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# Disaster Management and JIT of Automobile Supply Chain

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# Introduction -1

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## Niigata

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)



## Lectures:

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

## Research Interests:

- Simulation Modeling and Analysis of Traffic Systems, Logistics Systems and Production Systems.
- Simulation Teaching Method with Arena.

But, Today...

Because, ...

# Problems

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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

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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

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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



The Tohoku Earthquake and  
Tsunami (11 March 2011)



The Tohoku Earthquake and  
Tsunami (11 March 2011)

## 1. Recent Disaster in Japan

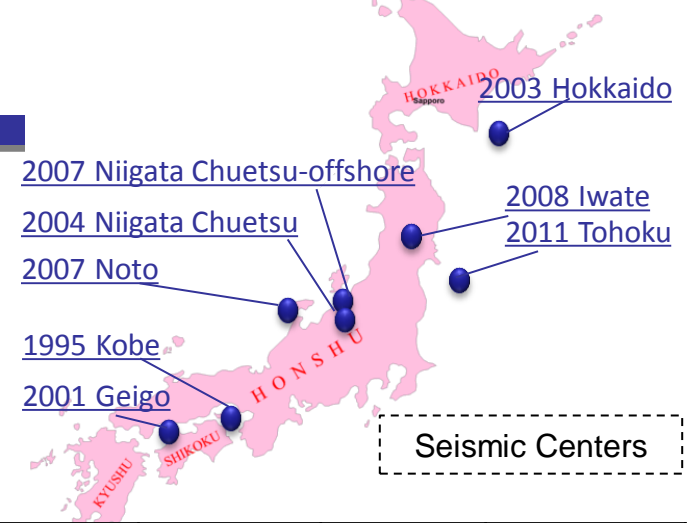
# Major Earthquake in Japan (since 1995)

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



Date	Magnitude	Seismic Intensity (Shindo)	Earthquake	Injuries	Deaths	Missing	Height of Tsunami
11 Mar 2011	M9	7	2011 Tohoku Earthquake and Tsunami	26,992	15,854	3,155	over 930cm
14 Jun 2008	M7.2	6+	2008 Iwate Earthquake	426	17	6	32cm
16 Jul 2007	M6.8	6+	2007 Niigata Chuetsu-Offshore Earthquake	2,316	15	0	-
25 Mar 2007	M6.9	6+	2007 Noto Earthquake	359	1	0	22cm
23 Oct 2004	M6.8	7	2004 Niigata Chuetsu Earthquake	4,163	68	0	-
26 Sep 2003	M8	6-	2003 Hokkaido Earthquake	849	1	1	255cm
24 Mar 2001	M6.7	6-	2001 Geiyo Earthquake	288	2	0	-
17 Jul 1995	M7.3	7	1995 Kobe Earthquake	43,800	6,434	3	-

Urban side

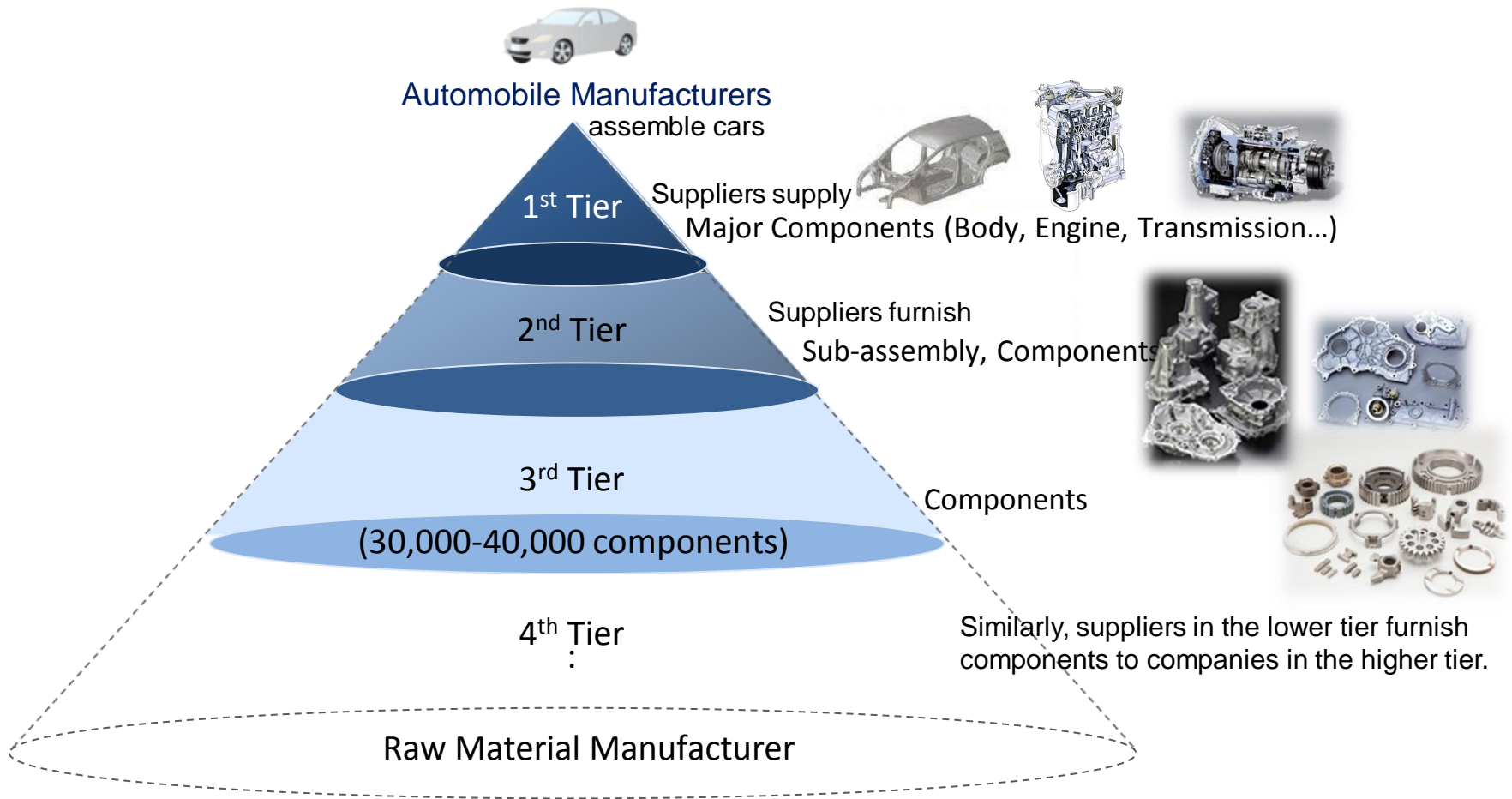
Countryside



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## **2. Structure of Automobile Industry in Japan**

