CTRF 51 Annual Conference

CTRF-TRF Joint Conference

North American Transport Challenges in an Era of Change
Les défis des transports en Amérique du Nord à une aire de changement

Toronto, Ontario
May 1-4, 2016

Platinum Sponsor

BUILDING RESILIENCE TO COUNTER THE IMPACT OF INTERNATIONAL SUPPLY CHAIN VULNERABILITIES

Rupert Allen, Industry Canada
Matthew Whelen and Ata Khan, Carleton University

Introduction

To satisfy one of the pre-requisites for success as a competitive trading nation and to be able to attract large-scale new investments as a part of global value chain, a trading nation's international supply chains have to be efficient as well as resilient to potential disruptions. Around the world, policy and planning efforts are underway to achieve these objectives. As a step in this direction, this paper contributes considerations for improving resiliency of the national component of the international supply chain.

Evidence-based information suggests that the national component of the international supply chain can be adversely impacted due to cascading effects of a variety of nature-induced and other events that occur beyond national borders. In order to reduce the impact of such supply chain events on industries and businesses, measures to improve resilience are to be planned and considerations for their implementation are required.

In this paper, selected multimodal international supply chains are defined for non-bulk, high value groups of commodities for illustration purposes. Sources of vulnerabilities and supply chain components that are likely to be impacted are identified. The cascade of effects is traced through the supply chain using systems analysis concepts.

Next, ideas are advanced on resiliency measures to counter the effect of international supply chain vulnerabilities. Illustrative examples provided are based on evidence-based information. Finally, suggestions are made on the implementation of resilience measures by stakeholders such as manufacturing industries and businesses.

Diverse Nature of International Supply Chains

Examples of marine and air transportation-based supply chain models for Canadian imports of interest to manufacturing companies are presented. The surface and marine model (Figure 1) is in essence an intermodal system and requires the participation of rail, truck and the marine modes. Complex terminal operations are carried out at an inland terminal and at the intermodal terminal at the sea port.

The supply chain based primarily on air cargo is illustrated in Figure 2. The pick-up and delivery tasks are performed by trucks and an essential consolidation step is performed by a freight forwarder (ICAO 2014). There are additional details of links and nodes that are not provided here due to lack of space.

Air cargo is an expedient but high cost component of a supply chain. Air cargo has linkages with other modes. Its pick-up and delivery (P&D) is performed by trucks. Also, a substantial amount of air cargo moves via other modes between origin and destination in the long haul routes. There are examples of air-surface moves as well as marine-surface-air moves. In such instances, the advantages of air speed for a portion of the routing, and of the lower marine and/or surface rates for the other portion, result in a reasonable blend of economy as well as transit time.

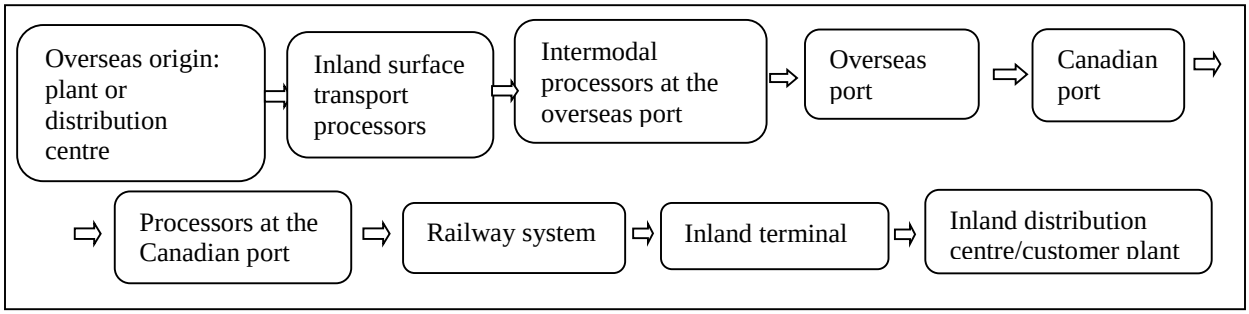

Figure 1. Transportation supply chain network (surface and marine model): Imports

