



IDENTIFICATION OF BOTTLENECKS OF BUSINESS RECOVERY FROM WIDE-AREA EARTHQUAKE & FLOOD DISASTER

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Abstract

This study aims to identify bottlenecks of business recovery from wide-area disasters such as the Great East Japan Earthquake in 2011 and the West Japan Torrential Rains in 2018. These disasters which have impacted wide areas which includes multiple prefectures revealed various hindrance factors of business recovery which were not significant in previous earthquake disasters such as the 1995 Hanshin-Awaji (Kobe) Earthquake or the 2007 Niigata Chuetsu-oki Earthquake.

Business and professional journal articles documenting facts on damage on industries and interruption of individual companies' operations, reports by local chambers of commerce and reports by individual companies were systematically collected and reviewed. Also, industry reports by the Development Bank of Japan and the Japan Industrial Location Center were reviewed. Individual case stories of 307 companies which were seriously affected by the Great East Japan Earthquake were compiled and analyzed.

The various hindrance factors of business resumption and recovery were extracted, and they were classified into "internal" and "external" factors. The "internal" factors are for example, damage to equipment and facilities in factories, loss of employees, which are induced by the earthquake or tsunami. The "external" factors are prolonged loss of utility services including electricity, gas, telecoms, loss of incoming supplies due to damage to the supplier companies, paralysis of transportation, scarcity of fuel, reputational risk, cancellation of previous orders and decline of demand. These are "external" in the sense that these risks are difficult to manage by the companies themselves. Furthermore, some of these external factors are resources subject to competition among the companies who wish to resume their businesses as soon as possible. Competition to secure fuel for transportation and power had negative impact on many industries. Such competition did not emerge in case of disasters where the directly affected geographical areas were limited. In case of the Kumamoto Earthquake in 2016, the physical destruction in the directly hit area was enormous, however since the hard-hit areas were limited, there were enough resources for business recovery outside the directly hit area. Therefore, companies were able to procure necessary supplies and transportation for recovery. In case of the 2018 West Japan Torrential Rains, due to the long disruption of JR Freight Railway, many companies were in acute need of cargo transportation, and the competition for securing alternate trucks for cargo emerged. Land transportation became the bottleneck in recovery.

The companies were classified into manufacturing, retail & wholesale and transportation. These "internal" and "external" factors are plotted according to the time period after the disaster. This revealed the characteristics of hindrance factors of business recovery.

These findings are expected to be reflected in the preparedness measures for industries and business continuity planning of individual companies to mitigate economic damage by possible Nankai-Trough earthquake.

Keywords: BCP, Bottleneck, Business Recovery, Resource Scarcity, Externality of Resources



1. Introduction

A gigantic tectonic earthquake and consequent tsunami are foreseen to hit the western Pacific coast of Japan in the near future. The affected areas will be quite wide, ranging from Shizuoka to Miyazaki prefectures and including Nagoya and Osaka Metropolitan Areas; hence the number of affected companies will be quite huge and the consequences are foreseen to cascade to areas which are not directly hit by the earthquake and tsunami and abroad through supply chains. Thus, it is important to draw the lessons from what happened in the case of the 2011 Great East Japan Earthquake (GEJE) and the 2018 West Japan Torrential Rains which both affected multiple prefectures in Japan.

2. Methodology

We have searched through article databases of Nikkei Newspaper & Nikkei Business Publishing, Toyo Keizai and Diamond Weekly (the three major business magazines in Japan) for articles on damage to companies' operation and recovery by the 2011 Great East Japan Earthquake. Individual documentary publications on business recovery and reports by the Iwate, Miyagi, Fukushima and Ibaraki Prefectures, Development Bank of Japan, Japan Industrial Location Center and others were checked. A total of 64 documents regarding 307 companies were collected.^{[1]-[32]} Through careful examination of the articles we have noticed that most of the collected cases were regarding manufacturing, retail/wholesale and transportation companies. Therefore, we have decided to focus our analysis on these three categories of industries and tried to identify what are the bottlenecks which hinder the recovery and resumption of operations of these industries. Since cases of manufacturing companies numbered the most, primary focus was put on manufacturing industries.

