality rice, sake
- A lot of snow in winter
- A lot of disasters
  (ex. earthquakes, flood, heavy snow)
Introduction -2

Lectures:
- Production Planning and Control
- Production Information Systems
- Logistics
- Simulation Modeling (with Arena)

Research Interests:
- Simulation Teaching Method with Arena.

But, Today…
Because, …
In spite of our experiences in huge disasters, we haven’t tried to unveil invisible damages, such as interruption in supply chain network, and production system.

On the other hand;

- Much has been emphasized about the impacts of human and physical visible damages since disasters struck.

- There are a lot of studies about disaster in terms of seismology, meteorology, geology, structural mechanics, etc.

But, the Invisible damages, such as supply chain network, production system has been obstructed, not revealed.
Objective

To unveil invisible damages.

- The affects to the supply chain network, production system in Japanese automobile manufacturers by these disasters.

To unveil fundamental issues of their damages.

- Why did automobile manufacturers immediately decide all assembly plants’ shutdown?
- What’s the difference disaster and depression.
- Is “the limitation of the JIT” really exists, or not?
Outline

1. Recent Disasters in Japan

2. Structure of Automobile Industry in Japan

3. Riken’s Kashiwazaki Plant
   (2007 Niigata Chuetsu-offshore Earthquake)

4. Renesas Electronics Corporation’s Naka Plant
   (2011 Tohoku Earthquake)

5. Summary of Earthquake Effects on Production
1. Recent Disaster in Japan

The Tohoku Earthquake and Tsunami (11 March 2011)
# Major Earthquake in Japan (since 1995)

**Magnitude:** The Degree of Energy

**Seismic Intensity:** The Degree of Shaking

The 92% of Deaths and Missing: Tsunami

Almost every human damage: crushed under houses or furniture

<table>
<thead>
<tr>
<th>Date</th>
<th>Magnitude</th>
<th>Seismic Intensity (Shindo)</th>
<th>Earthquake</th>
<th>Injuries</th>
<th>Deaths</th>
<th>Missing</th>
<th>Height of Tsunami</th>
</tr>
</thead>
<tbody>
<tr>
<td>11 Mar 2011</td>
<td>M9</td>
<td>7</td>
<td>2011 Tohoku Earthquake and Tsunami</td>
<td>26,992</td>
<td>15,854</td>
<td>3,155</td>
<td>over 930cm</td>
</tr>
<tr>
<td>14 Jun 2008</td>
<td>M7.2</td>
<td>6+</td>
<td>2008 Iwate Earthquake</td>
<td>426</td>
<td>17</td>
<td>6</td>
<td>32cm</td>
</tr>
<tr>
<td>16 Jul 2007</td>
<td>M6.8</td>
<td>6+</td>
<td>2007 Niigata Chuetsu-Offshore Earthquake</td>
<td>2,316</td>
<td>15</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td>25 Mar 2007</td>
<td>M6.9</td>
<td>6+</td>
<td>2007 Noto Earthquake</td>
<td>359</td>
<td>1</td>
<td>0</td>
<td>22cm</td>
</tr>
<tr>
<td>23 Oct 2004</td>
<td>M6.8</td>
<td>7</td>
<td>2004 Niigata Chuetsu Earthquake</td>
<td>4,163</td>
<td>68</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td>26 Sep 2003</td>
<td>M8</td>
<td>6-</td>
<td>2003 Hokkaido Earthquake</td>
<td>849</td>
<td>1</td>
<td>1</td>
<td>255cm</td>
</tr>
<tr>
<td>24 Mar 2001</td>
<td>M6.7</td>
<td>6-</td>
<td>2001 Geiyo Earthquake</td>
<td>288</td>
<td>2</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td>17 Jul 1995</td>
<td>M7.3</td>
<td>7</td>
<td>1995 Kobe Earthquake</td>
<td>43,800</td>
<td>6,434</td>
<td>3</td>
<td>-</td>
</tr>
</tbody>
</table>
2. Structure of Automobile Industry in Japan
1 car needs 30,000-40,000 components
The Japanese automobile industry was like a **pyramid**, divided into three or any more tiers of suppliers, centered on the automobile manufacturers at the top of the hierarchy.
Supply Chain Network of Automobile Industry in Japan

Pyramidal Structure

Diamond Structure
Crisis in the 1990’s
- the collapse of ‘bubble’ economy
- the yen’s appreciation (1990:140 yen, 1995:79 yen to the dollar)
- the 1995 Kobe Earthquake,
- the increase of the consumption tax (from 3% to 5%; 1997).