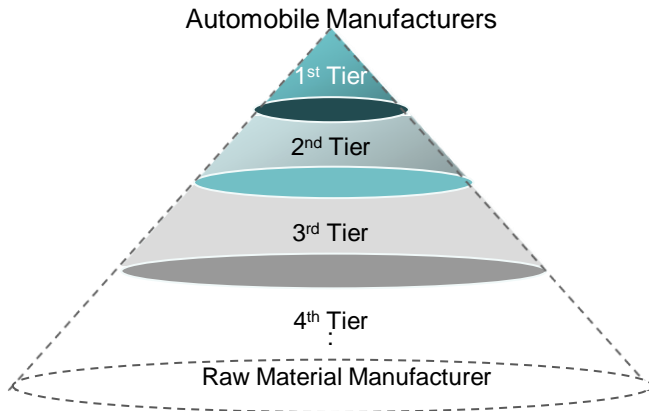
# Automobile Products



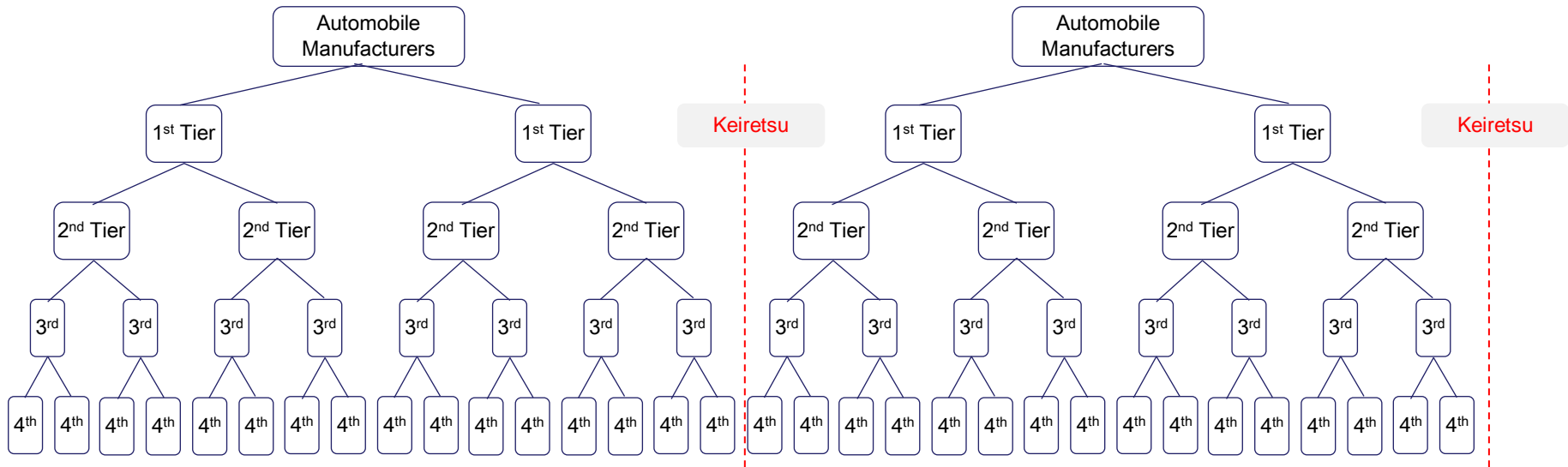
1 car needs 30,000-40,000 components

# Supply Chain Network of Automobile Industry in Japan -1

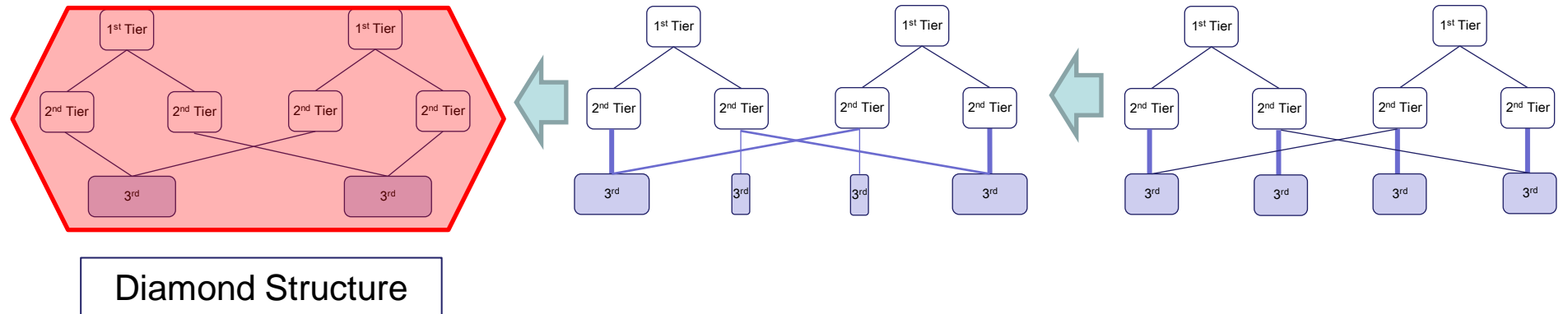
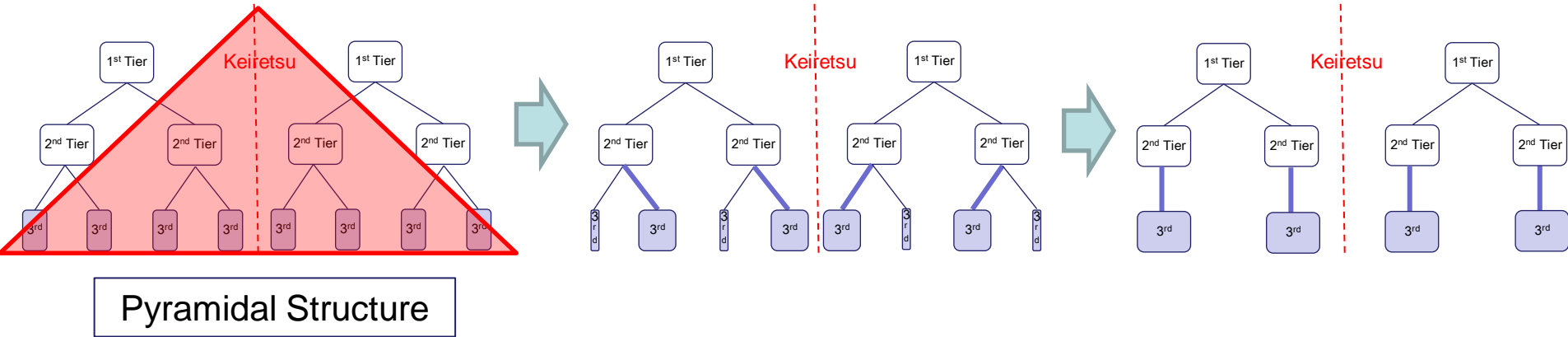
## Pyramidal Structure



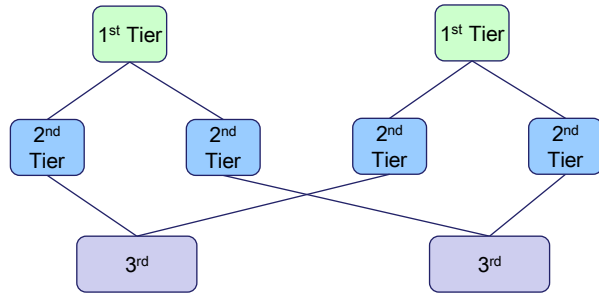
The Japanese automobile industry was like a **pyramid**, divided into three or any more tiers of suppliers, centered on the automobile manufacturers at the top of the hierarchy.



# Supply Chain Network of Automobile Industry in Japan -2



# Supply Chain Network of Automobile Industry in Japan -3



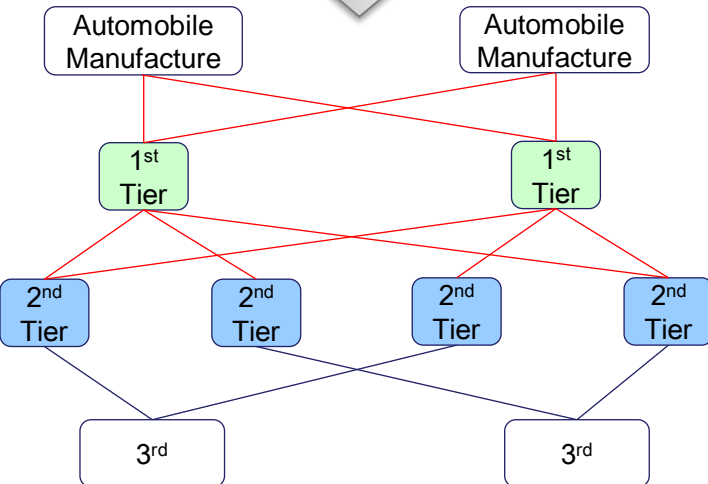
## Crisis in the 1990's

- 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.



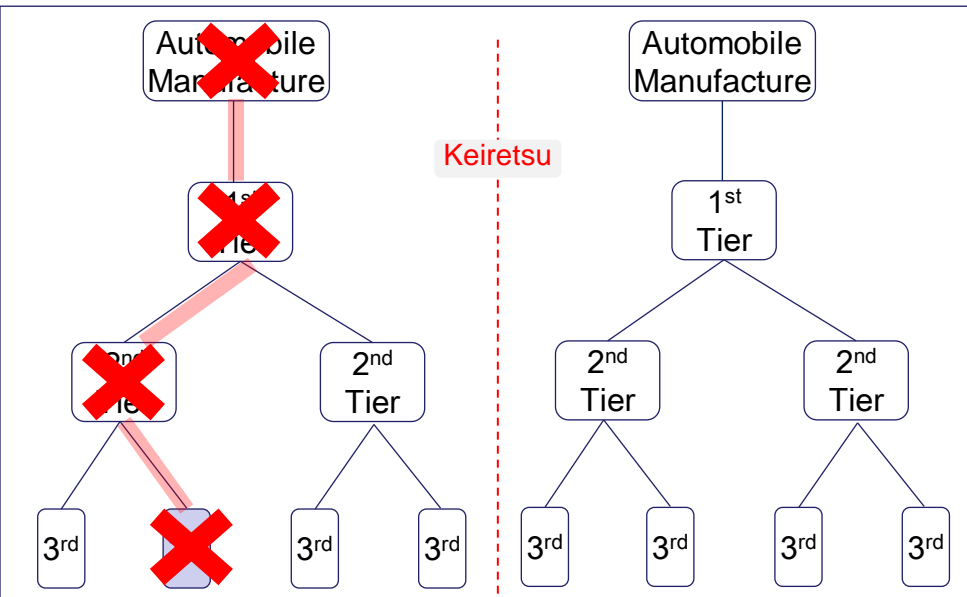
The first and second tier parts are **decentralized** suppliers, the lower tier parts are **centralized** in specific companies that has the specialized process technology

**Decentralized**

This situation was described in " the Japanese Automobile Industry " (Shimokawa 1994).

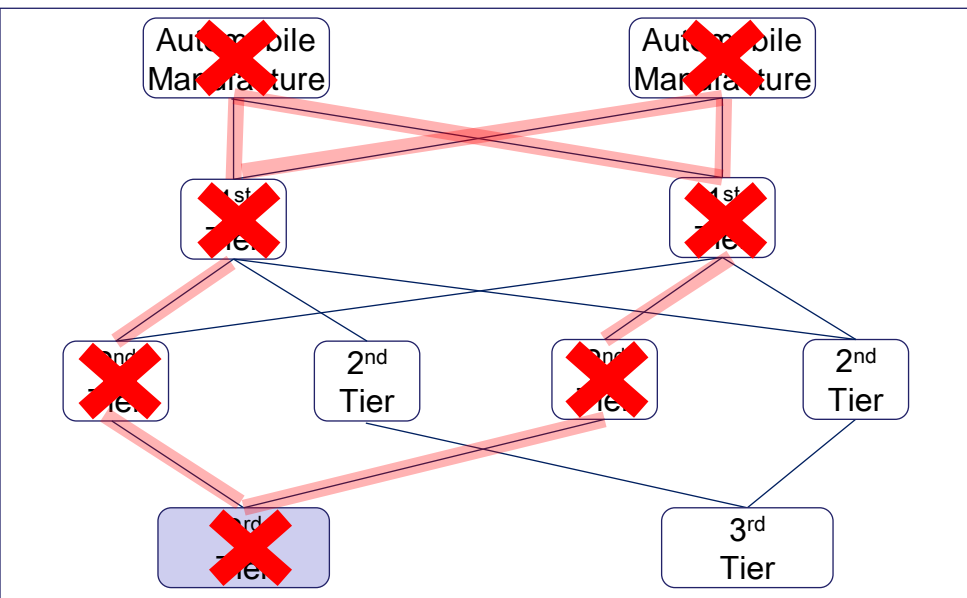
**Centralized**

# If Disaster Suffers in the Lower Suppliers' Plant, ...



## Pyramidal Structure

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**.



## Diamond Structure

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.



Source: Riken



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



Source: The Asahi Shinbun Digital (20 July 2007)

