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The Motor Vehicle Supply Chain: Effects of the Japanese Earthquake and Tsunami

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Summary

The March 2011 Great Tohoku Earthquake and Tsunami devastated the northeast coast of Japan with the most powerful natural disaster in Japan's modern history. Compounding the challenge for Japanese government, businesses, and communities was the resulting destruction of several nuclear reactors in the region which supplied electricity for homes and industry. Not only was electricity unavailable, but a large area was temporarily evacuated, making rapid reopening of affected industries impossible.

Located in the disaster region and adversely affected by these forces are a number of manufacturing facilities which are integral to the global motor vehicle supply chain. They include plants that assemble automobiles and many suppliers which build parts and components for vehicles. Some of the Japanese factories that were forced to close provide parts and chemicals not easily available elsewhere. This is particularly true of automotive electronics, a major producer of which was located near the center of the destruction.

The effect of these disasters has been first and foremost borne by Japanese automakers, which closed many of their Japanese assembly plants for several weeks as they assessed their supply chain issues and impact on their Tier 1, 2, and 3 suppliers. Japanese motor vehicle plants in other parts of the world have also been affected, including facilities owned by Toyota, Nissan, Honda, and other manufacturers in the Midwest and South of the United States. Detroit 3 automakers, by contrast, are less affected, although they, too, have taken extraordinary steps to keep production moving, including visiting suppliers in Japan to help them rebuild, locating alternative sources for some parts and chemicals, and shifting plants' summer vacations to accommodate the loss of parts.

IHS Global Insight, a global consulting firm, forecasts that over 4 million units of vehicle production will be lost because of the disasters in Japan, with 90% of them from Japanese automakers. It is possible that a shortage of some popular Japanese vehicles may develop over the summer in the United States. The Detroit 3 and South Korean automakers may be able to fill a portion of whatever demand Japanese producers are unable to meet.

Congress has shown an interest in the economic effects of these disasters, and at least one hearing has been planned to examine the effects. Not only is Japan one of the United States' largest trading partners, but it is also an ally in Asia, and its rebuilding is an important step in global economic recovery. In addition, Congress may be interested in evaluating the resilience of global supply chains as a result of new information about the vulnerabilities of supply chains in the automotive sector.

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Introduction

The March 2011 Great Tohoku Earthquake and Tsunami struck the northeast coast of Japan. These natural disasters were exacerbated by additional disruptions from the collateral damage to a seaside nuclear reactor that generated electricity for residential and commercial use in that part of Japan. Concern over leaking radiation caused the government of Japan to evacuate populations from the vicinity of the damaged reactors and to close highways connecting manufacturing and other employment centers. The damage to nuclear facilities also resulted in a shortage of electricity in parts of the country. Subsequent tremors and aftershocks continued to affect precision-oriented manufacturing, which automatically shut down operations when certain moderate-level aftershocks take place. Some ports, which ship product globally, were affected as well.

These disasters have thrown into bold relief the vagaries and fragility of some elements of the global auto supply chain. A typical motor vehicle has over 15,000 parts, and the lack of an essential component may halt the completion of vehicles and cause a slowdown or stoppage of assembly lines. Japan is the second-largest vehicle-producing nation (after China), and many of the world's vehicles and vehicle parts originate there.[1] It is also where many automotive technologies originate, giving Japanese suppliers "substantial and growing shares of the global market."[2] A relative handful of critical suppliers, especially of electronic components, were unable to meet their commitments. In some instances, the automakers that depended on them had few alternative sources of important inputs. Full restoration of supply capacity will take months.

Not long after the earthquake and tsunami, an industry analyst noted that "[g]iven the disruptions in Japanese industrial activity, the impact on global supply chains could also be significant. This is especially important in industries such as autos, telecommunications and consumer electronics."[3]

In the meantime, it is likely that a number of U.S. auto production facilities will see a slowdown of production throughout the spring and summer. Communities in the Midwest and South which have been returning to normal after the recent recession may see a parts shortage-induced drop in production that may affect employment and paychecks.

Overview of the Motor Vehicle Industry

The motor vehicle industry is a major part of the U.S. economy, accounting in 2010 for over 674,000 jobs, or 5.8% of all U.S. manufacturing employment.[4] Although some American manufacturers are adding production abroad, generating concern in Congress and in many states about the future of auto manufacturing in the United States, several automakers are opening new U.S. plants. In 2011, Toyota and Volkswagen (VW) have opened new plants in Mississippi and Tennessee, respectively, and Nissan is building a new plant to open in Tennessee in 2012.

[1] In 2010, Japan produced 9.6 million cars, light trucks, and commercial vehicles; China produced 18.3 million such vehicles; and the United States, as the third largest, produced 7.7 million. Data from statistics section, International Organization of Motor Vehicle Manufacturers (OICA), http://oica.net/category/production-statistics/.

[2] For example, over 60% of light vehicles in Japan are equipped with navigation systems, compared with 15% in western Europe. "Japan is Still a Leader in Automotive Electronics," IMS research press release, August 27, 2010.

[3] IHS Global Insight, "Japanese Earthquake, Tsunami and Nuclear Disaster," *World Car Industry Forecast Report*, March 2011, p. 10.

[4] Total employment in U.S. parts and assembly manufacturing was 674,000 in 2010; 62% of this employment, or

Few consumer products are as complex as automobiles: the 15,000 or more parts[5] in each vehicle are integrated at the time of assembly into durable vehicles, most of which will last more than a decade. Vehicles are among the most globally sourced products a consumer can buy. Autos produced in U.S. plants—whether owned by U.S. or foreign automakers—contain parts from not only nearby Canada and Mexico, but also from parts manufacturers in Europe and Asia. Parts are purchased from far away because the supplier base has developed niche markets in some countries. For example, some electronic parts used in U.S.-made automobiles are manufactured primarily in Japan.