Similar approach was made for the West Japan Torrential Rains in 2018 which heavily affected prefectures of Hiroshima, Okayama, Ehime and claimed 237 lives. In addition to the above-mentioned sources, online newsletter database of Risk Taisaku.com, periodic reports by METI Chugoku and Bank of Japan Okayama and Hiroshima branch focusing on business recovery, and databases of local newspapers were searched. A total of 175 documents were collected. Furthermore, in 2019, we made interviews to companies which were directly affected by this flooding disaster.

3. Identification of bottlenecks in case of Great East Japan Earthquake

The individual cases of companies vary depending on their location and their type of business and other factors. Each case has its own story. Our aim is to draw lessons for future similar large-scale disasters. Through the review of individual articles and reports we have extracted that the bottlenecks can be largely classified into "internal factors" and "external factors".

"Internal factors" are various obstacles in the company arising directly from the disaster, such as physical damage to buildings & facilities, loss & injury of employees and lack of employees due to absence. Numerous companies suffered from this type in the direct hit areas by the earthquake. Ground liquefaction lead to gaps in production lines which forced halt of operation for a long period. Tsunami inundation washed away equipment and facilities. Business disruption by internal factors to on-site companies are common to any earthquake, tsunami or flood disasters.

"External factors" are disruption of utilities such as electricity and water, disruption of transportation means due to damage to roads and ports, shortage of fuels for transportation, disruption of supply chains leading to shortage of raw materials & parts, planned power outages leading to rescheduling of factory operations, loss of sales due to rumors & restriction of distribution arising from radioactive precautions. Business interruption by external factors such as disruption of utilities are revealed when the direct hit area is broad, and the negative consequences spread out to a wide area. Through supply chains, business disruption to companies in the direct hit areas cascade to neighboring and remote areas, even beyond national borders.



Also, rapid change in the business environment, such as sharp decline of tourists and consequent decrease of souvenir sales is another external factor.

These factors are classified as Table 1.

Table 1 – Various bottleneck factors which hinder business resumption

Factors			
Internal factors	Physical damage to buildings & facilities	Loss or injuries of employees	Loss of critical data
External factors	Disruption of utilities (electricity, water etc.)	Disruption of communication lines	Shortage of fuel
	Damage to roads and ports, Disruption of rail	Halt of supply chain, lack of supply parts	Damage to distribution centers
	Planned power outages	Disruption of waste disposal	Disruption of sewerage disposal
	Cancellation of orders, Decline of demand	Finance shortages	
	Rumors & restriction of distribution	Leakage of radioactive fumes	

4. External factors affecting manufacturing companies in GEJE

Damage to supplier companies lead to shortage of parts and materials. Thus, some companies were forced to rearrange their production system and/or change the specifications of their products. In cases where the product specifications could not be changed, alternate parts and/or materials could not be accepted, the manufacturers had to limit or halt their productions. The planned power outages and restrictions on electricity consumption, damage to the roads and ports, disruption to the cargo transportation due to lack of fuel, furthermore, affected the production and became bottlenecks of business continuity and recovery operations.

4.1 Examples of external factor becoming bottlenecks for manufacturing companies

Shortage of necessary parts due to disruption of supply chain: The production line of the factory was restored but was not able to receive materials and important parts from our supplier, thus the production was delayed. A company was located in the Japan Sea side of Tohoku, no direct damage from the earthquake nor the tsunami, however supplier to the company had damage therefore the shortage of parts prolonged for several months. A company faced difficulty in obtaining plug-in electrical cables for wiring the factory.

Shortage of gasoline: Since majority of the employees commuted by their own cars, some of them were forced to be absent due to lack of gasoline.

Power outage after the earthquake: The factory had UPS system, however due to the prolonged commercial power outage, the main factory control system eventually went down. The emergency electric power generator did not function, which was totally unexpected. Power outage lead to halt of factory automation system, employees were forced to stay home.

Planned power outage: The schedule of “planned power outage” was not duly informed beforehand by TEPCO. Since copper refinery process must avoid unexpected interruption, metal factory was forced to cease for a long period. Medical syringes, to meet sanitation requirements must be produced within 12 hours from start, to avoid unexpected interruption, their production plan had to be delayed unexpectedly.



Interruption of telecommunications: The earthquake and tsunami damaged numerous mobile phone station towers which lead to paralysis of communications in the region and took hours to confirm the safety and whereabouts of employees.

Stoppage of industrial water supply: Factory could not operate due to shortage of industrial water for cooling.