### 3. Riken's Kashiwazaki Plant

The 2007 Niigata Chuetsu-offshore Earthquake

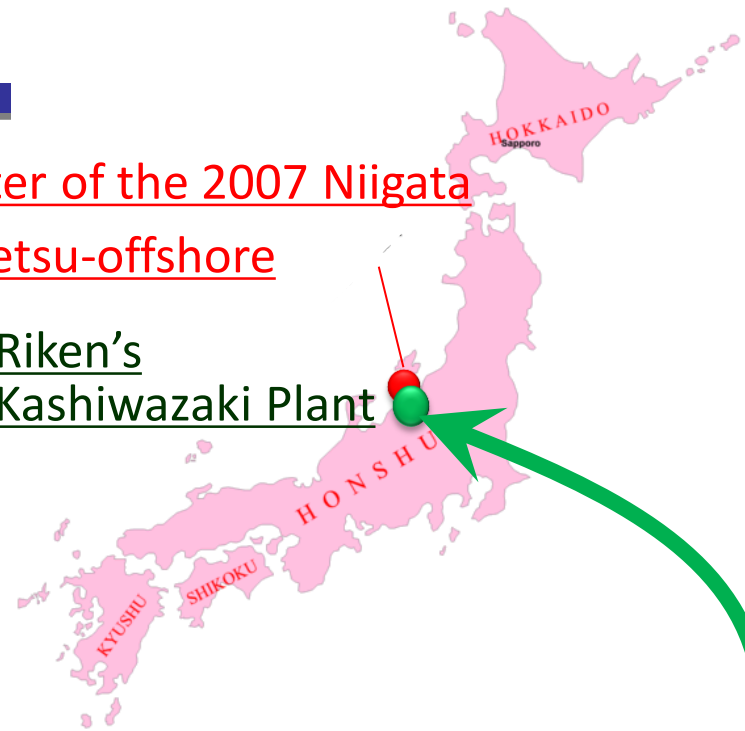
# Riken Corporation



Source: Riken

Center of the 2007 Niigata  
Chuetsu-offshore

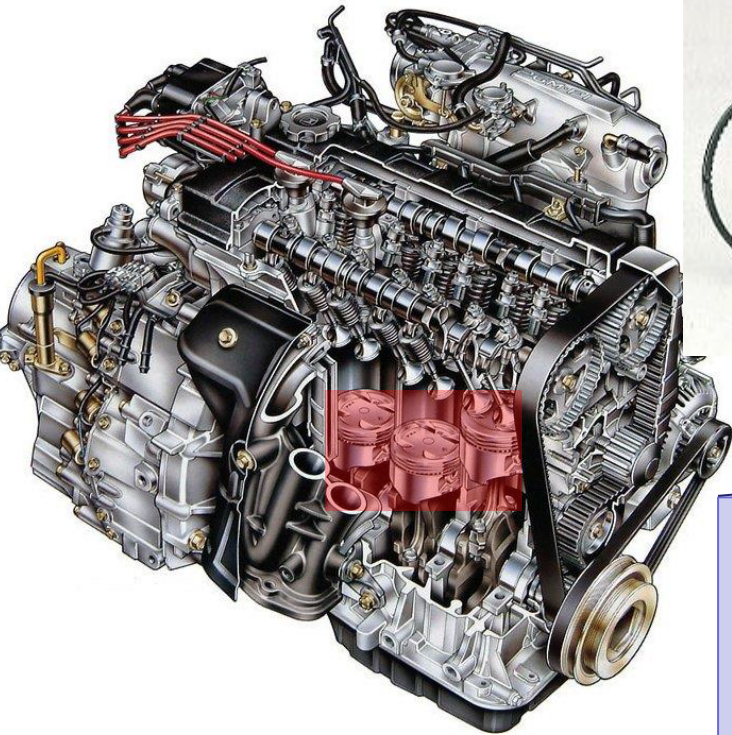
Riken's  
Kashiwazaki Plant



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	<p>Piston Ring</p> <ul style="list-style-type: none"><li>• Engine parts</li><li>• Approx. 50% of domestic market share</li></ul> <p>Seal Ring</p> <ul style="list-style-type: none"><li>• Transmission parts</li><li>• Approx. 70% of domestic market share</li></ul>



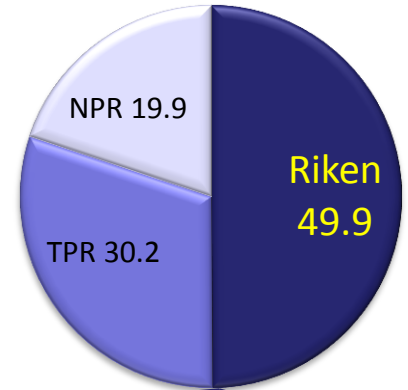
# Riken's Piston Rings -1



Automobile Engine

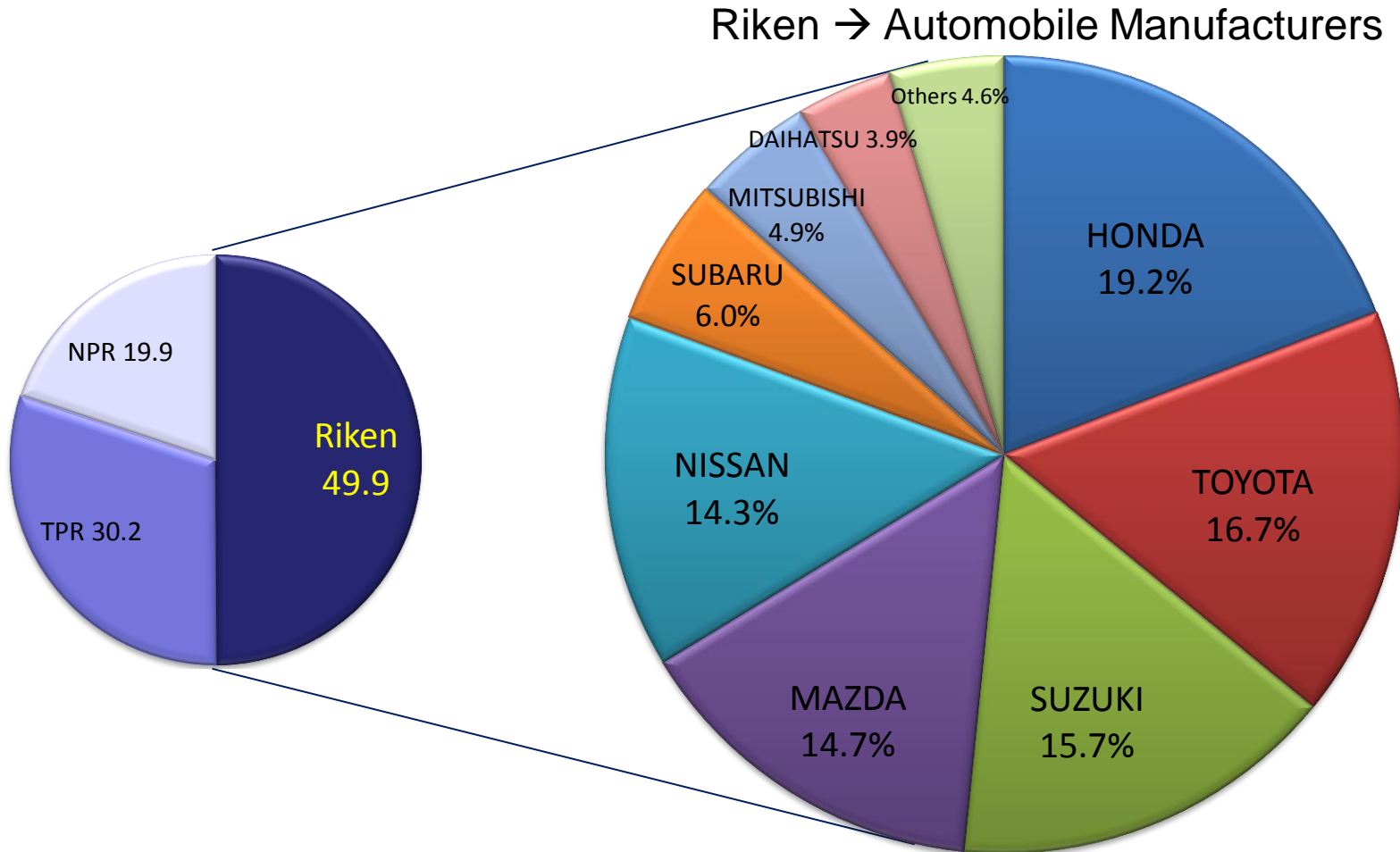


Domestic Market Share



- 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



Source: Daniel E. *Supply Chain Disruption Risk and Recovery: temporary Diversification and Its Limits*, 2011

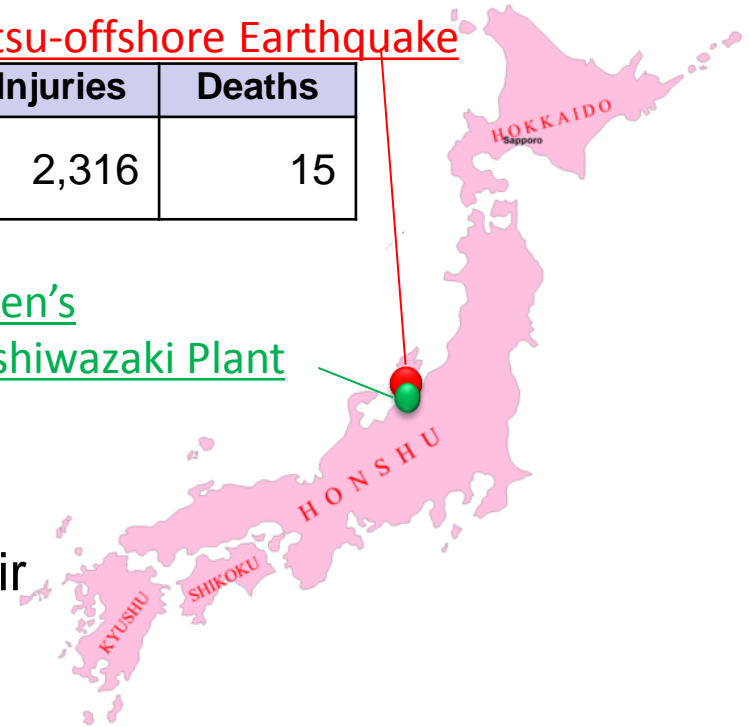
# Riken's Damages by the 2007 Niigata Chuetsu-offshore Earthquake

## Center of the 2007 Niigata Chuetsu-offshore Earthquake

Date	Magnitude	JMA Seismic Intensity	Injuries	Deaths
16 Jul 2007 10:13 a.m.	M6.8	6+	2,316	15

Holiday

Riken's  
Kashiwazaki Plant



- 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)

# Chronological Events at Riken's Kashiwazaki Plant (Operations)



Source: The Asahi Shinbun Digital (20 July 2007)

The Key Factor of Riken's Recovery: Team Work beyond Keiretsu Group  
Total 9,000 people from 25 automobile manufacturers / parts manufacturers.

Date	Days Later	Events	Operations
16 July 2007	0	The 2007 Chuetsu Offshore Earthquake struck at 10:13 a.m. All the production lines at Riken's Kashiwazaki plant had stopped. Toyota sent Riken about 20 employees to assess the situation of the damages.	0%
17 July - 2007	1	6 companies voluntarily provided 41 assistances to Riken's Kashiwazaki Plant.	0%
18 July 2007	2	Mazda sent Riken 8 employees.	0%
19 July - 2007	3	There were total 700 skilled volunteers from automobile manufacturers and parts manufacturers. ( Toyota:200 employees, Mazda: 13 maintenance engineers)	0%
22 July 2007	6	Riken started trial operation.	0%
23 July 2007	7	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.	Almost 100%
1 August 2007	16	Riken announced Riken's complete recovery.	100%

Source: Press Release of Riken and articles of Nihon Keizai Shinbun (Japan's most prestigious economic newspaper)

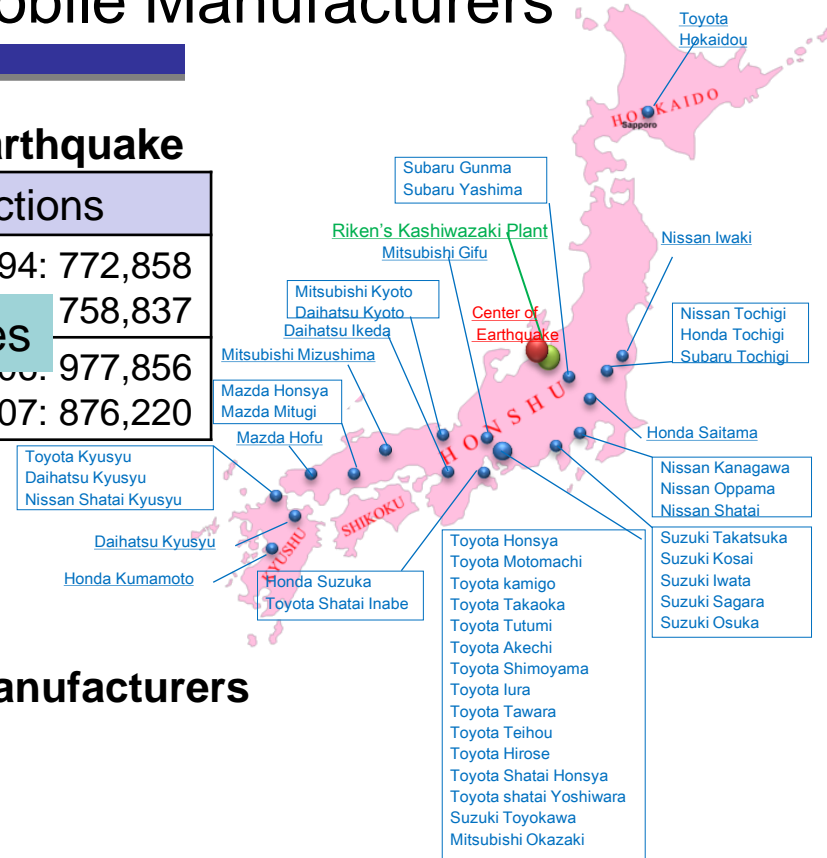
# Riken's Affects to Japanese Automobile Manufacturers

## Comparison of Reductions in Productions by the Earthquake

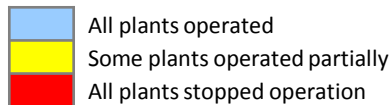
Earthquake	Reductions	Productions
The 1995 Kobe Earthquake	14,021 (January 1995)	January 1994: 772,858 July 1995: 758,837
The 2007 Niigata Chuetsu - offshore Earthquake	101,636 (July 2007)	July 2006: 977,856 July 2007: 876,220

7 times

Source: the AMDS of JAMA.