Since the recession of 2009, when U.S. auto sales and production fell to the lowest points in three decades, automakers have seen a recovery, as shown in **Table 1**.[6] Forecasts for 2011 indicate that North American production and U.S. sales may each hit about 13 million units, a level not seen since 2008.

Table 1. The Auto Industry Begins Recovery

Automobiles and light trucks, in millions of units

Year	North American Production	U.S. Sales
2007	15.5	16.2
2008	12.9	13.2
2009	8.6	10.4
2010	11.9	11.6

Source: *Automotive News*.

The U.S. Motor Vehicle Supply Chain

The supply chain is the network and related processes which transform raw materials and disparate parts into a finished vehicle. The supply chain also includes financing, advertising, management, and distribution to the final customer. Hundreds of firms are engaged in motor vehicle parts production, final assembly, and sales.

Supply Chain Nomenclature

The motor vehicle supply chain is composed of layers of manufacturers who make products for delivery to automakers, or Original Equipment Manufacturers (OEMs), who manage the final assembly into vehicles. Tier 1 suppliers provide product directly to the automakers; they in turn depend on supplies from smaller companies, referred to as Tier 2 and 3 suppliers.

415,000 jobs, was in parts manufacturing. U.S. Department of Labor, Bureau of Labor Statistics, Current Employment Statistics Survey.

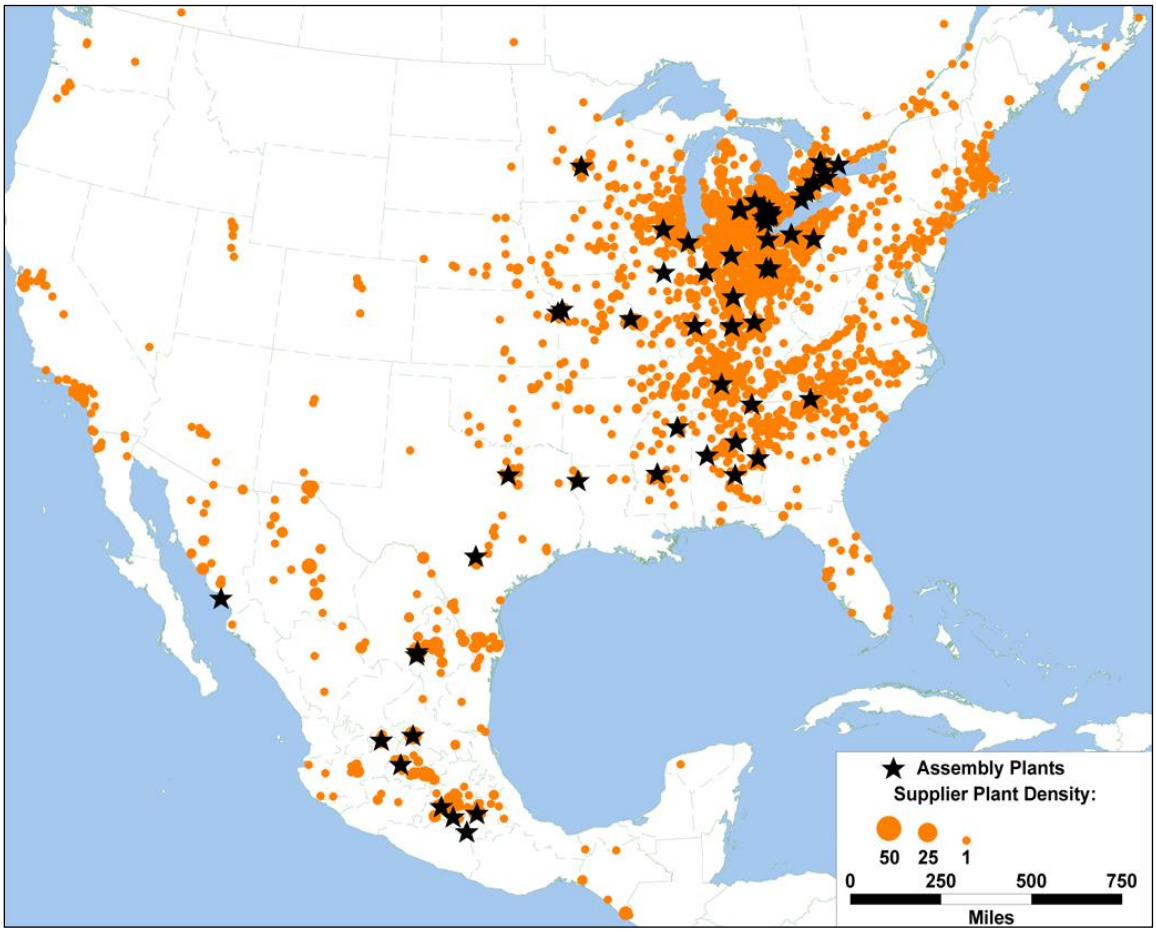
[5] Thomas Klier and James Rubenstein, *Who Really Made Your Car?*, W.E. Upjohn Institute for Employment Research, Kalamazoo, MI, 2008, p. 1.

[6] IHS Global Insight, *Forecast and Analysis*, March 30, 2011.

The geography of North American automaking is shown in **Figure 1**. Assembly plants are located primarily along an axis stretching southwest from Ontario to central Mexico. Thousands of parts suppliers (e.g., Lear, American Axle, BorgWarner) serve the final assemblers (e.g., General Motors, Honda). Under the North American Free Trade Agreement, parts and finished vehicles flow freely among Canada, Mexico, and the United States, without tariffs or other restrictions. In **Figure 1**, the parts suppliers are shown by circular dots and the auto assemblers with stars, including the two newest automaking plants: Toyota's Blue Springs, MS, facility and VW's plant in Chattanooga, TN. European and Asian automakers generally prefer to invest in lower-cost, right-to-work states in the South, and have primarily located their plants there during the past 25 years.

