AIR ISSUE BRIEF

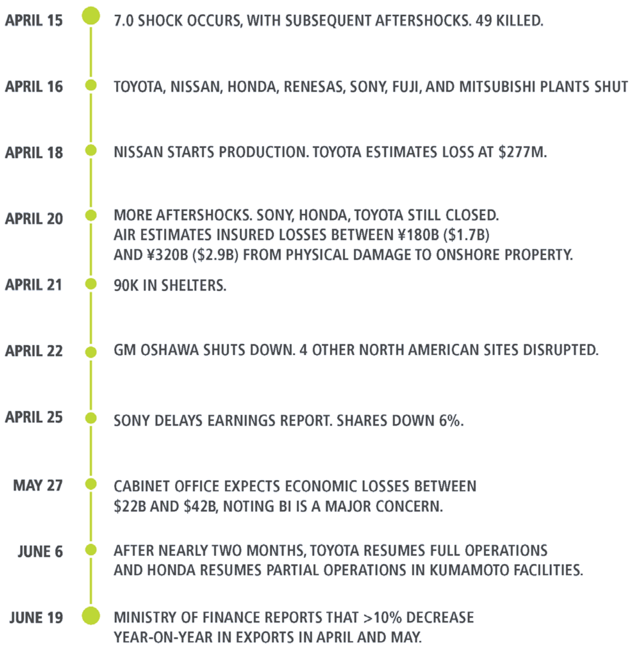
MODELING SUPPLY CHAIN DISRUPTIONS AND CONTINGENT BUSINESS INTERRUPTION LOSSES

This issue brief discusses several challenges associated with modeling contingent business interruption in supply chains, given the lack of current tools that allow corporations and insurers to rapidly assess the financial impacts of potential disruptions without a deep knowledge of and visibility into their complex network of product suppliers. Supply chain disruption mitigation techniques will be discussed, with a particular emphasis on the 3Rs of reserves, redundancy, and resilience. AIR's supply chain modeling framework for catastrophic events will be presented before examining a case study of its application to calculate the impact of the recent earthquakes in Kumamoto, Japan, on the global automotive industry.

INTRODUCTION

The recent earthquake sequence in Kumamoto, Japan, has served as a stark reminder that loss of life, property damage, and direct business interruption (BI) are only part of the story when measuring the impacts of natural and manmade disasters. These events have also highlighted a more intractable risk that concerns insurers and insureds alike, all of whom have inadequate tools available to them for predicting and quantifying both their exposure at risk and potential losses.

This risk is contingent business interruption (CBI), which frequently emanates from upstream supply chains that are outside of a corporation's direct control and often comprise a network of seemingly insignificant individual parts or materials. However, the absence of any one of these parts can have catastrophic impacts on manufacturers, and can unexpectedly immobilize entire industries as they scramble to access inventory (i.e., reserves), switch production to an unaffected manufacturer (i.e., redundancy), or repair and retrofit damaged factories (i.e., resilience). For example, following the 2011 Tohoku earthquake in Japan, Merck Chemicals International, the sole global manufacturer of the specialty pigment Xirallic, was taken offline for nearly two months, leading to a global shortage of an essential paint additive used by Ford, Chrysler, Volkswagen, BMW, Toyota, GM, Hyundai, and Honda.[1] The importance of this sole-sourced chemical was previously unknown to these companies and, when compounded with the multitude of other affected automotive part suppliers in Japan, contributed to an estimated automobile production shortfall of 4.2M vehicles globally (2.2M of which were in Japan).[2] A brief timeline of direct and indirect impacts resulting from the Kumamoto earthquake is illustrated in Figure 1, which demonstrates the potential latency of supply chain disruptions following major events.



APRIL 15	7.0 SHOCK OCCURS, WITH SUBSEQUENT AFTERSHOCKS. 49 KILLED.
APRIL 16	TOYOTA, NISSAN, HONDA, RENESAS, SONY, FUJI, AND MITSUBISHI PLANTS SHUT
APRIL 18	NISSAN STARTS PRODUCTION. TOYOTA ESTIMATES LOSS AT $277M.
APRIL 20	MORE AFTERSHOCKS. SONY, HONDA, TOYOTA STILL CLOSED. AIR ESTIMATES INSURED LOSSES BETWEEN ¥180B ($1.7B) AND ¥320B ($2.9B) FROM PHYSICAL DAMAGE TO ONSHORE PROPERTY.
APRIL 21	90K IN SHELTERS.
APRIL 22	GM OSHAWA SHUTS DOWN. 4 OTHER NORTH AMERICAN SITES DISRUPTED.
APRIL 25	SONY DELAYS EARNINGS REPORT. SHARES DOWN 6%.
MAY 27	CABINET OFFICE EXPECTS ECONOMIC LOSSES BETWEEN $22B AND $42B, NOTING BI IS A MAJOR CONCERN.
JUNE 6	AFTER NEARLY TWO MONTHS, TOYOTA RESUMES FULL OPERATIONS AND HONDA RESUMES PARTIAL OPERATIONS IN KUMAMOTO FACILITIES.
JUNE 19	MINISTRY OF FINANCE REPORTS THAT >10% DECREASE YEAR-ON-YEAR IN EXPORTS IN APRIL AND MAY.