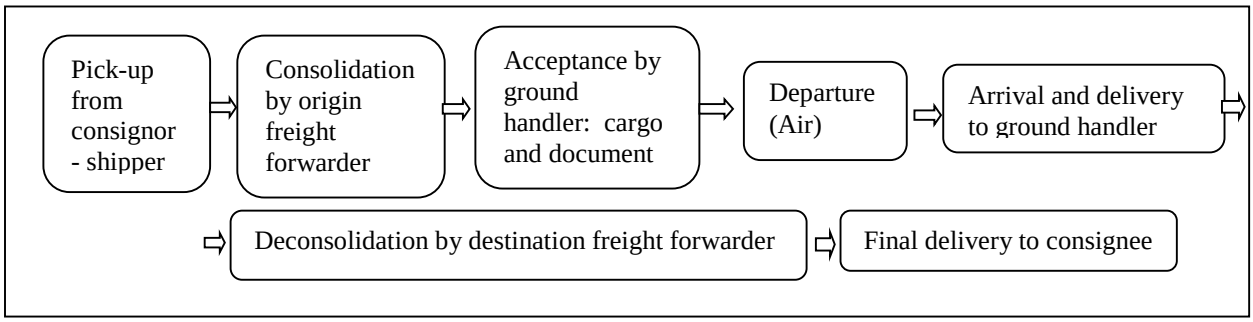

Figure 2. Air cargo movement overview (process)

In the case of the marine mode, consolidation has a role when a shipper has less than container load (LCL). The shipper only pays for space that is used. The consolidator combines cargo from a number of shippers and ships full containers to a common destination.

For policy and planning studies, the complexity and the "system" nature of a supply chain should be recognized. A short list of factors that contribute to the complex nature of the supply chain is presented next: (1) The changing business model of lean sourcing, outsourcing and offshoring. (2) Border crossing. (3) Spanning of continents. (4) Multimodal and intermodal transportation systems. (5) Parts of a freight supply chain sharing a vehicle/infrastructure with passenger transportation (e.g. cargo carried in passenger aircraft, airports, highways and roads). (6) Parts of the supply chain face the risk of disruption due to a number causes that could be man-made, nature-induced or technology/equipment failure.

Vulnerabilities in Supply Chain Components

Vulnerabilities in global supply chains are defined on a qualitative basis. For example, according to CIPS (2013), supply chain vulnerability is "*a point of weakness and/or possible threat to the supply chain network".* In some instances, quantitative measures on an ordinal scale are provided in terms of severity and probability of occurrence (Figure 3).

Vulnerabilities could be present in any component of the international supply chain. Figure 4 shows one example for illustration purposes. This type of analysis can lead to the identification of weak links in selected chains.

Vulnerabilities and Evidence-based Risks (Example of Automotive Global Supply Chain)

A vulnerability or vulnerabilities can change to risk of disruption and may even lead to disruptions. As an example, vulnerabilities in automotive global supply chain are presented in Figures 5 and 6. A large number

of sources of vulnerabilities are presented and these are classified as predictable, not predictable, controllable, and not controllable.

The supply chain of the automotive industry has developed into a large multi-tier network and presents much challenge even in disruption-free conditions (Iyer et al 2009). Given that a vehicle cannot be built without all parts, and there are thousands of parts which are sourced from diverse sources and sites, it is necessary that the supply chain should work according to the plan and if there is a disruption of any kind anywhere in the supply chain, there should be resilience in the chain to avoid adverse effects on production (Schmidt 2014; Kahan 2009). The subject of resilience is discussed later in this paper.