Figure 1. Geography of North American Auto Production

Auto Assembly and Parts Manufacturing Facilities



Source: Thomas Klier, Senior Economist, Federal Reserve Bank of Chicago, April 2011.

Notes: Auto assembly plants shown are major facilities, that is, those with production of at least 100,000 vehicles per year.

Most modern assembly plants have "supplier parks" nearby. As foreign automakers established plants in the South, so too did major suppliers, broadening the auto industry's impact on local economies well beyond the traditional Great Lakes region.[7] There are two major reasons for the close proximity of suppliers and automakers. According to a recent study,

> first, motor vehicles and their main parts, such as seats, engines, transmissions and body panels, are large, heavy and sometimes fragile, which increase transportation costs. Second, the industry-wide implementation of "lean" production techniques and increasing product and module variety since the mid-1980s have kept parts production close to final assembly. Just-in-Time (JIT) parts deliveries that keep working inventories low and reveal defects quickly are an important element of lean production.[8]

JIT is a strategy and system of inventory management "in which raw materials and components are delivered from the vendor or supplier immediately before they are needed in the manufacturing process," thereby cutting costs and reducing waste in the production process.[9]

Not all parts require close proximity to the assembly operations, however. A recent report[10] by researchers at MIT, Duke, and several other universities found that in the automotive sector, as in other industries, foreign direct investment and global sourcing of parts have increased significantly since the 1980s due to falling trade barriers. The authors also found that supplier firms are taking on more substantial responsibilities and operating globally.

It has been estimated that about one-fourth of all auto parts used in the United States are imported from Asia or Europe.[11] This is particularly true of electronics, which are made of light-weight components and can be shipped quickly by air freight from Asia, while still meeting the needs of JIT assembly in normal times. The largest non-U.S. auto parts suppliers are in Japan, Canada, and Mexico.[12] Among Japan's major exports of motor vehicle parts to the United States are tires, seat belts, air bags, bearings, fuel injection modules, exterior lighting (such as headlamps), and semiconductors.

It is important to note that the automotive supply chain is not fully global, as most vehicles are built in the regions in which they will be sold. As a result, the motor vehicle supply chain differs in important ways from supply chains for other manufactured products, such as electronics and apparel. Among key differences cited by the MIT/Duke researchers[13] are:

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[7] For more information on employment trends in the auto sector and the impact of foreign investment, see CRS Report R40746, *The U.S. Automotive Industry: National and State Trends in Manufacturing Employment*, by Michaela D. Platzer and Glennon J. Harrison.

[8] Timothy Sturgeon, Olga Memedovic, Johnannes Van Biesebroeck and Gary Gereffi, "Globalisation of the Automotive Industry: Main features and Trends," *International Journal of Technological Learning, Innovation and Development*, Vol. 2, Nos. 1 and 2, 2009, p. 14.

[9] *InvestorWords.com*, http://www.investorwords.com/2688/just_in_time.html.

[10] Timothy Sturgeon, Olga Memedovic, Johnannes Van Biesebroeck and Gary Gereffi, "Globalisation of the Automotive Industry: Main features and Trends," *International Journal of Technological Learning, Innovation and Development*, Vol. 2, Nos. 1 and 2, 2009.

[11] Domestic parts makers are owned by U.S., European, Japanese and South Korean companies. Klier and Rubenstein, *Who Really Made Your Car?*, p. 301.

[12] Klier and Rubenstein, *Who Really Made Your Car?*, p. 313.

[13] Timothy Sturgeon, Olga Memedovic, Johnannes Van Biesebroeck and Gary Gereffi, "Globalisation of the Automotive Industry: Main features and Trends," *International Journal of Technological Learning, Innovation and Development*, Vol. 2, Nos. 1 and 2, 2009, pp. 8-9.

- Assembly and parts production is regional and near major markets. Whereas a generation ago, those markets were primarily in Europe and the United States, economic growth in Asia has now spawned similar *regional* manufacturing of autos and parts in Japan, South Korea, southeast Asia, and China. Other consumer goods industries are more likely to be *globally* integrated, not regionally integrated, which allows their operations to be more concentrated geographically than is the case among automotive suppliers.
- The concentration of the auto industry in few companies in a few countries (11 lead firms in three countries of Japan, Germany, and the United States) has "blunted the efforts to establish the sort of industry-level technical and business process standards that prevail in less concentrated industries." The authors contend that the small number of very large companies exerts influence over small firms, leading to less standardization that would possibly benefit the small manufacturers.
- In turn, the absence of industry-wide standards has led to the widespread customization of parts and vehicles. The researchers note that "parts … tend to be specific to particular vehicle models in contrast to memory chips and microprocessors in the electronics industry and fabric and thread in the apparel industry.... Suppliers are often the sole source for specific parts."

These unique elements of the auto supply chain have implications for final auto assembly when there are parts disruptions.

High Technology Components Change Manufacturing Dynamics

After the recent earthquake/tsunami and ensuing nuclear events in Japan, the auto parts supply chain, especially with regard to certain electronics, has been disrupted. Understanding the growing role of such electronics in vehicles provides a basis for appreciating the challenge for motor vehicle manufacturers.