Cancellation of contracts: Due to stoppage of utilities and shortage of fuel, and damage to the suppliers of parts, a company had to cancel all of the sales contracts which was done before the earthquake.

Shortage of nitrogen gas: Nitrogen gas is indispensable to prevent fire & explosion, but the nitrogen gas supply plant was damaged and the shortage of gas lead to halt of the factory.

Shortage of hydrogen peroxide water: The halt of the neighboring Kashima industrial complex lead to shortage hydrogen peroxide water which is indispensable for bleaching of paper products.

Congestion and delay of works: In the confused aftermath of the earthquake, unable to find a building works professional for factory.

Refusal by repair worker: Needed repair of electrical works in the factory but was refused to come to the factory since it was located 50km from the nuclear power plant.

Reputational damage: Faced decline in demand of our products due to reputations regarding the nuclear power plant failure.

Inspection of radioactivity: The news of radioactive iodine found in Tokyo tap water supply, forced to halt the production line of food. Foreign importers demanded certificate of non-contamination by radioactive ash regarding our products.

Erroneous information: A Taiwanese thinktank published a fake report stating that a ceramic condenser factory was damaged, a rival company in Asia approached their traditional customer as an alternate supplier and imitation of their products went on market. The company immediately asked the thinktank to correct their report, however it took about a week to convince the customers of the accurate information.

4.2 Effect of external factors hindering business resumption by industry type

In order to further clarify the effect of external factors hindering business resumption to manufacturing industries, we have further classified the reports by industry type as Table 2. Major findings are as follows.

Among the disruption of utilities, loss of electric supply is serious compared to loss of water supply.

Disruption of logistics for physical distribution, affected most of the manufacturing companies.

Damage to ports affected many of the companies producing industrial materials.

Disruption of supply chain affected a wide array of industries, especially food, beverage and transportation equipment (automobiles) manufacturers were seriously affected, since many of their suppliers were damaged.

Planned power outage had seriously affected food & beverage manufacturers, also manufacturers of industrial materials and electric & electronic parts were affected. Processed food production which requires fermentation requires uninterrupted electric power supply for hours. Natto made from soybeans requires 20 hours of fermentation. Leavening of bread also require uninterrupted power supply. Fermentation of yoghurt as well. A manufacturer of yoghurt had to cease their production of Kanto factory and concentrate their production in Kyoto factory but was not able to meet the entire demand thus decreased their sales in Kansai.



Table 2 – Various bottleneck factors which hinder business resumption by manufacturing industry classification

Manufacturing Industry Classification	Number of Cases Surveyed	Utilities Disruption			Logistics, including shortage of fuel
		Electricity	Water	Gas	
FOOD, BEVERAGES, TOBACCO AND FEED	28	2	1	0	1
TEXTILE, CHEMICAL, PLASTIC, RUBBER, PULP, PAPER, PETROLEUM AND COAL PRODUCTS	116	16	11	7	2
CERAMIC, STONE AND CLAY PRODUCTS	7	1	0	0	1
IRON ,STEEL, NON-FERROUS METALS AND FABRICATED METAL PRODUCTS	22	2	0	1	2
GENERAL-PURPOSE MACHINERY, PRODUCTION MACHINERY AND BUSINESS ORIENTED MACHINERY	22	3	1	0	4
ELECTRICAL MACHINERY, EQUIPMENT, SUPPLIES, ELECTRONIC PARTS, DEVICES, ELECTRONIC CIRCUITS, INFORMATION AND COMMUNICATION ELECTRONICS EQUIPMENT	74	7	5	2	5
TRANSPORTATION EQUIPMENT	23	0	0	0	2
MISCELLANEOUS MANUFACTURING INDUSTRIES	8	1	1	1	1

Table 2 - continued

Transportation Infrastructure			Supply Chain Disruption			Production System			
Road	Railway Bus	Port	Shortage of Parts and Materials	Interruption and Delay of Products Supply	Damaged Supplier	Sortage of Oil	Planned Power Outage	Standard of Products	Shortage of Stock
3	1	0	6	4	5	1	8	2	1
3	0	4	9	5	1	2	4	0	5
0	0	0	0	0	0	0	0	0	2
1	0	1	0	0	0	0	0	0	1
0	0	0	4	1	1	1	0	1	1
1	0	2	12	1	2	2	4	1	0
1	1	0	10	1	12	0	1	2	3
0	0	0	0	0	0	0	1	0	0



Table 2 - continued

Accident of Nuclear Power Plant			Other
Restricted of Output	Evacuation	Reputation Damage	
2	1	3	4
2	4	0	8
0	1	0	0
0	0	0	2
2	0	0	1
0	3	1	7
0	1	0	0
0	2	0	0

5. Cascading effects of bottlenecks for manufacturing industries in GEJE

Analysis of external factors to manufacturing revealed that various damage to companies in the earthquake and tsunami hit areas propagate to other companies through supply chains. Also, shortage of fuel and power outages in the areas not directly affected by tsunamis propagate to other companies in other locations.