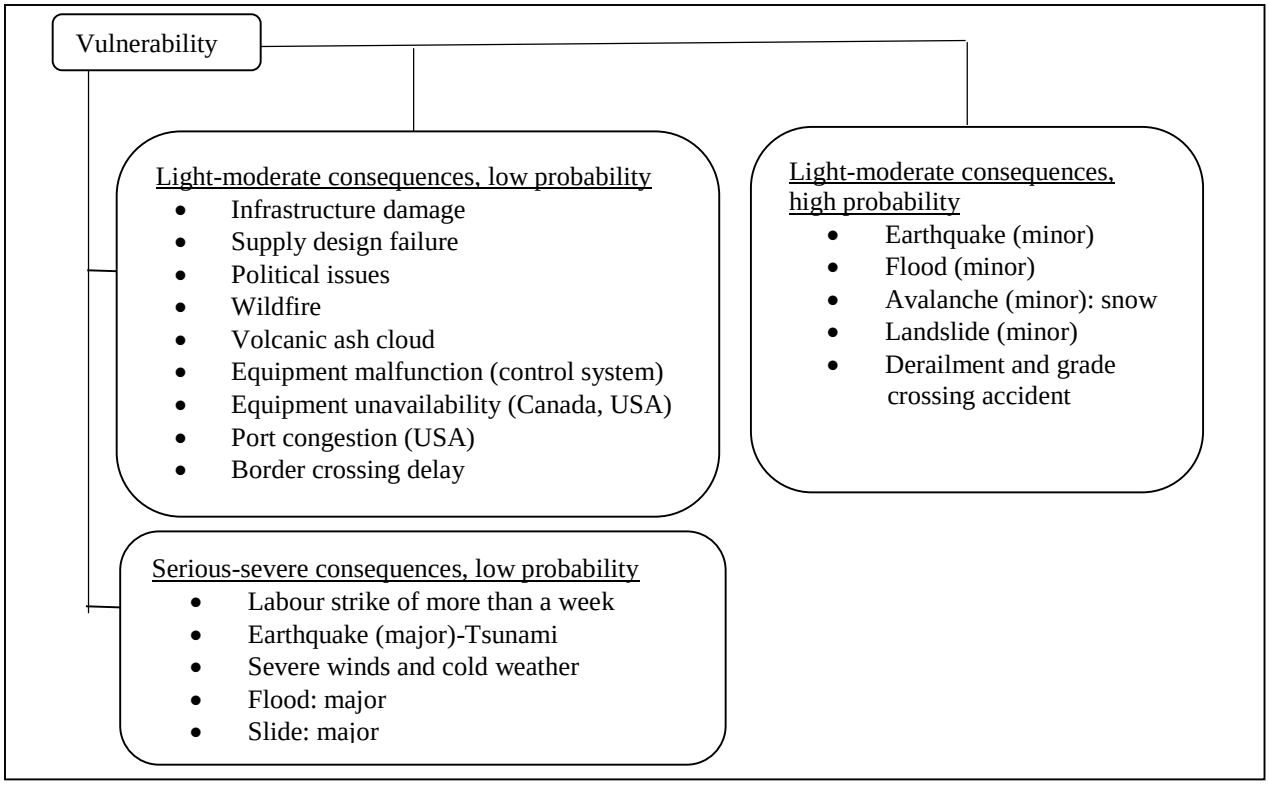

Figure 3. Risk associated with vulnerabilities (based on subjective judgment)

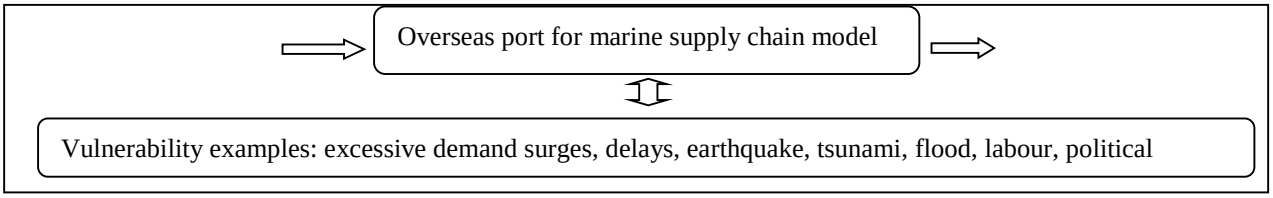

Figure 4. Vulnerability example

Supply chain risks in the automotive industry have increased significantly due to outsourcing and offshoring. Additionally, there is the possibility that the policies of just-in-time (JIT) manufacturing and low inventory levels that are intended for efficiency reason may not be able to cope with circumstances that are different than "business-as-usual".

Supply chain vulnerability studies in the automotive industry suggest that these are susceptible to risks. Further, complexity and sole focus on efficiency are key drivers for supply chain risks (Figures 5 and 6).