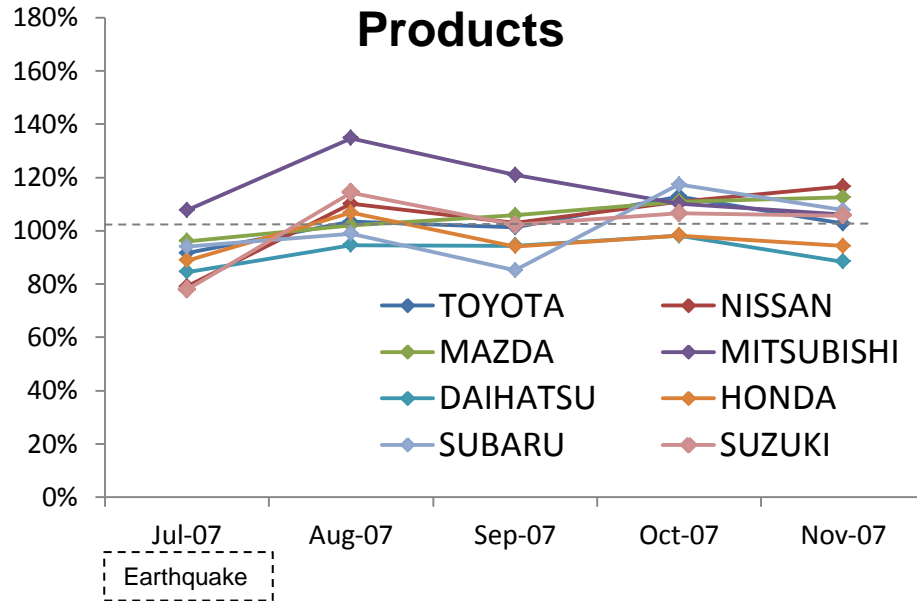
## Comparison of Operations of Major 8 Automobile Manufacturers



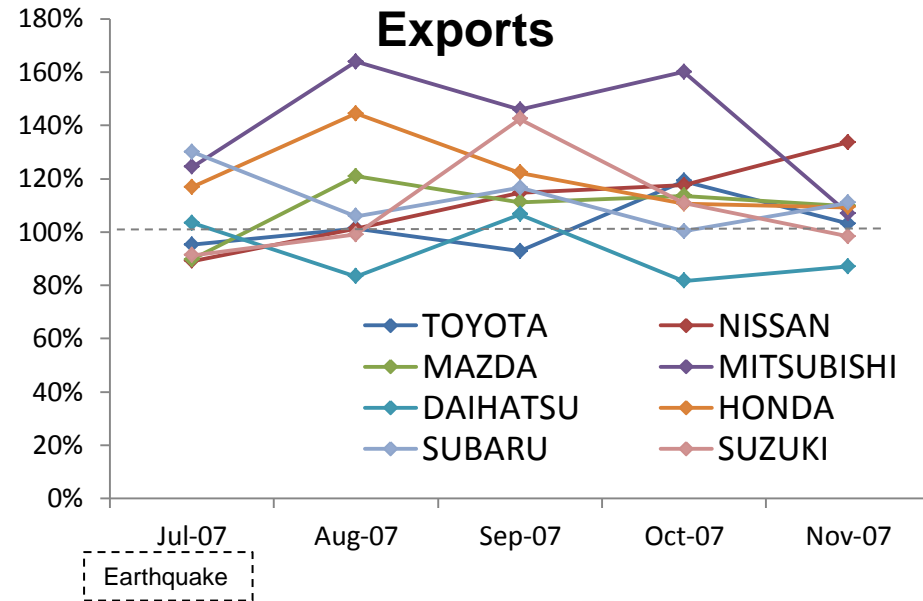
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	16 Jul	17 Jul	18 Jul	19 Jul	20 Jul	21 Jul	22 Jul	23 Jul	24 Jul	25 Jul	26 Jul	27 Jul	28 Jul	29 Jul	30 Jul	31 Jul	1 Aug
	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed
Toyota	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue
Nissan	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue
Honda	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue
Mazda	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue
Mitsubishi	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue
Subaru	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue
Suzuki	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue
Daihatsu	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue
Riken	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue

# The Changes(%) from the Previous Year of the Products and Exports

Number of the domestic finished products.



Number of the exports units in domestic productions.



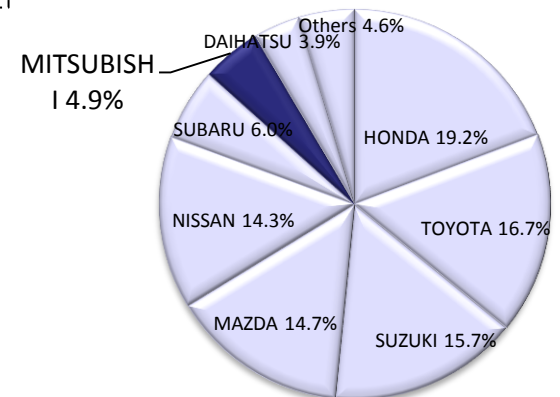
In July, 7 automobile manufacturers excluding Mitsubishi fell below products of the same month of the previous year.

Suzuki -22,413 units (-22.0%)

Nissan -22,667 units (-20.9%)

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Mitsubishi +4,836 units (+7.7%)



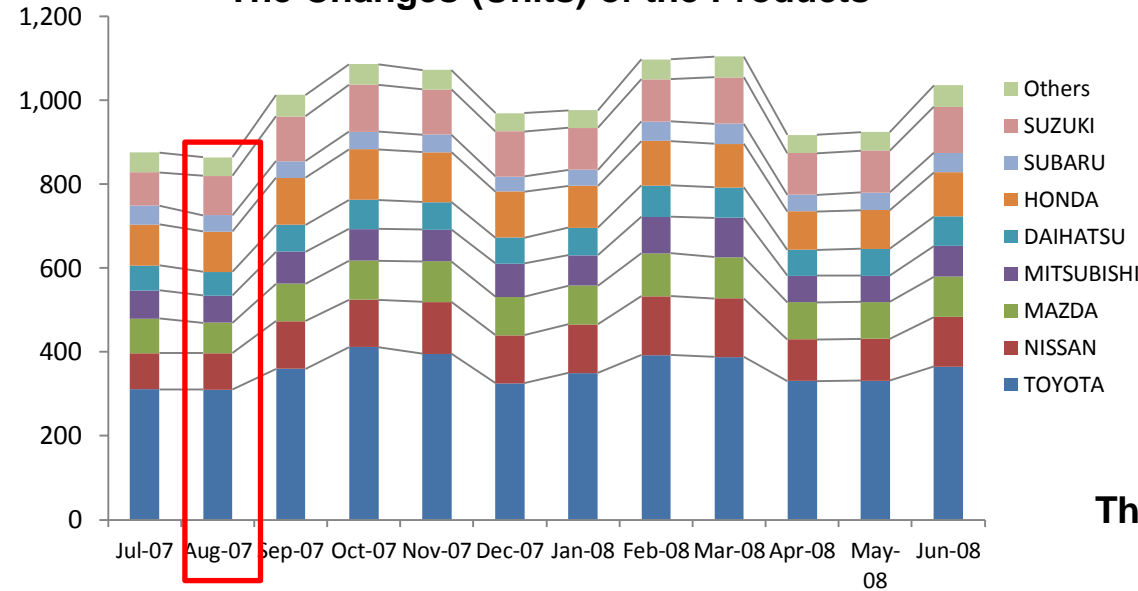
Ruken's Piston Ring

# The Changes of the Domestic Products of All Automobile Manufacturers

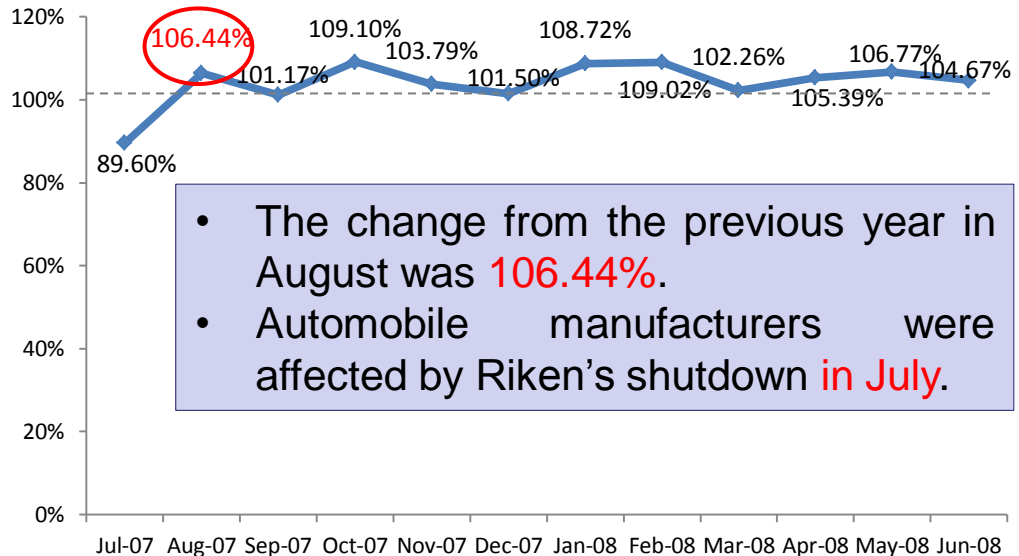
from Jul 2007 through June 2008

Thousands Units

## The Changes (Units) of the Products



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



- 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 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

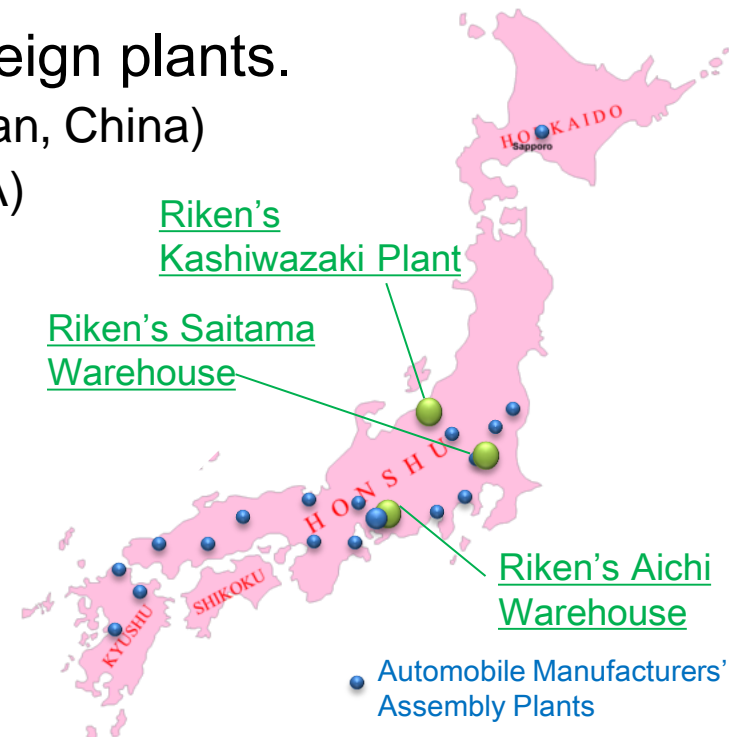
## Alternative Production

Production of piston rings spread to 2 foreign plants.