For most of its hundred-year existence, the internal combustion automobile has run on the principles of mechanics, which have only recently been supplemented with a wide array of mechanisms that use electronic signals to operate certain parts of the car. For example, a car key that operates mechanically turns tumblers in the lock, which opens the door, and it performs a similar mechanical function in the ignition. With most of today's car keys, however, there is both a mechanical and an electronic connection: a semiconductor in the plastic key molding sends a signal to the car's computer, enabling the key to open the door mechanically and then similarly to start the ignition. A key without that chip would be unable to provide those functions, even if it had the correct grooves in the key blade. The computers that control the key and ignition access—and hundreds of other functions in a car—are called microcontrollers.[14]

[14] A microcontroller is a computer that is embedded in another product to control the actions of that product. They are dedicated to one task and run just one program. Marshall Brain, "How Microcontrollers Work," How Stuff Works, http://electronics.howstuffworks.com/microcontroller1.htm.

Electronics have been a growing element in auto design and manufacturing since the early 1970s, when the first OPEC oil price hike encouraged automakers to begin thinking about new technology applications. Electronic ignition was one of the first major innovations.[15] In addition to aiding fuel economy and controlling emissions more effectively, electronics have also provided greater vehicle safety and many features once thought inconceivable in a motor vehicle.

It has been estimated that electronics comprised about 19% of vehicle cost in 2004, and that they may rise to 40% by 2015.[16] Computing capacity has also grown: according to an engineer at Motorola, in just three generations, microcontrollers have become 100 times more powerful, and the number of transistors on the chip has grown 300 times.[17] All vehicles manufactured and sold in developed countries have at least some level of computerization, even low-end models, which over time inherit electronic systems initially introduced into luxury vehicles.

Many critical automotive applications are now intertwined with electronics. For example:

- *Electronic fuel injection* replaced the carburetor, which mixed fuel and air prior to combustion. Electronic fuel injection uses an entirely different technology that forces the fuel under high pressure through small nozzles. A microcontroller apportions just the right amount of fuel needed by the engine.
- *Airbags*, which are now standard technology on all cars sold in the United States, are enabled by electronic sensors that measure the amount of sudden deceleration and inflate the air cushion. The microcontroller's job has grown more complex as airbags have been added throughout the vehicle, making deceleration calculations subject to more variables.
- *Antilock braking system* (ABS) prevents wheels from locking up (in a skid on ice, for example). Cars equipped with ABS have a dual braking system, including not only the traditional hydraulic brake system but also front and rear brake sensors and an electronic control unit.
- *All-wheel drive* (AWD) has been available on vehicles for decades, moving power from the engine to all four wheels and not just two, but current iterations of AWD harness electronics for traction control and to shift control between the front and rear axles.
- *Global positioning systems* (GPS) are electronic navigation tools that provide drivers with driving directions to their destinations. GPS can also transmit via satellite the location of a vehicle and track the direction it is moving and its speed, which can help locate the vehicle if stolen.
- *Computer diagnostics* are used to monitor systems throughout the vehicle and assist mechanics in diagnosing problems within the car. Microcontrollers check fluids, monitor tire pressure and temperature levels in various engine components, and communicate irregularities to the motorist. These computer diagnostics remove some of the guesswork in vehicle maintenance and repair.

[15] The 1958 Chrysler DeSoto was apparently the first vehicle to use electronics (it was in a fuel injection system application) but it was an expensive alternative to the carburetor and few customers chose that option. A good example of the aggregative nature of innovation, it was built by Bendix Aviation in its plant in Elmira, NY, and was an adaptation of a similar system used in Korean War aircraft. George Mattar, *Hemmings Classic Car*, 2005, http://www.allpar.com/cars/desoto/electrojector.html.

[16] "Car Innovation 2015: A Comprehensive Study on Innovation in the Automotive Industry," Oliver Wyman Automotive, http://www.oliverwyman.com/ow/pdf_files/CarInnovation2015_engl.pdf.

[17] Ross Bannatyne, "Microcontrollers for the Automobile," *Micro Control Journal*, 2011, p. 3, http://www.mcjournal.com/articles/arc105/arc105.htm.

- *Hybrid vehicles* employ electronics to manage the switch between the internal combustion engine and the electric motor. In all-electric vehicles, electronics manage the thermal controls that regulate the lithium-ion batteries' temperatures and communicate speed, battery discharge rates, and other information throughout the vehicle.

In some instances, the primary electronic control system is backed up with a redundant power system for safety reasons. For example, if a car's electrical system malfunctions, there is a special capacitor which kicks in to provide the electronic controls with the energy needed to inflate the air bags.

Events in Japan Affect U.S. Motor Vehicle Manufacturing and Retailing

The Japan disasters have affected projections of North American production and sales, with analysts forecasting that second quarter U.S. production will fall by 350,000-400,000 units. Small and mid-sized cars may be especially in short supply.[18]

Impact on the Parts Suppliers

A number of automotive products have been affected by the Japan disasters, especially certain microprocessors and a unique paint pigment, which are produced mainly in the earthquake-stricken region. The ensuing shortages have affected all major automakers to varying degrees.

Specialty paints. Xirallic pigments were among the first automotive inputs to be affected by the Japan disasters because the only plant in the world that makes them, owned by Merck Chemicals International of Germany, is near the Fukushima nuclear reactor. According to the manufacturer, Xirallic pigments produce "a stronger glitter effect than with all the other pigments. Lighter body color, greater color intensity and a more powerful luster are the advantages."[19]

While the Merck Chemicals plant has restarted production, according to a news report, "the shutdown of the plant affected many of the world's automakers, including Ford, Chrysler, Volkswagen, BMW, Toyota and GM. As a result, new cars the world over became a bit less shinier, dealers and carmakers lost markups."[20] Chrysler announced to dealers in April that 10 paint colors for vehicles were temporarily unavailable. Ford placed a similar hold on some paint colors, stating that it was working on a replacement source which would enable it to resume production in June or July of vehicles painted in "tuxedo black" and three shades of red. Hyundai and Honda said they would replace Xirallic pigments with other chemicals.