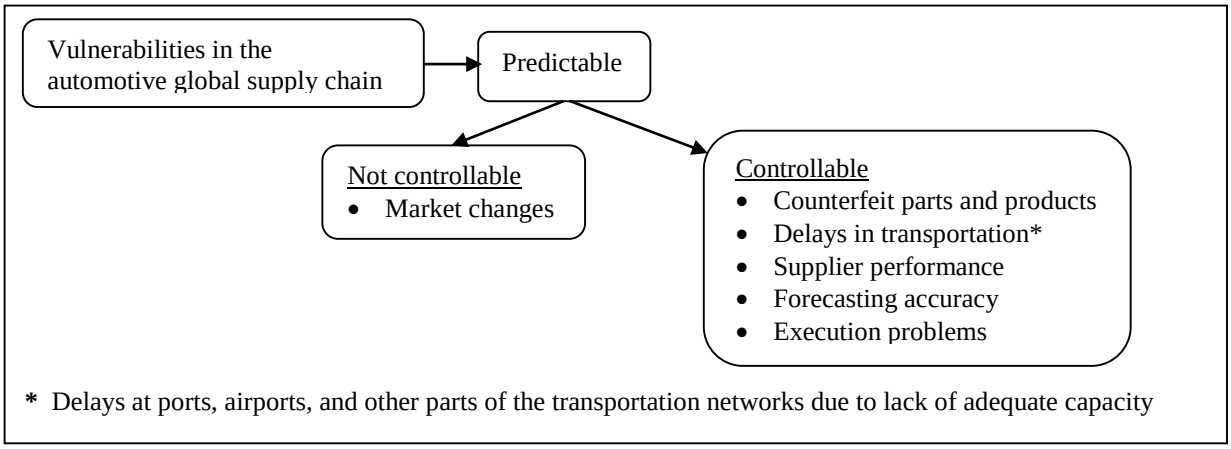

Figure 5. Predictable sources of vulnerability in automotive global supply chain (sourced in part from Schmidt et al. 2014)

Impacts of Disruptions

A present day supply chain of a major manufacturer is likely to be a complex network of multiple infrastructure elements, businesses, and relationships. Vulnerabilities can be encountered within the supply chain. For example, if there is an imbalance of demand and supply, the immediate effects include unreliability of transit time and other performance metrics, and ultimately adverse cost effects can occur. Also, there are external events/threats that must be taken into account.

A comprehensive survey of 532 respondents from 68 countries identified and ranked consequences of supply chain disruption. As expected, productivity, service, and economic factors receive high ranks (Figure 7).

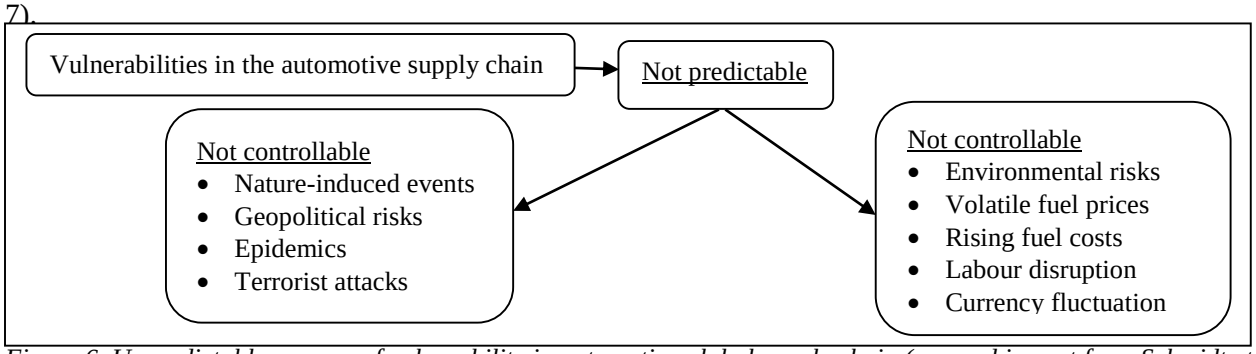

Figure 6. Unpredictable sources of vulnerability in automotive global supply chain (sourced in part from Schmidt et al. 2014)

Cascade of Disruption: Propagation of Intensity of Effects

The interruption of normal functions at one or more firms (e.g. a manufacturer of a part of the automobile) and/or a link in the freight supply chain (e.g. a disruption at a port) can cascade through the network and can cause severe effects. A large number of events can trigger cascades. Evidence based examples are: natural disasters, labour strikes, supplier going bankrupt, industrial accidents, and quality failures (Bakshi and Mohan 2015).