Figure 1. Timeline of direct and indirect impacts of the 2016 M7.0 Kumamoto earthquake (Source: AIR and Spend Matters)

Supply chain and CBI risk is nothing new, and corporate risk managers and insurers have developed effective methods for mitigating potential consequences of disruptions. Corporations generally rely on the “3Rs” mentioned previously: reserves, redundancy, and resilience. Reserves, in the form of excess supplies, and redundancy, in the form of alternative suppliers or equivalent parts, attenuate day-to-day, short-term, or site-specific disruptions that are often caused by shipping delays, industrial accidents, or the financial insolvency of a supplier. Resilience, which can be achieved via response planning, insurance, supplier relocation, or facility retrofits, such as base-isolation, additionally functions to abate disruptions caused by less frequent catastrophic events. Despite these well-known mitigation strategies, supply chains remain fragile. This fragility results in part from the inadequate application of the 3Rs, but also from a pervasive lack of visibility into the manufacturers that provide essential parts at each tier of the supply chain. Additionally, final product manufacturers often do not fully know how or where their suppliers and sub-suppliers manufacture certain parts due to purposeful obfuscation of the supply network by commodities manufacturers in order to protect trade secrets and remain cost-competitive.

The absence of visibility not only impairs a corporation’s ability to adequately prepare for supply chain disruptions, but also prevents insurers from having sufficient information to price and offer comprehensive supply chain insurance products. As a consequence, the availability of risk transfer products in the supply chain space is limited, and available products frequently require the insured to indicate the individual supplier(s) and peril(s) for which insurance is desired in order to receive adequate coverage. Less restrictive all-supplier and all-peril policies are also offered, but generally provide insufficient coverage. Quantitative tools for assessing multi-peril risks to insurance portfolios, such as those applied by (re)insurers for property and direct BI risks (e.g., Touchstone®), are either nascent or unavailable in the supply chain space.

MODELING FRAMEWORK

It is important to consider the primary data that is most useful for assessing the impact to corporations and insurers following a catastrophe, natural or otherwise. Corporations need to know the parts that are expected to be impacted and to have downtime estimates, while insurers need to know how that expected downtime is likely to translate to losses and subsequent claims. If a corporation has complete visibility and real-time data about the operational status of their supply chain, then assessing these impacts is trivial.

In reality, no corporation or insurer has the spectrum of information required to fully model their supply chain, and instead piecemeal data is typically cobbled together to construct partial risk management strategies and tools. Disruptions to the supply chains of corporations and portfolios of insureds can however be effectively modeled by applying several first-order assumptions.

First, one must quantify the parts that are likely affected, which can be obtained via a comprehensive commodity and material manufacturer exposure database. Second, one must know the general flow of parts within a typical supply chain of the affected industry (i.e., petroleum → gaskets → pistons → engines → cars) and how those parts are exchanged between suppliers, both domestically and internationally. Third, one must estimate the direct business interruption to suppliers derived from events as they unfold in real-time or from stochastically-generated potential future event sets, coupled with the aforementioned supplier exposure database. Fourth, one must employ a methodology to propagate the modeled disruption through each tier of the supply chain and calculate the total disruption experienced by each product manufacturer. Lastly, one must have a method to calculate the expected industry losses for final product manufacturers and distribute those losses to individual suppliers, product groups, or affected final product manufacturers.

The abovementioned methodology is illustrated schematically in Figure 2, as implemented in the AIR Supply Chain Model. The AIR framework leverages standard industry definitions and AIR's supply chain industry exposure database to calculate expected financial impacts to product manufacturers in 17 different broad industry groups (e.g., Automotive, Consumer Electronics, etc.). These model outputs can be tailored to individual corporations or used by insurers to generate expected BI and CBI losses deterministically immediately following an event or stochastically for quantifying the likelihood of future losses.