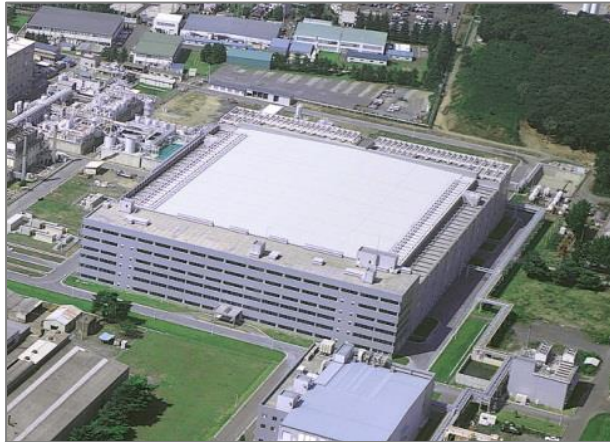
- Riken Automobile Parts Co., Ltd. (Wuhan, China)
- Allied Ring Corporation (Michigan, U.S.A)

## Standardization of Products

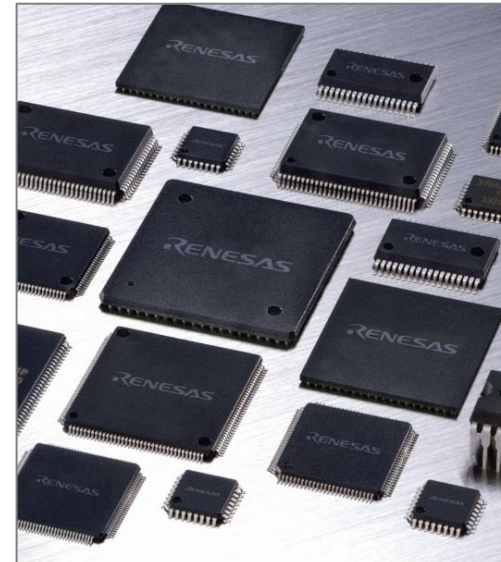
- TPR (Teikoku Piston Ring)
- NPR (Nippon Piston Ring)







300-mm line Renesas Electronics Corporation's Naka Plant  
Source: Corporate Outline of REC's.

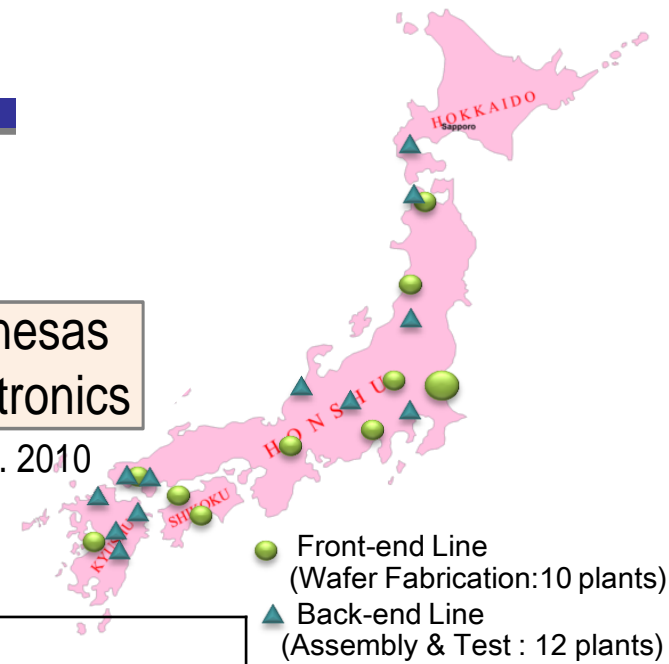
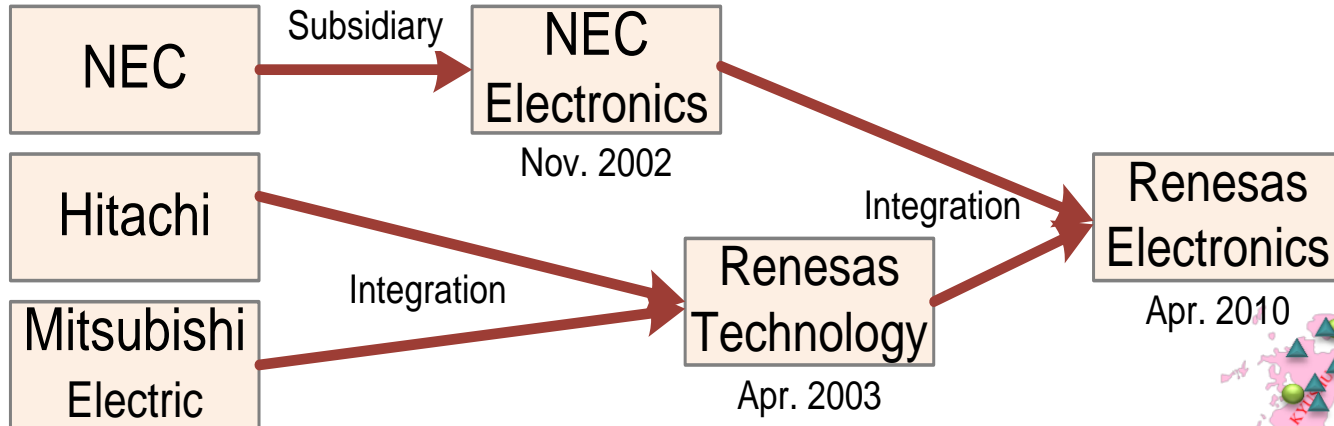


Source: Corporate Outline of REC's.

## 4. Renesas Electronics Corporation's Naka Plant

The 2011 Tohoku Earthquake

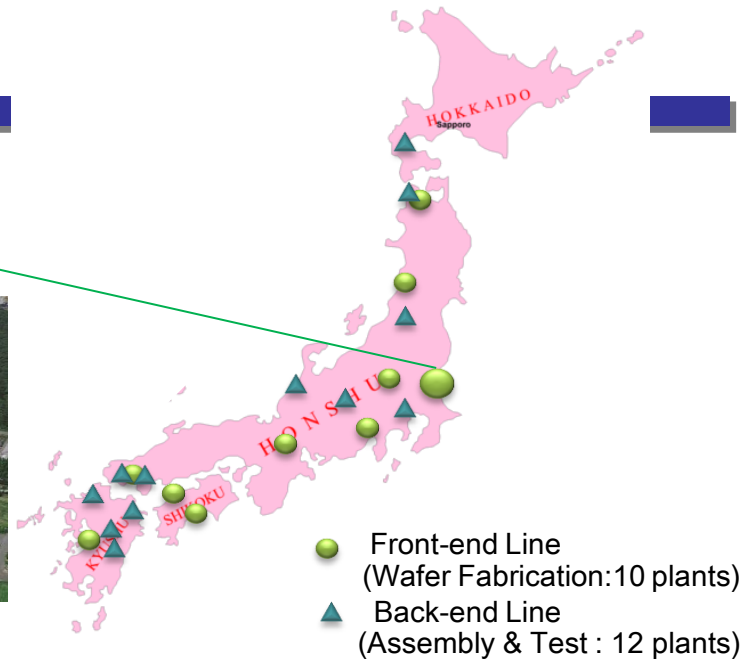
# Renesas Electronics Corporation (REC)



Capital	¥153.2 billion
Major Products	<ol style="list-style-type: none"> <li>1. Microcontroller</li> <li>2. System LSIs/SoC Devices</li> <li>3. Analogue &amp; Power Devices</li> </ol>
Employees	44,000 (Consolidated).
Group Companies	<p>In Japan</p> <ul style="list-style-type: none"> <li>▪ 1 Sales Companies.</li> <li>▪ 14 Manufacturing and Engineering Service Companies.</li> <li>▪ 7 Design and Application Technologies Companies.</li> <li>▪ 2 Business Corporations and Others.</li> </ul> <p>Overseas</p> <ul style="list-style-type: none"> <li>▪ 11 Sales Companies.</li> <li>▪ 8 Manufacturing and Engineering Service Companies.</li> <li>▪ 4 Design and Application Technologies Companies.</li> <li>▪ 6 Business Corporations and Others.</li> </ul>

# REC's Naka Plan

REC's Plant



Address	Hitachinaka City, Ibaraki Prefecture
Major Product (REC's Naka Plant)	<ul style="list-style-type: none"> <li>■ Microcontroller The Naka Plant produces a little fewer than <b>20%</b> MCUs in all REC.</li> <li>■ System LSIs/SoC Devices</li> <li>■ Analogue &amp; Power Devices. The Naka Plant produces a little fewer than <b>10%</b> of REC's Analogue &amp; Power Devices.</li> </ul>

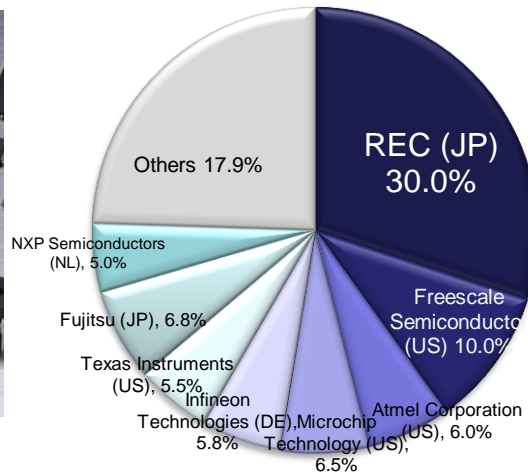


300-mm line REC's Naka Plant  
Source: Corporate Outline of REC's.