Electronics. Japanese electronics suppliers affected by the disaster include Renesas, Panasonic, Toshiba, and Hitachi. Renesas Electronics is one of the major global vehicle chip makers, producing as much as 40% of the world's supply of automotive microcontrollers at a plant disrupted by the earthquake. According to a *New York Times* analysis,

[18] "Automakers Slash N.A. Output Schedules," *Automotive News*, April 25, 2011, p. 10.

[19] Merck Chemicals International website, http://www.merck-chemicals.com/pigments/xirallic-/c_xpOb.s1L_UwAAAEWg8UfVhTn.

[20] "Japanese Parts Paralysis: The Shiny Paint is Leaving the Building," *The Truth About Cars*, May 10, 2011, http://www.thetruthaboutcars.com/2011/05/japanese-parts-paralysis-the-shiny-paint-is-leaving-the-building/.

> A reason for the industry's heavy reliance on Renesas is that it is the product of mergers involving three Japanese semiconductor companies. Hitachi and Mitsubishi Electric merged their semiconductor operations in 2003 to form Renesas Technology. Then, last April [2010], Renesas Technology merged with NEC Electronics, the former semiconductor division of NEC, to form the current company, Renesas Electronics.[21]

The Renesas plant is expected to be out of commission until mid-June at the earliest and then, when it restarts production, will operate at only about 10% of capacity for an undisclosed period of time. It is transferring production to Renesas plants in Singapore and northern Japan, but that may take several months. It takes two months to manufacture the chips, meaning it could be at least four months before production meets demand.[22]

Another large vehicle chip maker is U.S.-based Freescale Semiconductor. Its Japanese plant near Sendai was so damaged that Freescale is not going to reopen it.[23] Because so much of the auto industry's supply chain is customized for specific makes and models, parts like the microcontrollers that are suddenly in short supply are not easily found elsewhere. The software that instructs the chips in their functions is also not standardized, so even if an automaker could find a replacement chip quickly, it might not be able to communicate with the car's software programming.

Other Parts Issues. While some larger suppliers may reopen facilities soon, if smaller firms further up the chain remain closed, the larger firms will be unable to complete production. Some of these second- and third-tier suppliers have been affected by the power shortages and rolling blackouts that have been instituted in Japan since April, slowing their work. Others have yet to reopen.

An example of this domino effect is Keihin Corp., which supplies Honda with manifolds, engine control units, and other components. Four of Keihin's 11 plants were in the earthquake region, and although reopened, some of them are operating at less than 50% of capacity because several smaller suppliers have remained closed. This domino effect can also affect operations far from Japan: Keihin has five U.S. plants that have operated at capacity, but 10% of their components come from Japan, indicating a possible future supply chain problem if full Japan production cannot be resumed.[24]

Kawasaki Motors Manufacturing Corp., USA, manufactures motorcycles and small off-road vehicles at a plant in Lincoln, NE.[25] In March, it received a large shipment of faulty parts from a supplier in Japan. Because of the earthquake, the supplier had difficulty in replacing the parts quickly and Kawasaki laid off 115 employees. The plant hopes to be back to full production by the end of May.[26]

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[21] "A Japanese Plant Struggles to Produce a Critical Auto Part," *New York Times,* April 27, 2011.

[22] "Ahead: Months of Tight Supply," *Automotive News,* April, 11, 2011, p. 35.

[23] For over a year, Freescale had been planning to close the Sendai plant in December 2011. To meet automaker needs now, it is currently using inventories built up in preparation for that closing. "Freescale Updates Plans for Sendai Fabrication Facility," Freescale Semiconductor press release, April 5, 2011.

[24] "High-Tech Suppliers Are the Toughest to Replace," *Automotive News,* April 4, 2011, p. 31.

[25] In 1974, Kawasaki was the first foreign vehicle manufacturer to open a U.S. manufacturing facility.

[26] "Midlands Feel Japan's Aftershocks," *Omaha World Herald,* May 9, 2011.

Toyota has indicated that some parts with rubber components are in short supply. To address that concern, Toyota's Tier 1 supplier, Denso Corp., is lending one of its plants to Fujikura Rubber, a smaller supplier whose plant has been closed by the earthquake. Denso's plans to use the plant to assemble automotive air conditioners have been put on hold as restoring the industrial rubber products is deemed a priority for Toyota.[27]

Impact on Automakers

The March 11 disasters temporarily closed the plants that make 17 of the top 20 models of Japanese vehicles sold in the United States and prompted General Motors to close a plant in Louisiana and Peugeot a plant in Europe.[28] Japan's motor vehicle manufacturing facilities are not concentrated in one area of the country, but are variously located on the main Japanese island of Honshu. Most production takes place southwest of Tokyo, far from the epicenter of the earthquake.[29] Of the coastal area affected by the natural disasters, Nissan and Toyota operate assembly plants in Fukushima and Miyagi prefectures, respectively.

On May 10, the government of Japan announced that another nuclear plant would be closed because of its vulnerability to a future earthquake. The Chubu plant is more strategically located in Japan's auto-producing region southwest of Tokyo. Its closure will affect power available to half of Toyota's 18 Japanese plants, all four of Suzuki's facilities, and several Honda and Mitsubishi vehicle plants.[30] Unlike the U.S. electric system, Japan's has two different cycle frequencies, making it difficult to move electricity from one part of the country to another. This has implications for manufacturers, because plant equipment is calibrated for either 50-Hz or 60-Hz cycles,[31] and a manufacturer in the 50-Hz zone of eastern Japan cannot simply draw power from a supplier in the 60-Hz zone of western Japan. The Ministry of Economy, Trade and Industry has said that during the summer, Japan's electricity capacity could be cut by 25%.[32] The cumulative effect of the natural disasters and the electric plant shutdowns is having a significant impact on Japanese automakers in Japanese and North American auto plants.