AUTOMOTIVE INDUSTRY CASE STUDY

To demonstrate how the AIR Supply Chain Model works in a practical application, we use it to assess the direct and contingent business interruption losses to the global automotive industry following the M7.0 Kumamoto-shi earthquake in early April, 2016, in Japan.[3] Using AIR's default automotive supply chain industry, network, and global industry exposure databases, AIR Loss Estimates in Real Time™ (ALERT™) scenarios are analyzed in Touchstone® to assess a range of direct BI losses from the event. The AIR supply chain exposure database for Japan contains more than 40,000 manufacturers and the AIR default automotive industry and network databases include more than 2,500 products, which span across 11 supply chain tiers and include raw materials, intermediate parts, and final products. Automotive represents one of 17 default industries considered in the AIR model.

The direct BI outputs from Touchstone are subsequently evaluated using the AIR Supply Chain Model, which calculates estimates of the BI+CBI losses, both in Japan and in other countries that are indirectly impacted by the event. These estimates are derived from historical production values and from assumptions about the 3Rs, which act to buffer the impact of the disruption and collectively represent the mitigating influence of inventory, alternate suppliers, and response planning.

BI+CBI loss distributions for the median ALERT loss scenario are presented in Figure 3 for the 10 most impacted countries. These results are conditioned on the 3R mitigation assumptions implemented in the model, which constitute the combined number of days of disruption that can be avoided through pre-emptive actions, such as building inventory and dual-sourcing, or reactive measures such as repair coordination and increased production.

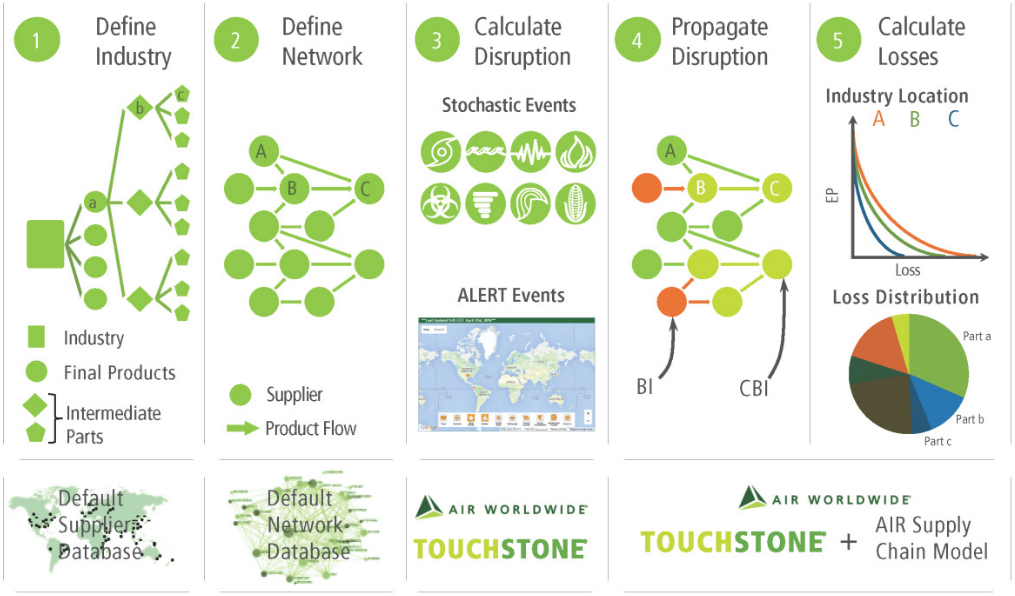


Figure 2. Schematic representation of the AIR Supply Chain Model framework

The model is capable of considering mitigating actions for individual suppliers and product groups, but frequently this level of detail is unavailable, particularly at an industry level. In the absence of detailed information, the supply chain model can be executed using a range of disruption mitigation assumptions (between 0 and 30 days, for example), which bound the analysis and provide a realistic range of expected losses that are conditioned on the variety of potential actions taken by corporations before or after an event. In this example, all results are normalized using the total BI+CBI loss generated using the baseline-, or worst-, case of 0 days of mitigation.

As expected, Japan incurs the largest proportion of the loss, which is in part due to the fact that more than 93% of the vehicles purchased in Japan are manufactured in Japan.[4] Figure 4 shows the distribution of total event losses for different final product groups (e.g., automobile mfg.), which are composed of approximately 30 finished product classes (e.g., compact cars, trucks, SUVs, etc.). Expected downtime in days for finished and intermediate products in different tiers (e.g., engine mfg., transmission mfg., etc.) can also be outputted, along with their respective BI+CBI losses.