Direct damage to factories of parts and supplies cascade to manufacturing factories in distant locations in several time series, immediately after, in one week and in one month. These “user” manufacturing companies are found to resume their operations & shipping in 1 to 3 months, however the recovery of their suppliers tend to be delayed. The propagation of these cascading effects reached out to distant locations, for some “rare” parts or materials even crossed borders to U.S.A.

Also, this cascading effect spread out to other categories of manufacturing, for example, metal parts manufacturing to food & beverage manufacturing, coal & petroleum product manufacturing to chemical and printing, electronic device manufacturing to automobile manufacturing.

Figure 1 shows 4 typical examples of cascading effects of bottlenecks which started from a direct damage to a manufacturing company (internal factor for that company), and then propagating through supply chains to other companies (external factor for these companies).

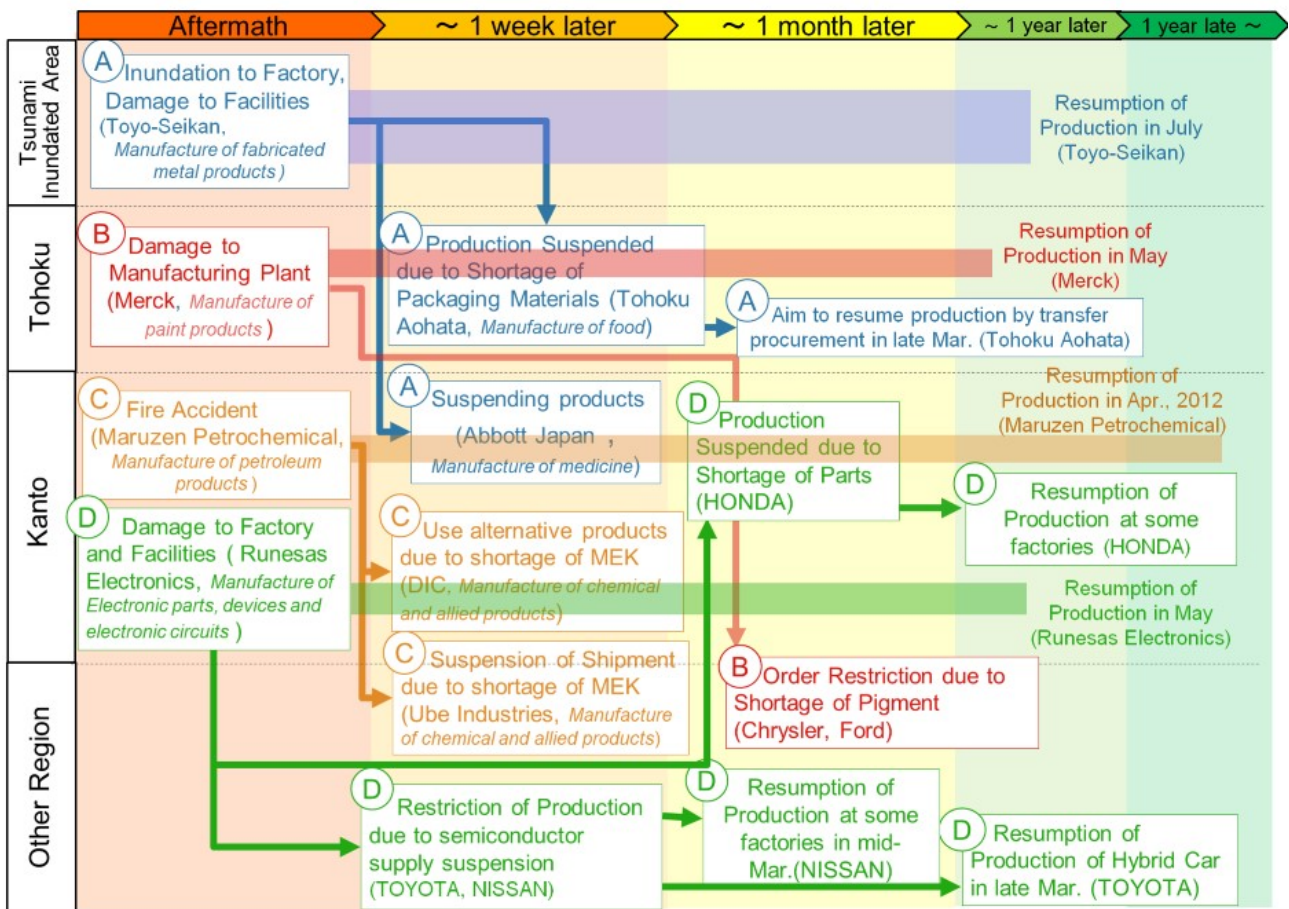


Fig. 1 – Examples of cascading effects of bottlenecks for manufacturing industries

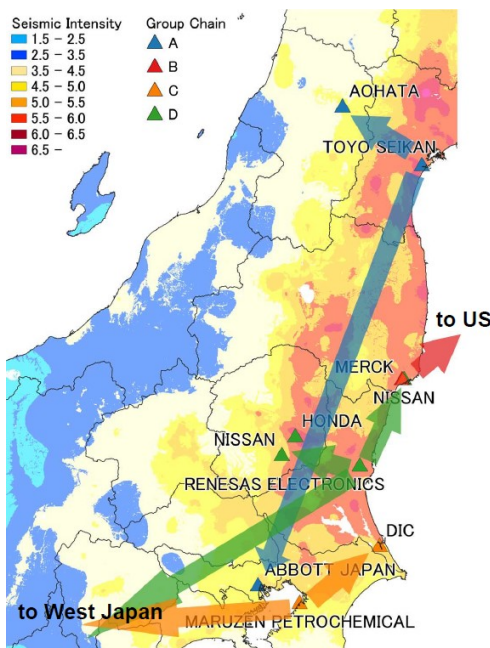


Fig. 2– Geographical relations of propagation of cascading effects to manufacturing industries

The colors on the base map indicates the seismic intensity (JMA scale) observed in the Great East Japan Earthquake. The colors of the triangle and arrows relate to the 4 cases of propagation of cascading effects shown in Figure 1.

The origin starts in the tsunami inundated area and/or strong seismic intensity area, the cascading effects propagate outside of these areas.



6. External factors affecting wholesale/retail companies in GEJE

The damage to manufacturing companies and disruption of supply chains lead to shortage of merchandise. Shortage of fuel affected wholesale/retail companies in various aspects. Consumer demand for merchandise fluctuated, sharp increase for certain items, on the contrary, reputations dropped demand.