[27] "Denso to Lend Plant to Quake-Damaged Fujikura Rubber," *Automotive News*, April 28, 2011.

[28] "Crisis Ends Talk of Price War," *Automotive News*, March, 28, 2011, p. 3.

[29] Japanese automakers have a few plants on the large islands of Hokkaido (to the north) and Kyushu (to the south). Japanese auto plant data from Edward Niedermeyer, "Japan Quake: Big Automakers Hit, Little Guys Spared (Except Subaru)," *The Truth About Cars*, March 11, 2011, http://www.thetruthaboutcars.com/2011/03/japan-quake-big-automakers-hit-little-guys-spared-except-subaru/.

[30] The nuclear plant that closed is the Hamaoka plant owned by Chubu Electric Power. "Japan Nuclear Plant Shutdown Adds New Risk to Economy, Auto Industry," *Reuters*, May 9, 2011.

[31] The symbol Hz refers to hertz, a measurement of electric power frequency, measuring cycles per second. "Electric Power Around the World," http://www.kropla.com/electric2.htm.

[32] "Japan Automakers Brace for Looming Electricity Shortfalls," *Automotive News*, March 28, 2011.

IHS Global Insight, an international economic and financial consulting firm, has forecast the impact of the disasters on auto production. It foresees disruptions lasting into the end of this year, with cumulative production for Japanese automakers in Japan dropping by as much as 2.2 million units this year and for Japanese automakers outside of Japan falling by as much as 1.6 million units. These would be sizeable reductions: according to the Japan Automobile Manufacturers Association, Japanese automakers in 2010 produced 8.3 million passenger cars in Japan and 13.2 million outside of Japan.[33] IHS believes non-Japanese automakers outside of Japan will lose about 450,000 units this year as a result of these events in Japan, bringing the total of lost production to 4.2 million units globally.[34] IHS's forecast of lost car production volume is shown in **Table 2**. For autos produced outside of Japan, IHS estimates the most difficult downtime will be in May and June, when parts availability will be the most limited.

Table 2. Effect of Japan Disaster on World Vehicle Production

Time Frame is 2011

Time Frame	Production Location	Production Decline from Jan.-Feb. 2011 Run Rate
April	Output in Japan	-80%
	Japanese automaker output of outside Japan	-15%
	Global output	-13%
May	Output in Japan	-41%
	Japanese automaker output of outside Japan	-33%
	Global output	-16%
June	Output in Japan	-31%
	Japanese automaker output of outside Japan	-21%
	Global output	-11%
July	Output in Japan	-24%
	Japanese automaker output of outside Japan	-12%
	Global output	-7%
August	Output in Japan	-20%
	Japanese automaker output of outside Japan	-4%
	Global output	-3%

Source: IHS Global Insight, "Japan Disaster Output Impact Update," April 28, 2011, p. 5.

[33] Japan Automobile Manufacturers Association, http://www.jama-english.jp/.

[34] Michael Robinet, "Japan Disaster Output Impact Update," IHS Global Insight, April 28, 2011.

Dealerships have been affected as well. Most Japanese automakers have notified their dealer networks that a number of vehicle parts, such as shock absorbers and body panel assemblies, will be in short supply or unavailable this spring.[35] AutoNation, the largest dealership group in the United States, has indicated that it may receive only half as many vehicles as it has ordered of certain imported vehicles from Japanese manufacturers. It reports that such inventory disruptions are likely to begin in May and run throughout the summer.[36]

The shortages in the Japanese automaking supply chain may be new opportunities for the Detroit 3 and South Korean automakers, all of which have been affected far less. These non-Japanese automakers may see a rise in their 2011 market shares in both the U.S. and Japanese markets.

Toyota

Toyota builds 45% of its vehicles in Japan, almost twice the level of Honda and Nissan.[37] Production cutbacks and sales declines in major markets are likely to knock it from its recently achieved position as the world's largest auto company in terms of unit sales. (GM will probably retake that position, which it had held for 77 years until 2008, this year). Toyota's net income for the quarter including the earthquake (January-March 2011) fell 77%, and it announced that ongoing uncertainties with the recovery in Japan[38] would prevent it from forecasting full-year results.

Most of Toyota's Japanese plants were closed for nearly a month after the dual disasters, and it has told its dealers that it will continue to produce at half its usual volume there until early June.[39] Inventory shortages of its Lexus line mean that the car will not be available in quantities large enough to meet demand and that it is likely to end its decade-long record as the top-selling U.S. luxury brand.

For several weeks, a shortage of over 150 parts left Toyota's North American operations operating at 30% of capacity.[40] Plants were closed on Mondays and Fridays and operated at half production on the other three weekdays. Toyota has announced that it will resume 70% of its worldwide production in June 2011 and will have a complete recovery by the end of the year. Not all Toyota models will resume production on this timetable, however, because of continuing parts availability issues for those models and plant limitation in Japan.[41] Toyota's European and Chinese facilities will run on a reduced basis until late summer to conserve parts.

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[35] "A Summer of Disruption," *Automotive News*, April 4, 2011, p. 1.

[36] "Ahead: Months of Tight Supply," *Automotive News*, April 11, 2011, p. 1.

[37] Toyota's U.S. production is affected by that corporate policy: 15% of it parts come from Japan, compared to 2% of GM's, "Piecing Together a Supply Chain," *New York Times*, May 12, 2011.