Accelerated
- shifting of production to overseas site,
- moving toward optimal parts,
- promotion of the establishment of a global supply network.

The first and second tier parts are decentralized suppliers, the lower tier parts are centralized in specific companies that has the specialized process technology.

This situation was described in “the Japanese Automobile Industry “ (Shimokawa 1994).
Although, automobile assembly plants not damage, they were interrupted. Because the supply from the suppliers in the lower tiers stopped. The impacts of automobile industry affected in the ‘Keiretsu’ group.

In this situation of centralized suppliers in the lower tiers; if these suppliers are affected by a disaster, the production at supplier’s plant stop, then almost every automobile manufacturer are affected by it.
3. Riken’s Kashiwazaki Plant

The 2007 Niigata Chuetsu-offshore Earthquake

Source: The Cabinet Office, Government of Japan (Page of Disaster prevention)

Source: The Asahi Shinbun Digital (20 July 2007)
### Riken Corporation

**Capital**

¥8,573,597,000 (as of March 2011, all of Riken Corporation)

**Number of Employees**

1,627 (as of March 2011, all of Riken Corporation)

**Major Products**

- **Piston Ring**
  - Engine parts
  - Approx. 50% of domestic market share

- **Seal Ring**
  - Transmission parts
  - Approx. 70% of domestic market share

Source: Riken

---

**Center of the 2007 Niigata Chuetsu-offshore**

- **Riken’s Kashiwazaki Plant**

Map showing the location of the Kashiwazaki Plant.
Piston ring is an oligopolistic market.
- Riken (49.9%)
- Teikoku Piston Ring (TPR: 30.2%)
- Nippon Piston Ring (NPR: 19.9%)

Approx. 20% of world market share.

1/2 of the domestic cars and 1/5 of the world cars have Riken’s piston rings.
Riken’s Piston Rings -2

Riken → Automobile Manufacturers

- HONDA 19.2%
- TOYOTA 16.7%
- SUZUKI 15.7%
- MAZDA 14.7%
- NISSAN 14.3%
- SUBARU 6.0%
- MITSUBISHI 4.9%
- DAIHATSU 3.9%
- Others 4.6%
- Riken 49.9%
- NPR 19.9%
- TPR 30.2%

Source: Daniel E. Supply Chain Disruption Risk and Recovery: temporary Diversification and Its Limits, 2011
Riken’s Damages by the 2007 Niigata Chuetsu-offshore Earthquake

Center of the 2007 Niigata Chuetsu-offshore Earthquake

<table>
<thead>
<tr>
<th>Date</th>
<th>Magnitude</th>
<th>JMA Seismic Intensity</th>
<th>Injuries</th>
<th>Deaths</th>
</tr>
</thead>
<tbody>
<tr>
<td>16 Jul 2007</td>
<td>M6.8</td>
<td>6+</td>
<td>2,316</td>
<td>15</td>
</tr>
</tbody>
</table>

Human Damages:
- A few employees injured.
- Many employees were destroyed their house by Earthquake.

Property Damages:
- Machines 100 million yen
- Inventories 200 million yen
- Recovery Cost 1,200 million yen

Source: The Cabinet Office, Government of Japan (Page of Disaster prevention)
## The Key Factor of Riken’s Recovery: Team Work beyond Keiretsu Group

Total 9,000 people from 25 automobile manufacturers / parts manufacturers.