The supply chain losses for the automotive industry in Japan are in addition to the AIR ALERT insured physical damage loss estimate for the Kumamoto event, which ranges between USD 1.7 billion and USD 2.9 billion.[5] The modeled CBI losses also extend to automotive production in other regions where losses from this event may be latent, such as the United States, Germany, and South Korea. For example, production shortfalls in the automotive sector may include General Motors, which announced two weeks of production suspension at four plants in North America due to parts shortages from suppliers in the Kumamoto region.[6] Lastly, Figure 5 illustrates the dramatic impact of the 3R mitigation assumptions for reducing expected losses. In this analysis, 30 days of mitigation, gained through inventory, dual-sourcing, back-up suppliers, or disaster response activity, is demonstrated to decrease disruptions to Japanese automotive manufacturers by over 75% when compared to the baseline case.

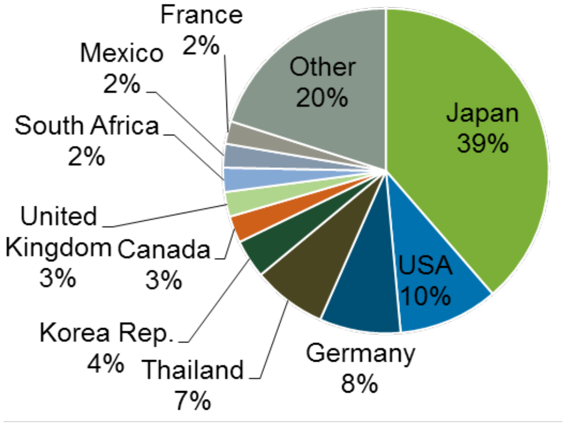


Figure 3. Automotive industry BI+CBI loss distribution by country

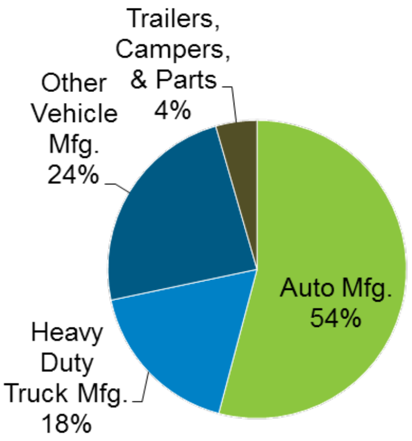


Figure 4. Automotive industry BI+CBI loss distribution by primary automotive product groups

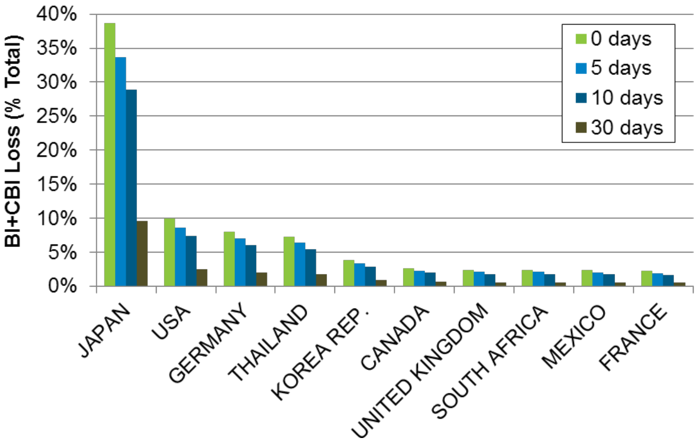


Figure 5. Automotive industry BI+CBI loss distribution by considering a range of inventory quantities

A corporate market share approach additionally allows for the industry level impacts of the event to be distributed to leading automotive manufacturers. The estimated distribution of modeled BI+CBI losses to individual automotive manufacturers in Japan and the USA is presented in Figure 6. These distributed losses provide rapid impact estimation for corporations and insurers that can be used within hours of an event to determine likely assets at risk. Initial reports from Japan validate well with the distribution in Figure 6. For example, Toyota's Japanese operations are expected to see profits reduce by USD 277 million[7] as a result of downtime associated with the earthquake.

Reports also indicate that Toyota, Honda, and Nissan are the automakers most impacted by this event in Japan,[8] which is consistent with the modeled results. Calculated losses in other markets, such as the U.S., can be distributed similarly. As noted previously, General Motors suspended operations at North American plants in both Canada and the U.S., and Toyota has yet to report whether other business units have been impacted. Loss latency is also an important consideration in supply chains, as disruptions can remain hidden due to visibility limitations and, although unreported immediately following an event, may appear unexpectedly in the months following the initial disruption. For example, despite initial reports by General Motors of immaterial losses from this event,[9] recent reports indicate considerable shortfalls in U.S. sales, which General Motors attributes to Japanese parts shortages resulting from the Kumamoto earthquake.[10]

SUMMARY

The sample outputs provided in this analysis scenario address many of the supply chain risk modeling deficiencies identified in this article, and have the potential to provide corporations and insurers the necessary information to rapidly assess disruptions as an event unfolds or to probabilistically estimate future disruptions from stochastic events. The material presented in this article merely scratches the surface of the capabilities of supply chain risk models, which also have applications for detailed corporate analyses, risk optimizations, transportation network disruptions, and non-natural catastrophe perils, to name a few.