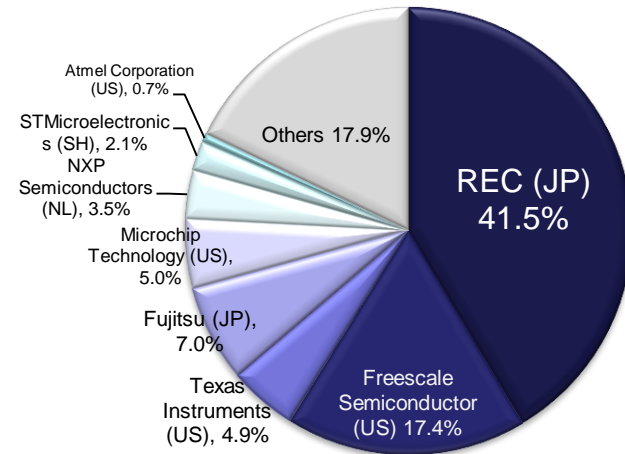
# REC's Microcontroller (MCU)



2010 MCU Market



2010 Automotive MCU Market



*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 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.

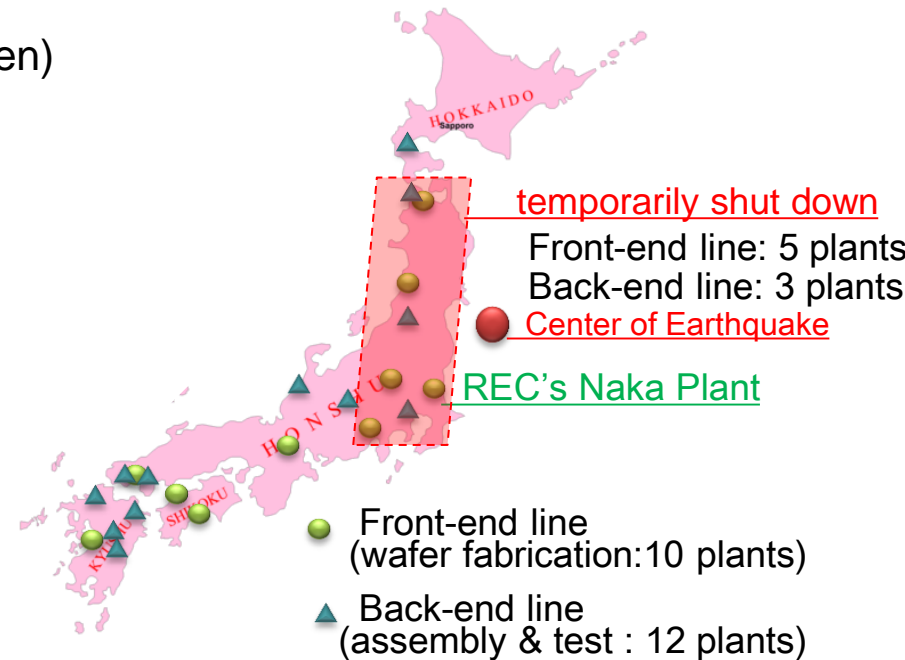
# REC's Damages by the 2011 Tohoku Earthquake

## Loss on Disaster

(In millions of yen)

Repair cost of fixed assets	43,116
Loss on disposal of inventories	7,283
Loss on disposal of fixed assets	6,187
Fixed costs during the temporary shutdown period of operations	5,919
Loss on cancellation of lease contracts	2,987
Other	12
Sub total	65,504
Insurance income receivable	(-16,000)
<b>Total</b>	<b>49,504</b>

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



## Naka Plant's Resumption Plan



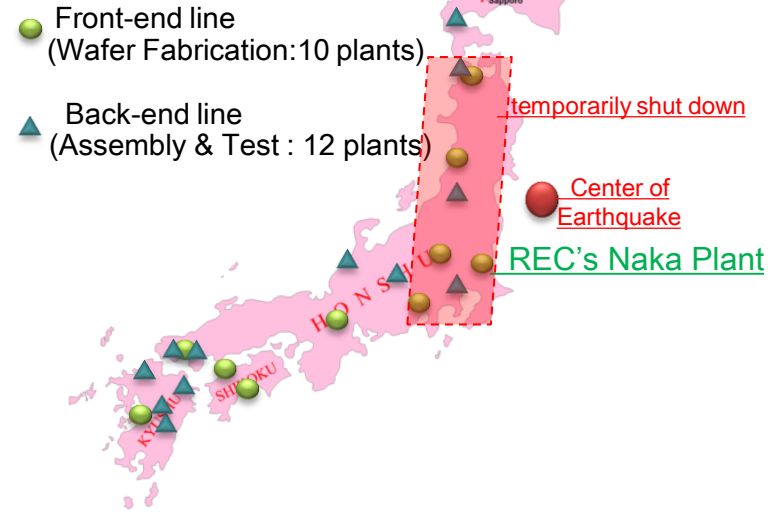
## The Key Factor of REC's Recovery: Team Work beyond Keiretsu Group, Industry

- Automobile manufacturers, Electrical manufacturers, construction industry.
- Total 80,000 people, max 2,500 assistances per day.
- 24h a day, 7days a week recovery operation.

# Chronological Events at REC's Naka Plant



Source: REC's Annual Report.

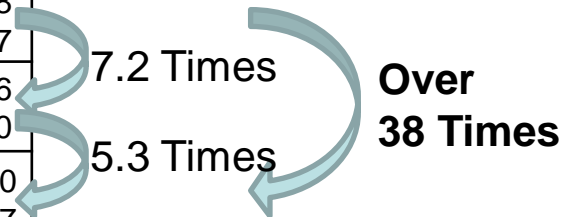


Date	Days Later	Events
11 March, 2011	0	<b>The 2011 Tohoku Earthquake struck at 2:46 p.m.</b> 7 (include Naka Plant) out of 22 of REC's plants in Japan have temporarily shut down production. REC's production volume felt to approximately 50%.
13-14 March, 2011	2-3	8 REC's offices/sites in Japan had been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

# 2011 Tohoku Earthquake's Affects to Japanese Automobile Manufactures

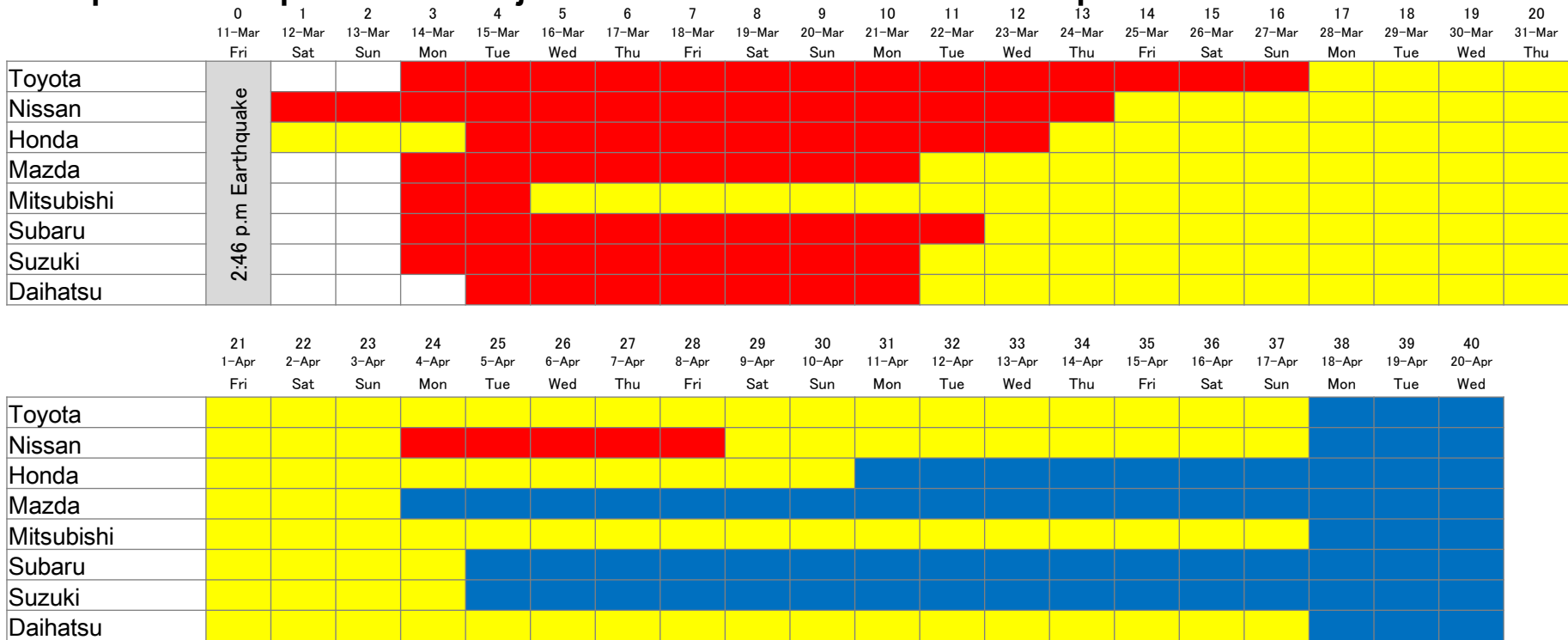
## Comparison of Reductions in Productions by the Earthquake

Earthquake	Reductions	Productions
The 1995 Kobe Earthquake	14,021 (January 1995)	January 1994: 772,858 January 1995: 758,837
The 2007 Chuetsu-offshore Earthquake	101,636 (July 2007)	July 2006: 977,856 July 2007: 876,220
The 2011 Tohoku Earthquake	541,283 (March 2011)	March 2010: 945,220 March 2009: 403,937



Source: the AMDS of JAMA.