<table>
<thead>
<tr>
<th>Date</th>
<th>Days Later</th>
<th>Events</th>
<th>Operations</th>
</tr>
</thead>
<tbody>
<tr>
<td>16 July 2007</td>
<td>0</td>
<td>The 2007 Chuetsu Offshore Earthquake struck at 10:13 a.m. All the production lines at Riken’s Kashiwazaki plat had stopped. Toyota sent Riken about 20 employees to assess the situation of the damages.</td>
<td>0%</td>
</tr>
<tr>
<td>17 July - 2007</td>
<td>1</td>
<td>6 companies voluntarily provided 41 assistances to Riken’s Kashiwazaki Plant.</td>
<td>0%</td>
</tr>
<tr>
<td>18 July 2007</td>
<td>2</td>
<td>Mazda sent Riken 8 employees.</td>
<td>0%</td>
</tr>
<tr>
<td>19 July - 2007</td>
<td>3</td>
<td>There were total 700 skilled volunteers from automobile manufacturers and parts manufacturers. (Toyota:200 employees, Mazda: 13 maintenance engineers)</td>
<td>0%</td>
</tr>
<tr>
<td>22 July 2007</td>
<td>6</td>
<td>Riken started trial operation.</td>
<td>0%</td>
</tr>
<tr>
<td>23 July 2007</td>
<td>7</td>
<td>Riken resumed productions of major products (piston rings, seal rings, and camshafts) at 10 a.m. Part of the lines didn’t resume yet. 25 companies provided 830 assistances 23-24 July.</td>
<td>Almost 100%</td>
</tr>
<tr>
<td>1 August 2007</td>
<td>16</td>
<td>Riken announced Riken’s complete recovery.</td>
<td>100%</td>
</tr>
</tbody>
</table>
Riken’s Affects to Japanese Automobile Manufacturers

Comparison of Reductions in Productions by the Earthquake

<table>
<thead>
<tr>
<th>Earthquake</th>
<th>Reductions</th>
<th>Productions</th>
</tr>
</thead>
<tbody>
<tr>
<td>The 1995 Kobe Earthquake</td>
<td>14,021</td>
<td>January 1994: 772,858</td>
</tr>
<tr>
<td>(January 1995)</td>
<td></td>
<td>(January 1995) 758,837</td>
</tr>
<tr>
<td>The 2007 Niigata Chuetsu - offshore Earthquake</td>
<td>101,636</td>
<td>July 2007: 977,856</td>
</tr>
<tr>
<td>(July 2007)</td>
<td></td>
<td>July 2007: 876,220</td>
</tr>
</tbody>
</table>

Source: the AMDS of JAMA.

Comparison of Operations of Major 8 Automobile Manufacturers

<table>
<thead>
<tr>
<th>Toyota</th>
<th>Nissan</th>
<th>Honda</th>
<th>Mazda</th>
<th>Mitsubishi</th>
<th>Subaru</th>
<th>Suzuki</th>
<th>Daihatsu</th>
<th>Riken</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Additional information:

- All plants operated
- Some plants operated partially
- All plants stopped operation

- Toyota
- Nissan
- Honda
- Mazda
- Mitsubishi
- Subaru
- Suzuki
- Daihatsu
- Riken

10:13 a.m. Earthquake

Legend:

- Toyota Kyusu
- Daihatsu Kyusu
- Riken’s Akiyama
- Honda Motomachi
- Mazda Hirose
- Mitsubishi Mizushima
- Suzuki Sagara
- Daihatsu Kashiwazaki
- Toyota Honsya
- Honda Kumamoto
- Suzuki Takatsuka
- Honda Shatai
- Toyota Honsya
- Honda Takaoka
- Daihatsu Ikeda
- Toyota Tutumi
- Honda Iwaki
- Nissan Shatai Kyusyu
- Toyota Kamigo
- Suzuki Kosai
- Toyota Iura
- Honda Shatai Kyusyu
- Toyota Tawara
- Suzuki Sagara
- Toyota Mikage
- Toyota Shatai Kyusyu
- Nissan Oppama
- Suzuki Osuka
- Toyota Gunma
- Nissan Kanagawa
- Suzuki Iwata
- Daihatsu Hofu
- Suzuki Honsya
- Suzuki Shatai
- Suzuki Honsya
- Honda Tochigi
- Honda Shatai
- Daihatsu Hofu
- Toyota Takatsuka
- Toyota Teihou
- Mazda Hofu
- Toyota Gunma
- Suzuki Kanazawa
- Mazda Mitugi
- Suzuki Honsya
- Toyota Gunma
- Suzuki Kanazawa
- Daihatsu Hofu
- Toyota Takatsuka
- Toyota Teihou
- Mazda Hofu
- Toyota Gunma
- Suzuki Kanazawa
- Daihatsu Hofu
- Toyota Takatsuka
- Toyota Teihou
- Mazda Hofu
- Toyota Gunma
- Suzuki Kanazawa
- Daihatsu Hofu
- Toyota Takatsuka
- Toyota Teihou
- Mazda Hofu
- Toyota Gunma
- Suzuki Kanazawa
- Daihatsu Hofu
- Toyota Takatsuka
- Toyota Teihou
- Mazda Hofu
- Toyota Gunma
- Suzuki Kanazawa
- Daihatsu Hofu
- Toyota Takatsuka
- Toyota Teihou
- Mazda Hofu
- Toyota Gunma
- Suzuki Kanazawa
- Daihatsu Hofu
- Toyota Takatsuka
- Toyota Teihou
- Mazda Hofu
- Toyota Gunma
- Suzuki Kanazawa
- Daihatsu Hofu
- Toyota Takatsuka
- Toyota Teihou
- Mazda Hofu
- Toyota Gunma
- Suzuki Kanazawa
- Daihatsu Hofu
- Toyota Takatsuka
- Toyota Teihou
- Mazda Hofu
- Toyota Gunma
- Suzuki Kanazawa
- Daihatsu Hofu
- Toyota Takatsuka
- Toyota Teihou
- Mazda Hofu
- Toyota Gunma
- Suzuki Kanazawa
- Daihatsu Hofu
- Toyota Takatsuka
- Toyota Teihou
- Mazda Hofu
- Toyota Gunma
- Suzuki Kanazawa
- Daihatsu Hofu
- Toyota Takatsuka
- Toyota Teihou
- Mazda Hofu
- Toyota Gunma
- Suzuki Kanazawa
- Daihatsu Hofu
- Toyota Takatsuka
- Toyota Teihou
- Mazda Hofu
- Toyota Gunma
- Suzuki Kanazawa
- Daihatsu Hofu
- Toyota Takatsuka
- Toyota Teihou
- Mazda Hofu
- Toyota Gunma
- Suzuki Kanazawa
- Daihatsu Hofu
- Toyota Takatsuka
- Toyota Teihou
- Mazda Hofu
- Toyota Gunma
- Suzuki Kanazawa
- Daihatsu Hofu
- Toyota Takatsuka
- Toyota Teihou
- Mazda Hofu
- Toyota Gunma
- Suzuki Kanazawa
- Daihatsu Hofu
- Toyota Takatsuka
- Toyota Teihou
- Mazda Hofu
- Toyota Gunma
- Suzuki Kanazawa
- Daihatsu Hofu
- Toyota Takatsuka
- Toyota Teihou
- Mazda Hofu
- Toyota Gunma
- Suzuki Kanazawa
- Daihatsu Hofu
- Toyota Takatsuka
- Toyota Teihou
- Mazda Hofu
- Toyota Gunma
- Suzuki Kanazawa
- Daihatsu Hofu
- Toyota Takatsuka
- Toyota Teihou
- Mazda Hofu
- Toyota Gunma
- Suzuki Kanazawa
- Daihatsu Hofu
- Toyota Takatsuka
- Toyota Teihou
- Mazda Hofu
- Toyota Gunma
- Suzuki Kanazawa
- Daihatsu Hofu
- Toyota Takatsuka
- Toyota Teihou
- Mazda Hofu
- Toyota Gunma
- Suzuki Kanazawa
- Daihatsu Hofu
- Toyota Takatsuka
- Toyota Teihou
- Mazda Hofu
- Toyota Gunma
- Suzuki Kanazawa
- Daihatsu Hofu
- Toyota Takatsuka
- Toyota Teihou
- Mazda Hofu
- Toyota Gunma
- Suzuki Kanazawa
- Daihatsu Hofu
- Toyota Takatsuka
- Toyota Teihou
- Mazda Hofu
- Toyota Gunma
- Suzuki Kanazawa
- Daihatsu Hofu
- Toyota Takatsuka
- Toyota Teihou
- Mazda Hofu
- Toyota Gunma
- Suzuki Kanazawa
- Daihatsu Hofu
- Toyota Takatsuka
- Toyota Teihou
- Mazda Hofu
- Toyota Gunma
- Suzuki Kanazawa
- Daihatsu Hofu
- Toyota Takatsuka
- Toyota Teihou
- Mazda Hofu
- Toyota Gunma
- Suzuki Kanazawa
- Daihatsu Hofu
- Toyota Takatsuka
- Toyota Teihou
- Mazda Hofu
- Toyota Gunma
- Suzuki Kanazawa
- Daihatsu Hofu
- Toyota Takatsuka
- Toyota Teihou
- Mazda Hofu
- Toyota Gunma
- Suzuki Kanazawa
- Daihatsu Hofu
- Toyota Takatsuka
- Toyota Teihou
- Mazda Hofu
- Toyota Gunma
- Suzuki Kanazawa
- Daihatsu Hofu
- Toyota Takatsuka
- Toyota Teihou
- Mazda Hofu
- Toyota Gunma
- Suzuki Kanazawa
- Daihatsu Hofu
- Toyota Takatsuka
- Toyota Teihou
- Mazda Hofu
- Toyota Gunma
- Suzuki Kanazawa
- Daihatsu Hofu
- Toyota Takatsuka
- Toyota Teihou
- Mazda Hofu
- Toyota Gunma
- Suzuki Kanazawa
- Daihatsu Hofu
- Toyota Takatsuka
- Toyota Teihou
- Mazda Hofu
- Toyota Gunma
- Suzuki Kanazawa
- Daihatsu Hofu
- Toyota Takatsuka
- Toyota Teihou
- Mazda Hofu
- Toyota Gunma
- Suzuki Kanazawa
- Daihatsu Hofu
- Toyota Takatsuka
- Toy...
The Changes(%) from the Previous Year of the Products and Exports