6.1 Examples of external factor affecting wholesale/retail companies

Shortage of merchandise: Could not fill the store shelves due to shortage of merchandise coming from damaged manufacturer. Some customers bought up certain items from their anxiety, thus in a convenience store chain most of their shops in Kanto area lacked certain merchandise. For example, there was great demand for gas cartridge for table-top cooker (due to damage to gas and electricity supply to households).

Shortage of fuel: Some employees were not able to commute by their car due to shortage of gasoline. Shortage of heavy oil for food factory lead to shortage of ready-to-eat food. Hot pots became very popular menu but could not meet the demand for chicken meat due to shortage of fuel for steam processing for sanitation of meat.

Planned power outage: The store hours of department store had to be shortened accordingly and this lead to decline of sales.

Competition with overseas: The halt of domestic production lead to influx of similar products handled by foreign companies. Although the domestic production resumed in due course, lost the price competition and went out of business.

7. External factors affecting transportation companies in GEJE

Transportation companies were influenced by various external factors. The damage to roads, ports and transportation facilities, shortage of fuel, disruption of utilities all affected transportation companies. The damage to ports cascaded to shortage of fuel and halt of LNG supply, then to difficulties for employees to commute by cars, diversion of routine delivery routes, then cascaded to other industries, such as retail and publishing industries.

7.1 Examples of external factor affecting transportation companies

Shortage of fuel and driver: Parcel delivery service centers had to be closed and to be integrated and faced shortage of fuel and driver. Had to limit the parcel services to acceptance and delivery only at service centers and no home delivery.