## Comparison of Operations of Major 8 Automobile Manufacturers in Japan

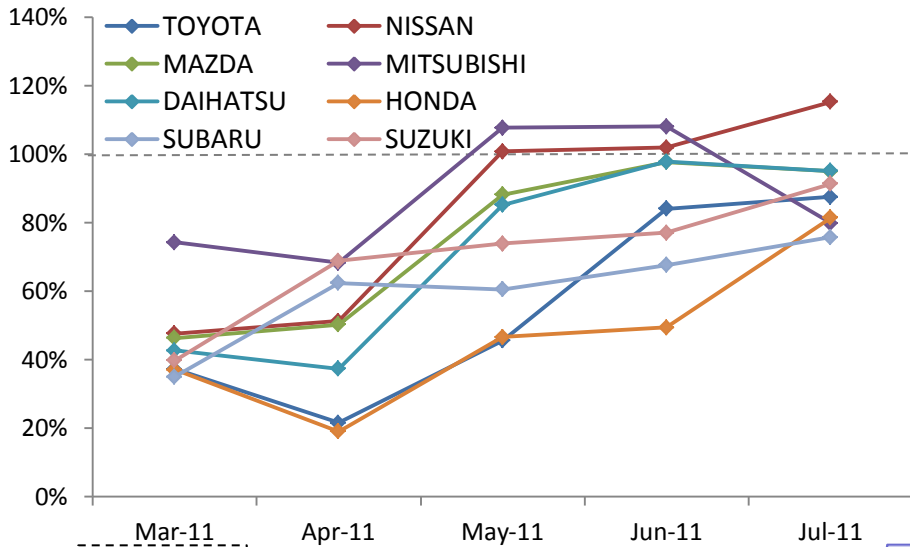


■ All plants operated     
 ■ Some plants operated partially     
 ■ All plants stopped operation

# The Changes(%) from the Previous Year

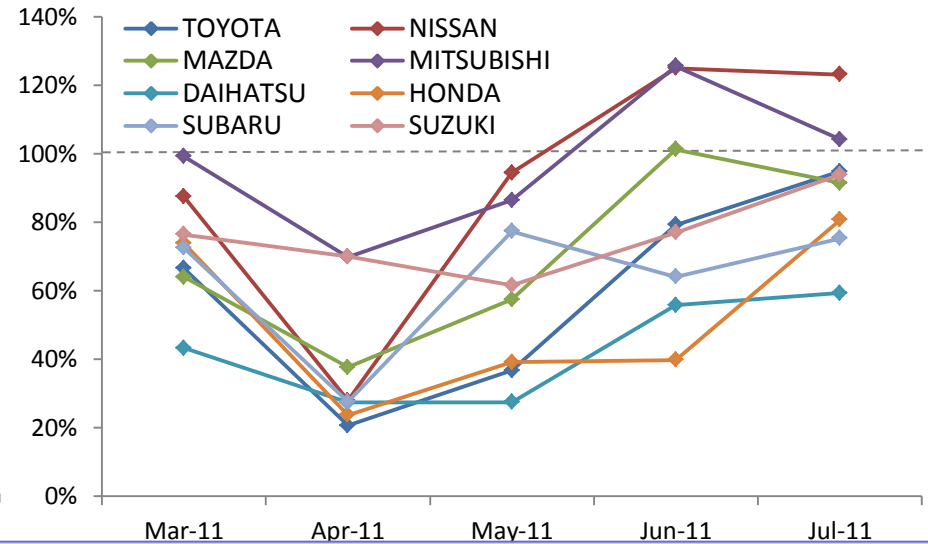
Number of the domestic finished products.

## Products



Number of the exports units in domestic productions.

## Exports



Earthquake

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.

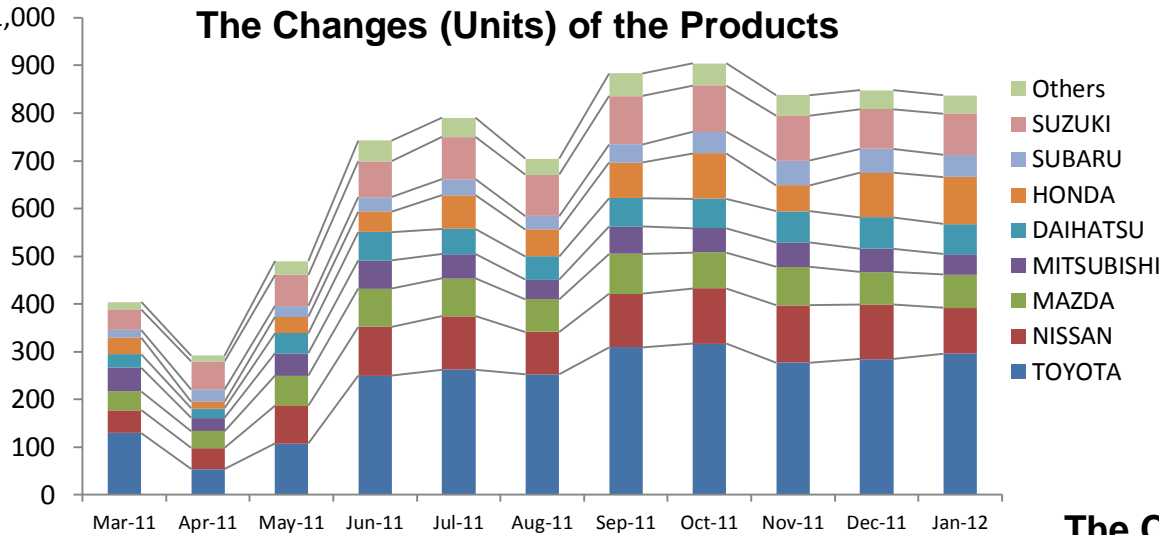


# The Changes of the Domestic Products of All Automobile Manufacturers

Thousands Units

## The Changes (Units) of the Products

from Mar 20 through Jan 2012

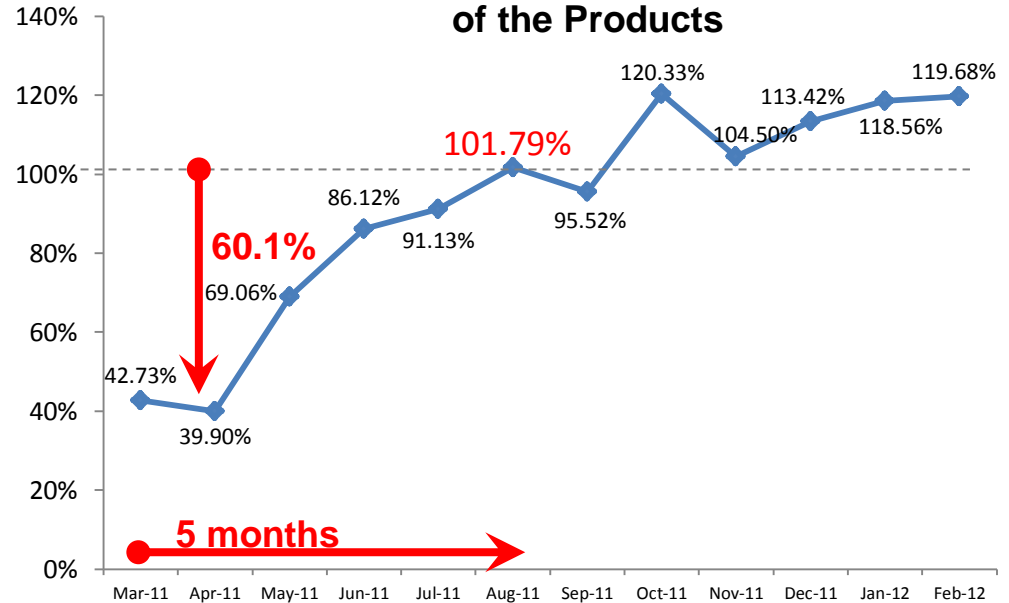


In April, there was down **60.1%** from the same month in the previous year.

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 Changes (%) from the previous year of the Products



# The REC's Provision against a Disaster

after the 2011 Tohoku Earthquake

## Facilities

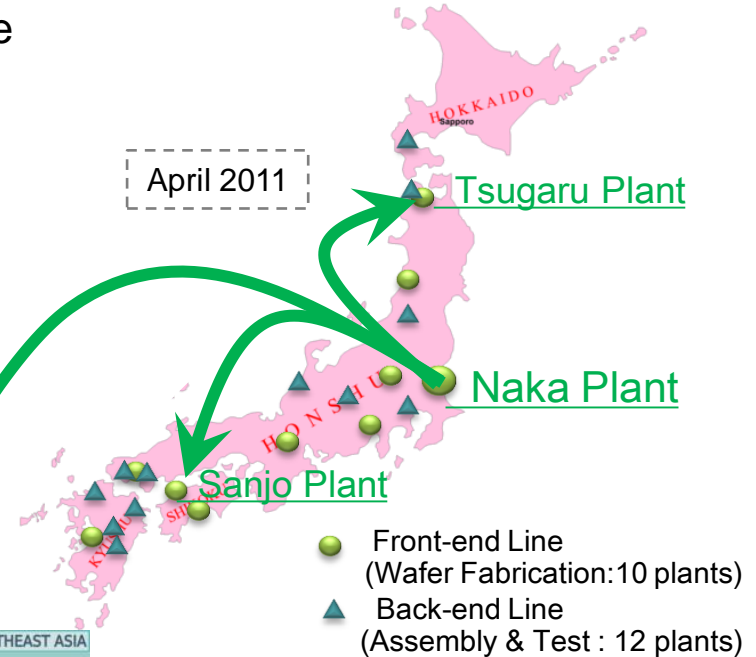
Making 10 plants strong enough so that REC can resume production within 1 month after an earthquake.

- Until the end of 2013.
- 30 billion yen.

## Alternative Production

(In April 2011)

- Tsugaru Plant
- Sanjo Plant
- Singapore Plant of GlobalFoundries  
(the world third largest Independent semiconductor foundry)

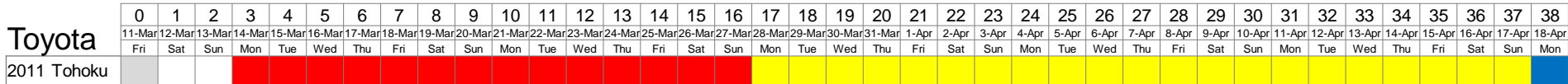
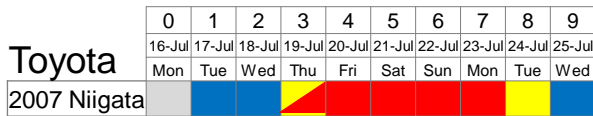


<http://www.youtube.com/watch?v=Vwkd7j65lQ&lr=1&feature=mhee>

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## **5. Summary of Earthquake Effects on Production**

# Comparison of Automobile Manufacturer's Recovery Time -1



Operation at all plants
  Part of operation at some plants
  No operation at all plants

	2007 Niigata			2011 Tohoku			(days)
	Still all plants stopped	All plants was Stopping	Still all plants resumed	Still all plants stopped	All plants was Stopping	Still all plants resumed	
Toyota	2.5	4.5	9	3	14	38	
Nissan	4	5	9	1	18	38	
Honda	7	1	9	4	9	31	
Mazda	5	2	9	3	8	24	
Mitsubishi	4	3	9	3	2	38	
Subaru	2.5	5.5	9	3	9	25	
Suzuki	3	4	9	3	8	25	
Daihatsu	2.5	3.5	9	4	7	38	
Average	3.8	3.6	9.0	3.0	9.4	32.1	

Automobile manufacturers decided that all assembly plants stopped operation from 3.8 or 3.0 days after the earthquake. Why?

# Toyota Production System - JIT

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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.