In July, 7 automobile manufacturers excluding Mitsubishi fell below products of the same month of the previous year.

- Suzuki: -22,413 units (-22.0%)
- Nissan: -22,667 units (-20.9%)
- Mitsubishi: +4,836 units (+7.7%)

Source: Active Matrix Database System of JAMA.
Note: The previous year’s result indexed at 100.
The Changes of the Domestic Products of All Automobile Manufacturers from Jul 2007 through June 2008

- Amount of the domestic production decreased in August rather than July.
- This was not due to Riken's effects.
- This reason was that all most every company in Japan takes summer holiday in August.

The Changes (%) from the previous year of the Products

- The change from the previous year in August was 106.44%.
- Automobile manufacturers were affected by Riken’s shutdown in July.

Source: Active Matrix Database System of JAMA.
Note: The previous year’s result indexed at 100.
The Riken’s Strategy against a Disaster

after the 2007 Niigata Chuetsu-offshore Earthquake

Facilities
New 2 warehouses (stocks for 2 weeks).
  - Riken’s Aichi Warehouse
  - Riken’s Saitama Warehouse

Alternative Production
Production of piston rings spread to 2 foreign plants.
  - Riken Automobile Parts Co., Ltd. (Wuhan, China)
  - Allied Ring Corporation (Michigan, U.S.A)

Standardization of Products
  - TPR (Teikoku Piston Ring)
  - NPR (Nippon Piston Ring)
4. Renesas Electronics Corporation’s Naka Plant

The 2011 Tohoku Earthquake
Source: Corporate Outline of REC’s.

## Renesas Electronics Corporation (REC)

### Corporate Structure
- **Subsidiary**
  - NEC Electronics
- **Integration**
  - Nov. 2002
  - Apr. 2003
  - Apr. 2010

### Key Facts
- **Capital**
  - ¥153.2 billion

### Major Products
1. Microcontroller
2. System LSIs/SoC Devices
3. Analogue & Power Devices

### Employees
- 44,000 (Consolidated)

### Group Companies
- **In Japan**
  - 1 Sales Companies.
  - 14 Manufacturing and Engineering Service Companies.
  - 7 Design and Application Technologies Companies.
  - 2 Business Corporations and Others.
- **Overseas**
  - 11 Sales Companies.
  - 8 Manufacturing and Engineering Service Companies.
  - 4 Design and Application Technologies Companies.
  - 6 Business Corporations and Others.