While the AIR Supply Chain Model relies on default values and global averages in the absence company specific information, custom products and supplier networks are easily integrated using built-in model functionality, if that information is made available.

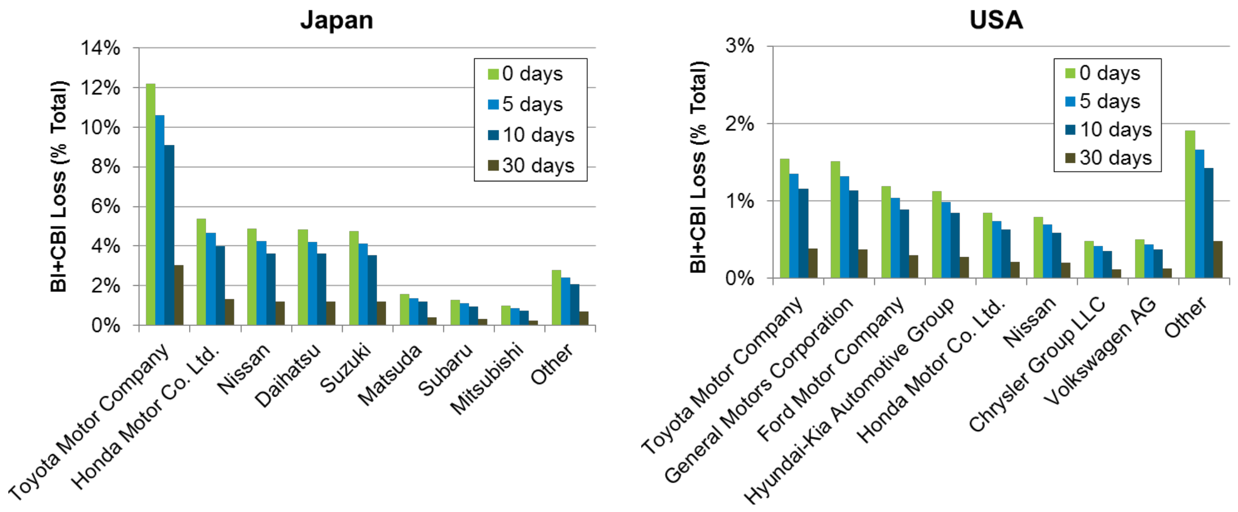


Figure 6. BI+CBI losses distributed to leading automotive manufacturers in Japan (left) and the USA (right) based on a market share analysis

This example analysis also highlights the importance of globalization and international interconnectivity when assessing supply chain impacts, as non-intuitive secondary effects of catastrophes often arise in corporations elsewhere in the world.

The Kumamoto earthquake and other recent disruptions underscore the need for new supply chain models that keep pace with increasingly complex global networks of products and provide actionable outputs for decision makers to assess and manage their risk.

CONTACT US

To find out more about AIR's supply chain modeling solutions, please contact the team at **supplychain@air-worldwide.com**

ABOUT AIR WORLDWIDE

AIR Worldwide (AIR) provides catastrophe risk modeling solutions that make individuals, businesses, and society more resilient. AIR founded the catastrophe modeling industry in 1987, and today models the risk from natural catastrophes, terrorism, and pandemics globally. Insurance, reinsurance, financial, corporate, and government clients rely on AIR's advanced science, software, and consulting services for catastrophe risk management, insurance-linked securities, site-specific engineering analyses, and agricultural risk management. AIR Worldwide, a Verisk Analytics (Nasdaq:VRSK) business, is headquartered in Boston with additional offices in North America, Europe, and Asia. For more information, please visit **www.air-worldwide.com**.

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[1] http://www.thetruthaboutcars.com/2011/05/japanese-parts-paralysis-the-shiny-paint-is-leaving-the-building/
[2] https://www.fas.org/sgp/crs/misc/R41831.pdf
[3] http://earthquake.usgs.gov/earthquakes/eventpage/us20005iis#general
[4] http://www.jama.org/japan-auto-industry-data/auto_motorcycle_industry_statistics/
[5] http://alert.air-worldwide.com/EventSummary.aspx?e=828&tp=72&c=1
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