Shortage of supply parts: A manufacturing factory of electrical parts of train motors was damaged, the supply of the parts to West Japan Railway Shinkansen Bullet Trains faced shortage, number of Shinkansen services had to be restricted in western Japan.

7.2 Cascading effects of bottlenecks for transportation companies

Analysis of external factors to transportation companies revealed that various damage to transportation facilities and manufacturing companies in the earthquake and tsunami hit areas propagate to transportation companies through supply of fuel and parts. Also, difficulty in securing employees especially drivers restricted transportation services. Disruption of transportation and shortage of truck services affected a wide range of industries nationwide. Consequently competition over limited supply of on-spot truck services prevailed for about a year.



Figure 3 shows examples of cascading effects of bottlenecks which started from a direct damage to transportation facilities, including ports, and then to transportation services and further to other companies (external factor for these companies).

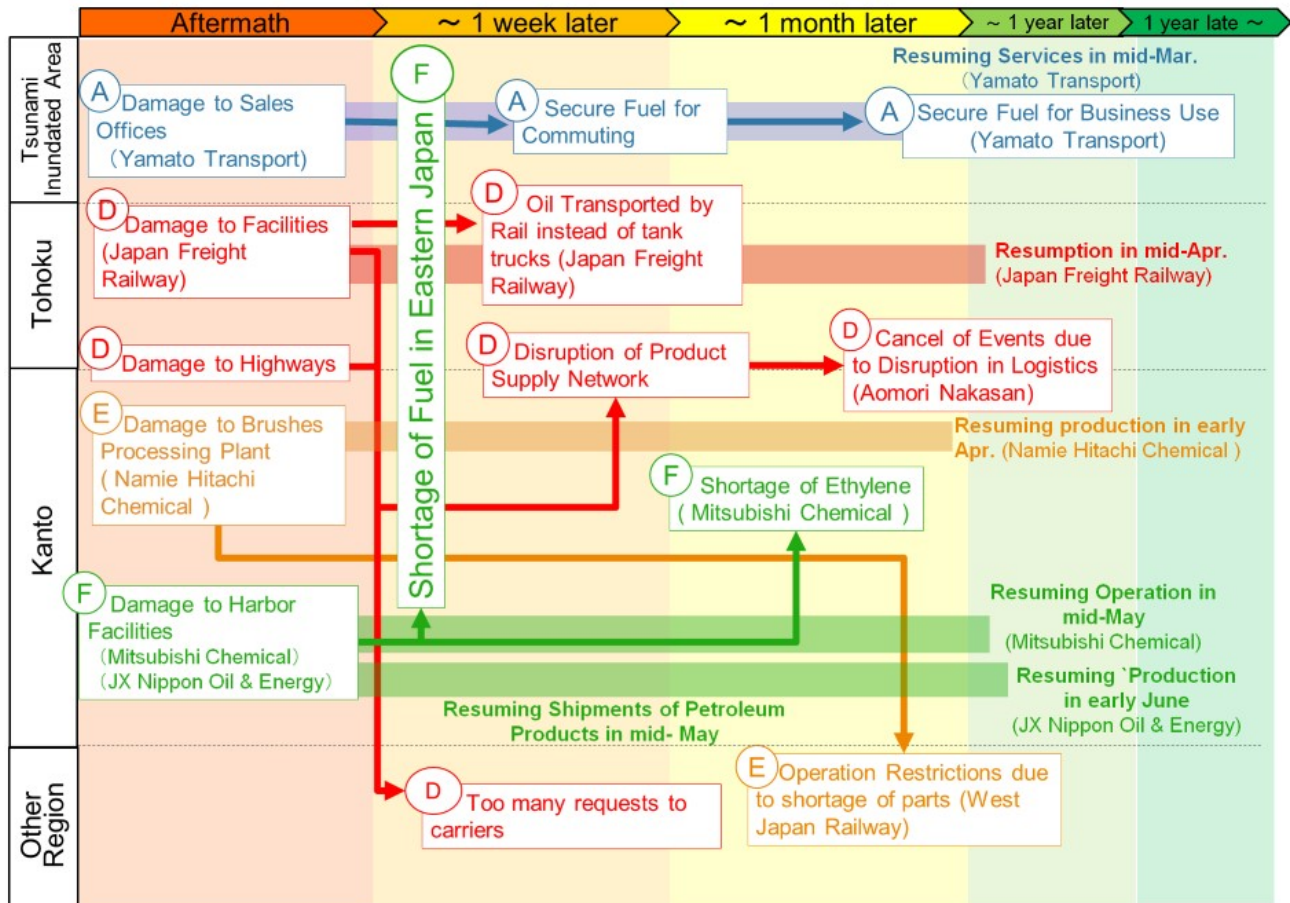


Fig. 3 – Examples of cascading bottlenecks for transportation industries

8. West Japan Torrential Rains 2018

From 28 June to 7 July 2018 an active rain front prevailed over western Japan which was then stimulated by Typhoon Prapiroon. Western half of Japan experienced record-breaking rainfall up to twice to quadruple of monthly rainfall in one week. 232 casualties and 459 injuries. This rainfall induced wide area inundation and numerous landslides especially in the prefectures of Hiroshima, Okayama and Ehime. Arterial roads and railroads were damaged and halted passage for weeks. Electricity, gas and water supplies were disrupted.

The physical inundation and landslides seriously affected numerous companies as “internal factors”. In addition, the disruption of transportation seriously affected the commuting of employees and transportation of materials, supplies and products as “external factors” for the companies in the torrential rain affected areas. In the Hiroshima metropolitan area, the stoppage of JR West Kure line had serious consequences to the commuters.^[33] Furthermore, the stoppage of JR West Sanyo Honsen which is the main artery rail connecting Osaka and Kyushu, forced nationwide parcel service companies to delay and detour their services.^{[34][35]}

In addition to the survey of documents and databases, we visited Hiroshima in December 2019 to the affected companies for interviews. In the interview with Mazda, one of the major automobile company, their



own factory did not suffer direct damage, some of their suppliers had damage which was some obstacle for their operation, they reported that the stoppage of JR lines was the biggest bottleneck for their resumption of operations. Mazda had to wait till 10 Sept., when the JR West Kure line resumed services, for their full operation, since their employees faced difficulties in commuting.^[36] In the interview with 3 SMEs in Kure City and Kure Koiki Society of Commerce and Industry, in addition to the direct damage by inundation, the blockage of roads by floods and subsequent chronic traffic jam was identified as serious bottleneck to resumption of business.^[37]