### Manufacturing and Testing
- **Front-end Line**
  - (Wafer Fabrication: 10 plants)
- **Back-end Line**
  - (Assembly & Test: 12 plants)
# REC’s Naka Plan

*REC’s Plant*

---

<table>
<thead>
<tr>
<th>Address</th>
<th>Hitachinaka City, Ibaraki Prefecture</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Major Product</strong></td>
<td><strong>Microcontroller</strong></td>
</tr>
<tr>
<td></td>
<td>The Naka Plant produces a little fewer than 20% MCUs in all REC.</td>
</tr>
<tr>
<td></td>
<td><strong>System LSIs/SoC Devices</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Analogue &amp; Power Devices.</strong></td>
</tr>
<tr>
<td></td>
<td>The Naka Plant produces a little fewer than 10% of REC’s Analogue &amp; Power Devices.</td>
</tr>
</tbody>
</table>

---

Source: Corporate Outline of REC’s.
REC’s Microcontroller (MCU)

- REC’s is the world’s largest manufacturers of microcontroller with market share (27.3%).
- It takes 2 months to produce one MCU from fabrication.
- There are about 1,000 processes.
- A car needs over 50 MCUs, and a high grade car needs about 100 MCUs.
- Most Japanese cars are loaded REC’s MCUs.

Source: Databeans Estimates, Company Reports
Note: Amount of the MCU revenue was 14.8 billion dollar in 2010.
Amount of the automotive MCU revenue was 5.36 billion dollar in 2010.
# REC’s Damages by the 2011 Tohoku Earthquake

## Loss on Disaster

<table>
<thead>
<tr>
<th>Description</th>
<th>Amount (in millions of yen)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Repair cost of fixed assets</td>
<td>43,116</td>
</tr>
<tr>
<td>Loss on disposal of inventories</td>
<td>7,283</td>
</tr>
<tr>
<td>Loss on disposal of fixed assets</td>
<td>6,187</td>
</tr>
<tr>
<td>Fixed costs during the temporary shutdown period of operations</td>
<td>5,919</td>
</tr>
<tr>
<td>Loss on cancellation of lease contracts</td>
<td>2,987</td>
</tr>
<tr>
<td>Other</td>
<td>12</td>
</tr>
<tr>
<td>Sub total</td>
<td>65,504</td>
</tr>
<tr>
<td>Insurance income receivable</td>
<td>(-16,000)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>49,504</strong></td>
</tr>
</tbody>
</table>

Source: News Release of REC (as of 18 May).

### Naka Plant’s Resumption Plan

- **1 August** (estimated in 21 March)
- **15 July** (28 March)
- **15 June** (22 April)
- **1 June** (11 May)

2 Months Reduce

### The Key Factor of REC’s Recovery: Team Work beyond Keiretsu Group, Industry
- Automobile manufacturers, Electrical manufacturers, construction industry.
- Total 80,000 people, max 2,500 assistances per day.
- 24h a day, 7 days a week recovery operation.
## Chronological Events at REC’s Naka Plant

<table>
<thead>
<tr>
<th>Date</th>
<th>Days Later</th>
<th>Events</th>
</tr>
</thead>
<tbody>
<tr>
<td>11 March, 2011</td>
<td>0</td>
<td>The 2011 Tohoku Earthquake struck at 2:46 p.m. 7 (include Naka Plant) out of 22 of REC’s plants in Japan have temporarily shut down production. REC’s production volume felt to approximately 50%.</td>
</tr>
<tr>
<td>13-14 March, 2011</td>
<td>2-3</td>
<td>8 REC’s offices/sites in Japan had been impacted from the blackout measure by Tokyo Electric Power Company. These offices/sites shut down operation production.</td>
</tr>
<tr>
<td>23 April, 2011</td>
<td>43</td>
<td>Naka Plant started test production at the 200-mm wafer fabrication line.</td>
</tr>
<tr>
<td>25 April, 2011</td>
<td>45</td>
<td>Naka Plant started test production at the 300-mm wafer fabrication line.</td>
</tr>
<tr>
<td>1 June, 2011</td>
<td>82</td>
<td>200-mm wafer fabrication line started mass production.</td>
</tr>
<tr>
<td>6 June, 2011</td>
<td>87</td>
<td>System LSI (300-mm) wafer fabrication line started mass production.</td>
</tr>
<tr>
<td>June 2011</td>
<td></td>
<td>REC’s production volume recovered to approximately 85%.</td>
</tr>
<tr>
<td>Mid-September 2011</td>
<td></td>
<td>The supply(shipment) capacity returned to that more than pre-earthquake (100%).</td>
</tr>
</tbody>
</table>