[38] At least one of Toyota's plants, which builds the Yaris, remains closed. The outlook for electric capacity due to nuclear power plant closures also remains an issue. In addition, the strong Japanese yen has resulted in raising prices on Toyota vehicles exported from Japan and is cutting into profitability. For every 1 yen appreciation against the dollar, Toyota estimates its annual profits decline by about 30 billion yen. "Quake Hammers Toyota Net Income, But Recovery Pace Bumped Up," *Automotive News*, May 11, 2011.

[39] "Massive Cuts for Toyota and Nissan," *Automotive News*, April 18, 2011, p. 29.

[40] In early May, Toyota indicated that the shortage of parts had been reduced to 30 types of parts.

[41] "Toyota: North American Output to hit 70% of Pre-Quake Levels b End of June," *Automotive News*, May 11, 2011.

Nissan

In early May, Renault-Nissan's CEO, Carlos Ghosn, said that the company had cut its supplier problems in half, from 40 supplier companies with critical production issues in March. He projected a return to normal production by October and announced that Nissan's quarterly net income (for January-March 2011) was $380 million, compared to a $140 million loss a year earlier.[42] Directly affected by the earthquake/tsunami was the company's plant at Iwaki, where engines for popular models such as the Murano, Infiniti, and Z350 sports car are built. To plug the gap caused by this break in its internal supply chain, Nissan may import engines from its Decherd, TN, engine plant.[43] Nissan builds a quarter of its vehicles in Japan; in April, Nissan's U.S. plants were initially closed for six days and its Mexican plants for five days.[44]

Nissan told its dealers in April that it would primarily produce just the best-selling models during the parts shortage and that it would give priority to delivery of vehicles for the U.S. and Chinese markets. It told U.S. dealers that they could expect 7,500 units in May (from Japan and Mexico), compared with 40,000 imported in March 2011.[45]

Honda

As with Toyota, the March disasters in Japan affected Honda's quarterly income (January-March 2011), which fell 38% to $545 million compared to the same period a year earlier. In March, Honda suspended production of three of its top sales models[46] sold in the United States and its Japan plants were temporarily shut. Now reopened, the Japanese plants will remain on half-time production until July.

Output at eight of its U.S., U.K., Indian, and Canadian plants was cut by 50% in early April.[47] In mid-April, a U.S. Honda executive said he foresaw parts shortages running for 60 to 90 days.[48] Honda's CFO said that the impact of the disasters on Honda's U.S. businesses will be mostly felt in the July-September period because of the long time to ship vehicles and parts from Japan.[49] Honda, which builds about 26% of its vehicles in Japan, expects its global production to return to normal by the end of this year.[50]

General Motors

Immediately after the earthquake, GM closed its Shreveport, LA, plant because of an immediate shortage of mass air flow sensors made by Hitachi, which in turn led to short layoffs at its Tonawanda, NY, plant that makes engines for the Shreveport assembly plant.[51] Some shifts were also temporarily cancelled at plants in South Korea, Spain, and Germany.

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[42] "Ghosn Says Fewer Than 20 Quake-Hit Suppliers Are in Critical State," *Automotive News*, May 13, 2011.

[43] "Slow Comeback Ahead for Top U.S. Imports," *Automotive News*, March, 28, 2011, p. 34.

[44] "A Summer of Disruption," *Automotive News*, April 4, 2011, p. 1.

[45] "Massive Cuts for Toyota, Nissan," *Automotive News*, April 18, 2011, p. 29.

[46] The Honda Fit, and CR-V and Acura TSX.

[47] "Quake Update," *Automotive News*, April 4, 2011, p. 6.

[48] "Ahead: Months of Tight Supply," *Automotive News*, April 11, 2011, p. 33.

[49] "Honda Awaits Quake Toll on U.S. Business," *Automotive News*, May 2, 2011.

[50] "Honda's Quarterly Profit Plunges 38% on Earthquake, Lower Demand," *Automotive News*, April 28, 2011.

[51] The GM plants reopened a week later when Hitachi production resumed. "Piecing Together a Supply Chain," *New York Times*, May 12, 2011.

GM sent experts to Japan to work with suppliers having difficulties reopening. According to GM's CFO, it has an internal team with purchasing, manufacturing, and supply management at work identifying components that may be in short supply and identifying possible replacements.[52] GM's chairman and CEO, Dan Akerson, told a reporter in April that he called an executive at number two chipmaker, Freescale Semiconductor, to discuss supplying GM. Akerson said, "we can't rely on one source [for automotive computer chips]. So I picked up the phone, I called the CEO of Freescale and I said, 'I know you make chips of this type.'"[53]

Ford

In April, Ford closed assembly plants in Taiwan, the Philippines, China, and South Africa for two weeks to conserve parts in short supply. Ford had planned to idle some of these plants later in 2011, but moved up the schedule because of a shortage of undisclosed Japan-origin parts.[54] Its plants in Genk, Belgium, and Louisville, KY, were closed for a week in April. Like other automakers, Ford has experienced shortages of Xirallic-based paints, but has found replacements for some colors.

Chrysler

Chrysler anticipates that it may face unidentified parts shortages in late May or June. To mitigate the impact, the company has announced that its traditional summer plant shutdowns for three plants will be moved up from July to June. This will give parts suppliers more time to bring plants online or for Chrysler to identify alternative sourcing. The plants and products affected are in Warren, MI (Ram and Dakota pick-up trucks), and two facilities in Toledo, OH (Jeep Liberty and Wrangler and Dodge Nitro).[55] Chrysler also has limited color selections due to the shortage of Xirallic pigments in Japan.

What Is the Near-Term Impact in the United States?