9. Conclusion

The ground motion and the tsunami inundation by GEJE claimed lives, brought physical damage to factories, retail shops, transportation facilities and utilities. Companies directly suffered from these phenomena as “internal factors” hindering their operations. Damage to one company propagated to other company through the chain of transactions. Furthermore, damage to transportation facilities, damage to fuel production, all of which are common inputs & services to numerous companies, they have turned into “external factors” hindering company operations both in the directly affected and distant areas, even beyond borders. The cascading of bottlenecks for manufacturing companies through supply chains has been observed in previous disasters such as the 1995 Hanshin-Awaji (Kobe) Earthquake, 2004 Niigata Chuetsu Earthquake and 2007 Niigata Chuetsu-oki Earthquake. Manufacturing companies, in drawing their business continuity plans have become conscious of such propagation of bottlenecks due to shortage of parts supplies or disruption of certain transport routes.

However, since the Great East Japan Earthquake & consequent tsunami directly affected a broad area, numerous supply chains were disrupted, numerous common inputs & services were disrupted. Thus, numerous companies faced restrictions. Competitions over limited resources, such as fuel, trucks and drivers emerged. Also, the shortage of gasoline affected commuting of employees. These shortage of common “external factors” was “unexpected” for most of the companies affected. The “planned power outage” was a great obstacle to business activities. In case of the West Japan Torrential Rains 2018, damage to rail and roads lead to prolonged obstruction of commuting & product transportation which became “external factors” for businesses both in and outside of the flood affected areas.

Also, the market environment changed due to reputational damage by nuclear power plant accident, prolonged evacuation, competition with overseas companies.

Japan is foreseeing a gigantic ocean tectonic Nankai Trough earthquake in the near future. The findings regarding various “external factors” would be valuable materials for minimizing economic damage by future Nankai Trough earthquake and consequent tsunami. The finding from this study needs to be disseminated to the business societies in Japan. The shortage of common “external factors” will definitely emerge in this upcoming earthquake. We need to create awareness in the business sector regarding such risk and encourage multi-sector dialogues with the public sector and the academia to avoid unnecessary conflict over limited recovery resources.^[38]

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