Source: Press Release of REC and articles of Nihon Keizai Shinbun
Comparison of Reductions in Productions by the Earthquake

<table>
<thead>
<tr>
<th>Earthquake</th>
<th>Reductions</th>
<th>Productions</th>
</tr>
</thead>
<tbody>
<tr>
<td>The 1995 Kobe Earthquake</td>
<td>14,021</td>
<td>January 1994: 772,858</td>
</tr>
<tr>
<td>The 2007 Chuetsu-offshore Earthquake</td>
<td>101,636</td>
<td>July 2006: 977,856</td>
</tr>
<tr>
<td></td>
<td>(July 2007)</td>
<td>July 2007: 876,220</td>
</tr>
<tr>
<td>The 2011 Tohoku Earthquake</td>
<td>541,283</td>
<td>March 2010: 945,220</td>
</tr>
<tr>
<td></td>
<td>(March 2011)</td>
<td>March 2009: 403,937</td>
</tr>
</tbody>
</table>

Comparison of Operations of Major 8 Automobile Manufacturers in Japan

Source: the AMDS of JAMA.

- Toyota
- Nissan
- Honda
- Mazda
- Mitsubishi
- Subaru
- Suzuki
- Daihatsu

Legend:
- All plants operated
- Some plants operated partially
- All plants stopped operation
In March and April, all automobile manufacturers considerably fell below products of the same month of the previous year. In April

Honda -59,017 units (-80.0%)
Toyota -217,790 units (-62.7%)

Approx. 80% of Honda’s cars used REC’s MCUs, and Honda was decreasing stocks of semiconductor because it had just ordered new one immediately before the 2011 Tohoku Earthquake.

There was the lack of approx. 500 types of components immediately after earthquake, the lack of approx. 150 types in April, and the lack of 30 types in May.

Note: The previous year's result indexed at 100.
In April, there was down 60.1% from the same month in the previous year.

It took 5 months until the domestic production of all automobile manufacturers in Japan returned to normal production.

Source: Active Matrix Database System of JAMA.
Note: The previous year’s result indexed at 100.
The REC’s Provision against a Disaster

Facilities
Making 10 plants strong enough so that REC can resume production within 1 month after an earthquake.
- Until the end of 2013.
- 30 billion yen.

Alternative Production
(In April 2001)
- Tsugaru Plant
- Sanjo Plant
- Singapore Plant of GlobalFoundries
  (the world third largest Independent semiconductor foundry)

http://www.youtube.com/watch?v=Vwkdf7j65lQ&lr=1&feature=mhee
5. Summary of Earthquake Effects on Production
Automobile manufacturers decided that all assembly plants stopped operation from 3.8 or 3.0 days after the earthquake. Why?
Toyota Production System - JIT

JIT: Making only what is needed, when it is needed, and in the amount needed!

Reducing in-process Inventory

If disaster strike anywhere there are automobile parts manufacturers’ plants,

Nothing in-process Inventories

All automobile manufacturers’ assembly plants will be interrupted immediately.
Toyota Production System - Jidoka

Jidoka

自動化  = Automation
自働化  = Automation with human touch Correct!

1. If an abnormal situation on the production line arises.
2. The affected machine automatically stops, and the worker will stop the production line.
3. The worker fixes or the immediate condition.
4. Investigate the root cause and take a measure.

If disaster strike, ( = abnormal situation)

All automobile manufacturer’s production lines/plants stopped immediately.