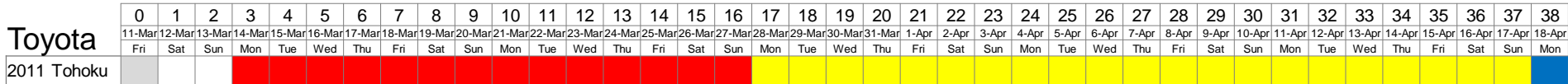
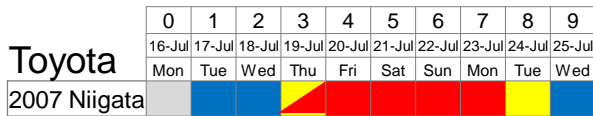
If disaster strike, (= **abnormal situation**)



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

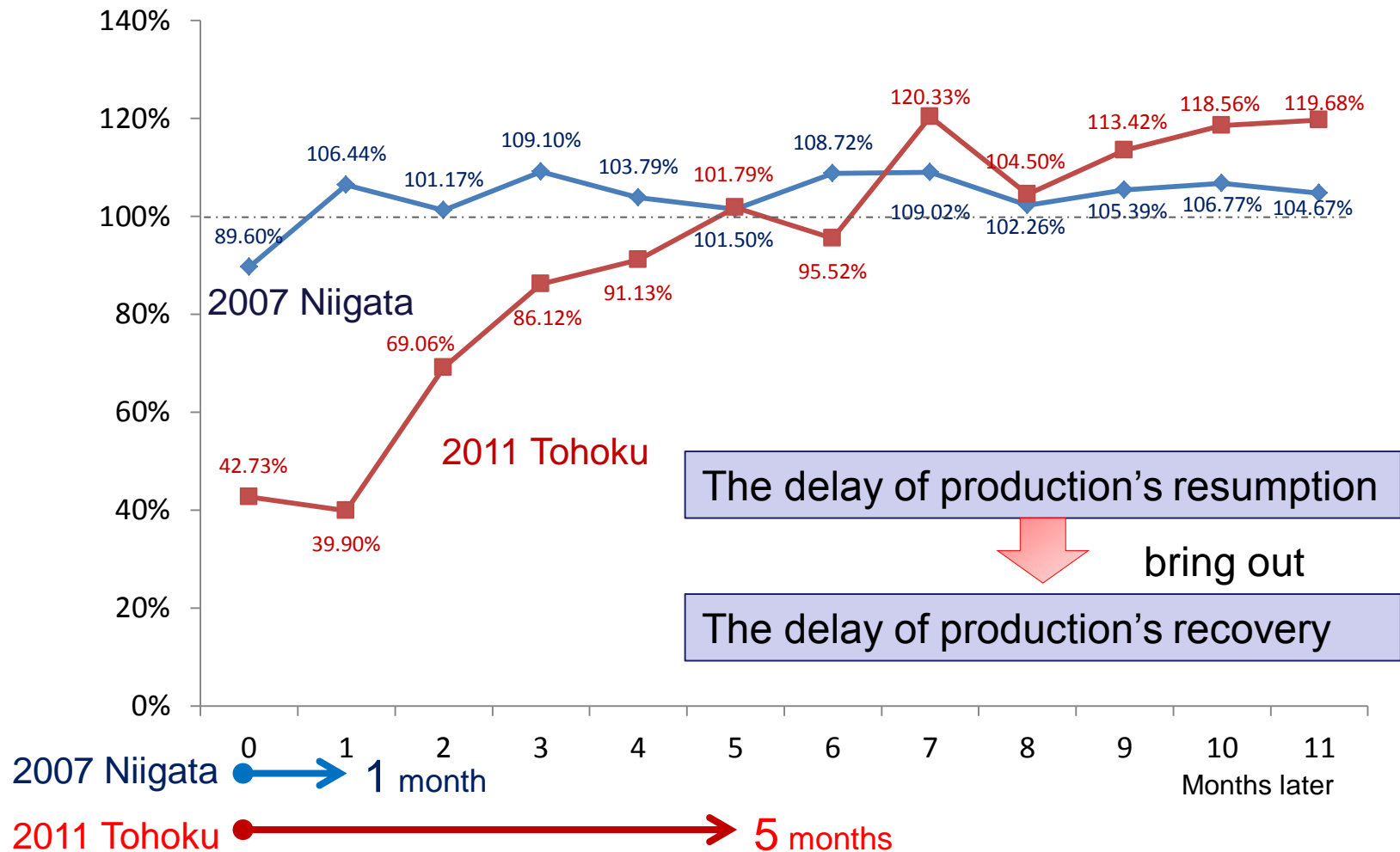


Operation at all plants
  Part of operation at some plants
  No operation at all plants

	Riken (2007 Niigata)			REC (2011 Tohoku)			(days)
	Still all plants stopped	All plants was Stopping	Still all plants resumed	Still all plants stopped	All plants was Stopping	Still all plants resumed	
Toyota	2.5	4.5	9	3	14	38	
Nissan	4	5	9	1	18	38	
Honda	7	1	9	4	9	31	
Mazda	5	2	9	3	8	24	
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Subaru	2.5	5.5	9	3	9	25	
Suzuki	3	4	9	3	8	25	
Daihatsu	2.5	3.5	9	4	7	38	
Average	3.8	3.6	9.0	3.0	9.4	32.1	

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.



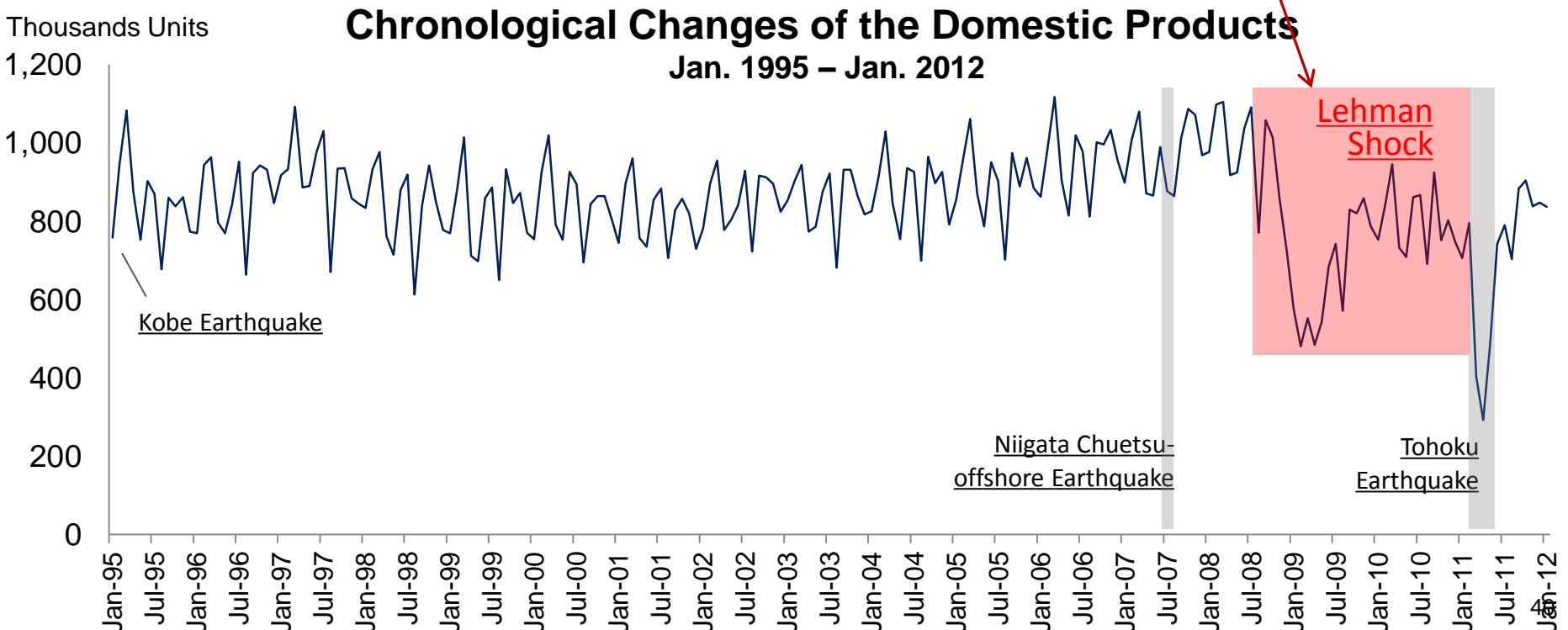
# What we have to recognize things

## 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.



# Was JIT good or no good?

Normal	Inventory Level / Cost	Transportation L.T. / Cost	Environment Adaptability
JIT	Low / Low	Short / High	High
Non JIT	High / High	Long / Low	Low

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

Abnormal (Depression)	Storage Time	Inventory Cost	Inventory Risk
JIT	Constant (short)	Constant (Low)	Constant (Low)
Non JIT	Longer	Higher	Higher

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

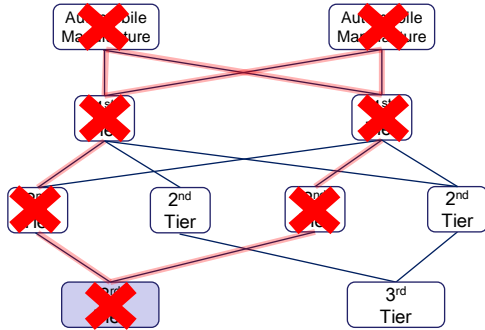
Abnormal (Disaster)	Shutdown of Plants	Loss on disposal of Inventories	Recovery Speed of Plants
JIT	Damaged Plants: Immediately Other Plants: Earlier	Damaged Plants: <b>Low</b> Other Plants: Non	Damaged Plants: <b>High</b> Other Plants: <b>High</b>
Non JIT	Damaged Plants: Immediately Other Plants: Later/Avoid	Damaged Plants: High Other Plants: Non	Damaged Plants: Low Other Plants: Low

"Recovery Speed" are very importance!

It is impossible to say definitely that 'The Limitations of JIT' exists

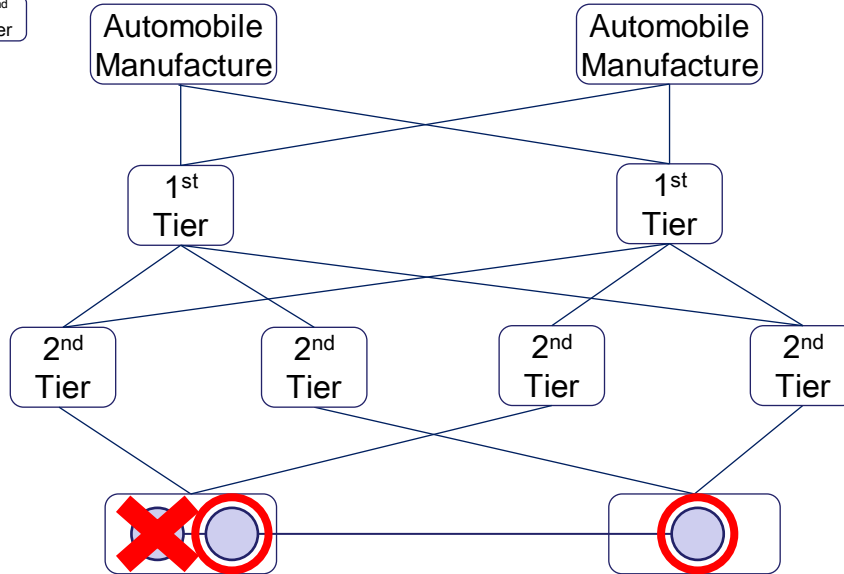
# If plant suffer disaster, ...

## Riken & REC



Almost every automobile manufacturer affected by earthquake.

## In future



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

# Conclusion

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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

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- 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.

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Thank you for your kind attention.