As the preceding section of this report demonstrates, the disasters in Japan had immediate, albeit modest, impacts on most U.S.-based automakers. A number of plants were idled for a short period of time as parts from Japan were interrupted and most manufacturers were sent scrambling to find new sources for other parts. The initial impact domestically was mitigated, however, by the long supply chain, which normally has a month or more of parts on their way to U.S. auto plants. Michael Robinet, director of global production forecasting for IHS Automotive, said in a March interview that "most vehicle manufacturers will have anywhere between four to six weeks of inventory either on hand or in shipment."[56]

[52] "Ahead: Months of Tight Supply," *Automotive News*, April 11, 2011, p. 33.

[53] "Chasing Chips: GM's Ace in the Hole," *Automotive News*, April 25, 2011, p 50.

[54] "Quake Ripples at Ford, Johnson," *Wall Street Journal*, April 26, 2011.

[55] "Chrysler Moves Up Summer Plant Shutdowns to June," *Associated Press*, May 13, 2011.

[56] "Japan Quake Parts Shortages Worsening," CBS Detroit, March, 28, 2011, http://detroit.cbslocal.com/2011/03/28/japan-quake-parts-shortages-worsening/.

It appears that the Japanese automakers in the United States will be the most affected by the natural disasters because of their stronger supply chain connection with their facilities in Japan. IHS Global Insight forecasts that of the 4.2 million vehicles that IHS believes will now not be built in 2011 based on their pre-earthquake projections, 90% of the lost volume will stem from Japanese OEMs in their global operations, including the United States.

The IHS model predicts that of these 4.2 million units that will not be produced in 2011, 497,000 will be lost to Japanese OEMs in North America, second only to the 2.2 million units forecast to be lost in Japan itself. The vehicle production losses will peak in the second quarter (April-June). By comparison, IHS believes that lost volume by the Detroit 3 and European and South Korean OEMs will be minimal.[57]

Separately, A.T Kearney, an international consulting firm, issued a report on May 17, 2011, suggesting that 200,000 U.S. customers may switch brands this year due to the unavailability of many Japanese models.[58]

In the United States, the loss of production will be felt over the summer most keenly at the Japanese transplant facilities and suppliers, primarily in the Midwest and South, where Japanese OEMs operate their manufacturing facilities. According to the Japan Automobile Manufacturers Association figures,[59] this may temporarily affect some of the 51,000 Americans employed in Japanese-owned assembly plants, 19,000 in transportation and logistics distributor firms, and 327,000 at U.S. auto dealers selling Japanese vehicles.

In addition, suppliers to the Japanese-owned assemblers employ thousands in U.S. supply plants. The Japanese automakers spent $38.3 billion in U.S. parts purchases in 2009, as up to 75% of their parts are produced domestically.

These production drops in 2011 may be largely erased in 2012, however. IHS sees increases in Japanese OEM production next year over their earlier baseline as they ramp up to provide vehicles for demand that cannot be met this year.

Conclusion

The March disasters in Japan caused immediate concern among automakers everywhere because of the nature of today's motor vehicle supply chain. It is highly integrated and global, with most vehicles having parts from many countries. Japan, as the second-largest auto-producing country, is a major force in that global supply chain. The events in Japan may spur the motor vehicle industry to reevaluate its longtime practice of customizing so many of its parts. The industry may seek to develop standards and diverse sources for certain parts so that in the case of future global supply chain interruptions, there will be alternative manufacturers for such components.

The shortage of Xirallic pigments is a case in point, as they have been manufactured only in what is now the earthquake zone. A range of Japanese, U.S., and European automakers quickly found themselves without this important paint additive after the earthquake/tsunami. The supplier, Merck Chemicals, almost immediately said it would supplement its Japan production with a new facility in Germany.

[57] "Japan Disaster Output Impact Update," IHS Global Insight Automotive Group, May 10, 2011.

[58] "Japan Crisis Puts 200,000 U.S. Auto Sales Up for Grabs," *Automotive News*, May 17, 2011.

[59] "Building in America," Japan Automobile Manufacturers Association (JAMA), October 2010, http://www.jama.org/pdf/brochure_Oct2010_2page.pdf.

Geographic diversity would seem to be particularly important in automotive electronics. The pace of change is accelerating: as much as 40% of the value of a motor vehicle may be in its electronics as soon as 2015. Beyond today's extensive use of microcontrollers, there are many more possibilities for electronic applications in vehicles.

Many vehicles are now beginning to be equipped with a range of entertainment and communications options that require microcontrollers. Technology that can parallel park a car is also enabled by internal computers. In the future, vehicles could use "drive by wire" technology (DbW) that will use electronic control systems to manage a wider scope of vehicle operations. With DbW, the steering column, pumps, hoses, and belts might be eliminated, changing the very nature of the vehicle. In addition to these new functions, the networks of existing electronic components will be better integrated so that they "can share data in real-time, thus making more intelligent systems possible."[60] Given the increasingly critical role of electronic components, automakers may be concerned about geographically diversifying their sources of supply so that future natural disasters have less potential to disrupt vehicle production.

Congress is interested in the global motor vehicle supply chain for several reasons. Japan is a major trading partner and ally in Asia, and the restoration of its industrial production is central to strengthening the world economic recovery. In the United States, where vehicle and parts manufacturing has gone through a difficult period, the auto industry's recovery is dependent on the smooth flow of parts throughout the global supply chain. Additionally, these disasters have shown vulnerabilities in the manufacturing supply chain, with potential implications for economic and military security. Members of Congress may want to explore ways that federal or state policies may enhance supply-chain resilience in the future.

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[60] Ross Bannatyne, "Microcontrollers for the Automobile," *Micro Control Journal*, 2011, p. 2, http://www.mcjournal.com/articles/arc105/arc105.htm.