There were not wrong decisions for Japanese automobile manufacturers to stop production lines/plants by both these disasters.
Comparison of Automobile Manufacturer’s Recovery Time -2

<table>
<thead>
<tr>
<th>Toyota</th>
<th>Riken (2007 Niigata)</th>
<th>REC (2011 Tohoku)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Still all plants stopped</td>
<td>All plants was Stopping</td>
</tr>
<tr>
<td>Toyota</td>
<td>2.5</td>
<td>4.5</td>
</tr>
<tr>
<td>Nissan</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Honda</td>
<td>7</td>
<td>1</td>
</tr>
<tr>
<td>Mazda</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>Mitsubishi</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Subaru</td>
<td>2.5</td>
<td>5.5</td>
</tr>
<tr>
<td>Suzuki</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Daihatsu</td>
<td>2.5</td>
<td>3.5</td>
</tr>
<tr>
<td>Average</td>
<td>3.8</td>
<td>3.6</td>
</tr>
</tbody>
</table>

If it takes long time to resume, what are affects to automobile manufacturers?
The Changes(%) of the Domestic Automobile Products

Source: Active Matrix Database System of JAMA.
Note: The previous year’s result indexed at 100.
What we have to recognize things

1. The Impacts to Supply to Automobiles Manufacturers
   Disaster’s impacts were not more than the depression’s impacts.

2. Recovery Speed of Supply to Automobiles Manufacturers
   Recovery speeds at disaster were quicker rather than the depression.

Chronological Changes of the Domestic Products

Thousands Units

- Kobe Earthquake
- Niigata Chuetsu-offshore Earthquake
- Lehman Shock
- Tohoku Earthquake
Was JIT good or no good?

<table>
<thead>
<tr>
<th></th>
<th>Normal Inventory Level / Cost</th>
<th>Normal Transportation L.T. / Cost</th>
<th>Environment Adaptability</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>JIT</strong></td>
<td>Low / Low</td>
<td>Short / High</td>
<td>High</td>
</tr>
<tr>
<td><strong>Non JIT</strong></td>
<td>High / High</td>
<td>Long / Low</td>
<td>Low</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Abnormal (Depression)</th>
<th>Storage Time</th>
<th>Inventory Cost</th>
<th>Inventory Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>JIT</strong></td>
<td>Constant (short)</td>
<td>Constant (Low)</td>
<td>Constant (Low)</td>
</tr>
<tr>
<td><strong>Non JIT</strong></td>
<td>Longer</td>
<td>Higher</td>
<td>Higher</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Abnormal (Disaster)</th>
<th>Shutdown of Plants</th>
<th>Loss on disposal of Inventories</th>
<th>Recovery Speed of Plants</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>JIT</strong></td>
<td>Damaged Plants: Immediately Other Plants: Earlier</td>
<td>Damaged Plants: Low Other Plants: Non</td>
<td>Damaged Plants: High Other Plants: High</td>
</tr>
<tr>
<td><strong>Non JIT</strong></td>
<td>Damaged Plants: Immediately Other Plants: Later/Avoid</td>
<td>Damaged Plants: High Other Plants: Non</td>
<td>Damaged Plants: Low Other Plants: Low</td>
</tr>
</tbody>
</table>

Many articles that insist ‘the Limitations of JIT’ has emphasized this point.

There were not wrong decisions for Japanese automobile manufacturers to stop production lines/plants by both these disaster.

“Recovery Speed” are very importance!

It is impossible to say definitely that ‘The Limitations of JIT’ exists
If plant suffer disaster, …

Almost every automobile manufacturer affected by earthquake.

To build the mutual complement network of production, it will reduce the affects to companies in the upper tier.

Riken & REC

In future

Almost every automobile manufacturer affected by earthquake.

To build the mutual complement network of production, it will reduce the affects to companies in the upper tier.

Riken

Alternative Production:
2 foreign plants

Nodes of the Mutual Complement Network of Production

the Mutual Complement Network

REC

Alternative Production:
- 2 Domestic Plants
- GlobalFoundries
Invisible damages were unveiled.

- The affects to the supply chain network, production system in Japanese automobile manufacturers by these disasters.
- As for recovery speed from disasters, JIT operated to advantage to the Japanese automobile industry.

Fundamental issues of their damages were unveiled.

- As for TPS, there were not wrong decisions for Japanese automobile manufacturers to stop production lines/plants by both these disasters.
- The comparison of disaster and depression in terms of the decreasing speed/volume of supply and the recovery speed.
- It is impossible to say definitely that the limitation of the JIT exists.
Vision for Future Research

• The affects to Japanese automobile industry by the floods in Thailand in 2011

• Simulation modelling/analysis of the affects to supply chain network by disasters.
Thank you for your kind attention.