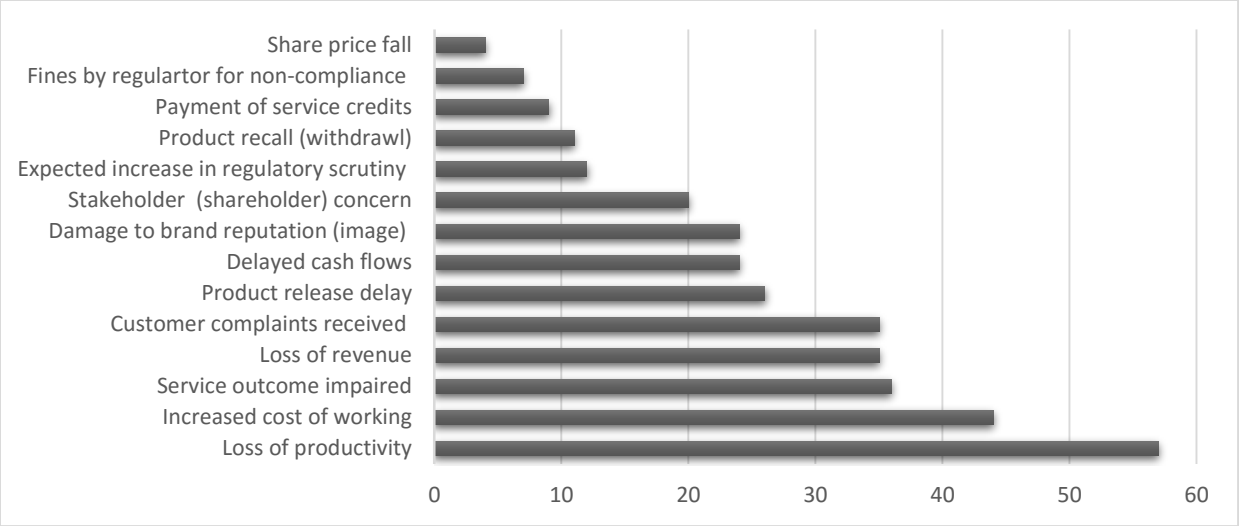

Figure 7. Consequences of supply chain disruption (532 respondents from 68 countries). Source: Punter 2013.

A notable example of cascade effect of disruptions is as follows. In March 2011, three low probability high impact events occurred ins succession (Punter 2013, Ye and Abbe 2012): the Great East Japan earthquake, resulting tsunami, and the Fukushima Daiichi nuclear disaster. Next, transportation links in the supply chain were disrupted, and industries in Japan and elsewhere around the world were impacted. Manufacturing facilities owned by Toyota, Nissan, Honda, and other manufacturers in the USA and Canada experienced serious disruptions.

Resilience Measures

Resilience is the capability to resist the occurrence of a disruption or at least to reduce its effects. It consists of two parts, the inherent resilience and the dynamic resilience. Inherent resilience can be built into the various components of the supply chain and dynamic resilience actions are activated so as to cope with effects and enable recovery in the shortest possible time. Private and public sectors in Canada have roles to play in order to enhance the resilience of the supply chain for improving the competitive position of Canada. Also, private-public sectors can play joint roles.

Evidence-based information suggests that changes are required in corporate supply chain planning and management. Ideas are advanced in this paper, supported by literature, that corporate supply chain planning and management can benefit by formally incorporating resilience concepts and methods. Figure 8 presents the framework for risk assessment studies.

The following factors can enhance the supply chain management: (1) A certain safety stock of good quality parts and relax rigid interpretation of JIT. (2) Alternative sources of the product. (3) Alternative modes/routes. (4) Good understanding of the implication of resilience responsibility residing outside Canada (i.e. issues that are out of control of Canadian importer/exporter/government). (5) Reliability, and balance of efficiency and flexibility.

In Figure 9, four designs are presented that highlight the need for a change in corporate supply chain planning and management. In the first case, the current policy results in major adverse effect on the supply chain. As compared to Design 1, Designs 2 to 4 should result in less effect on the supply chain. However, the relative desirability of these requires detailed risk analysis according to the method illustrated in Figure

8. In essence, the changing risk management agenda should balance efficiency with flexibility and adaptive resilience.

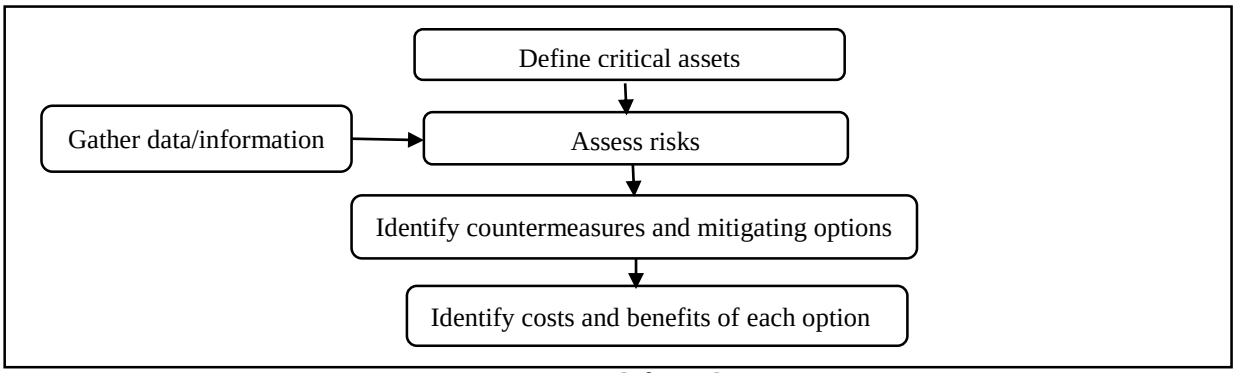

Figure 8. Framework for risk assessment

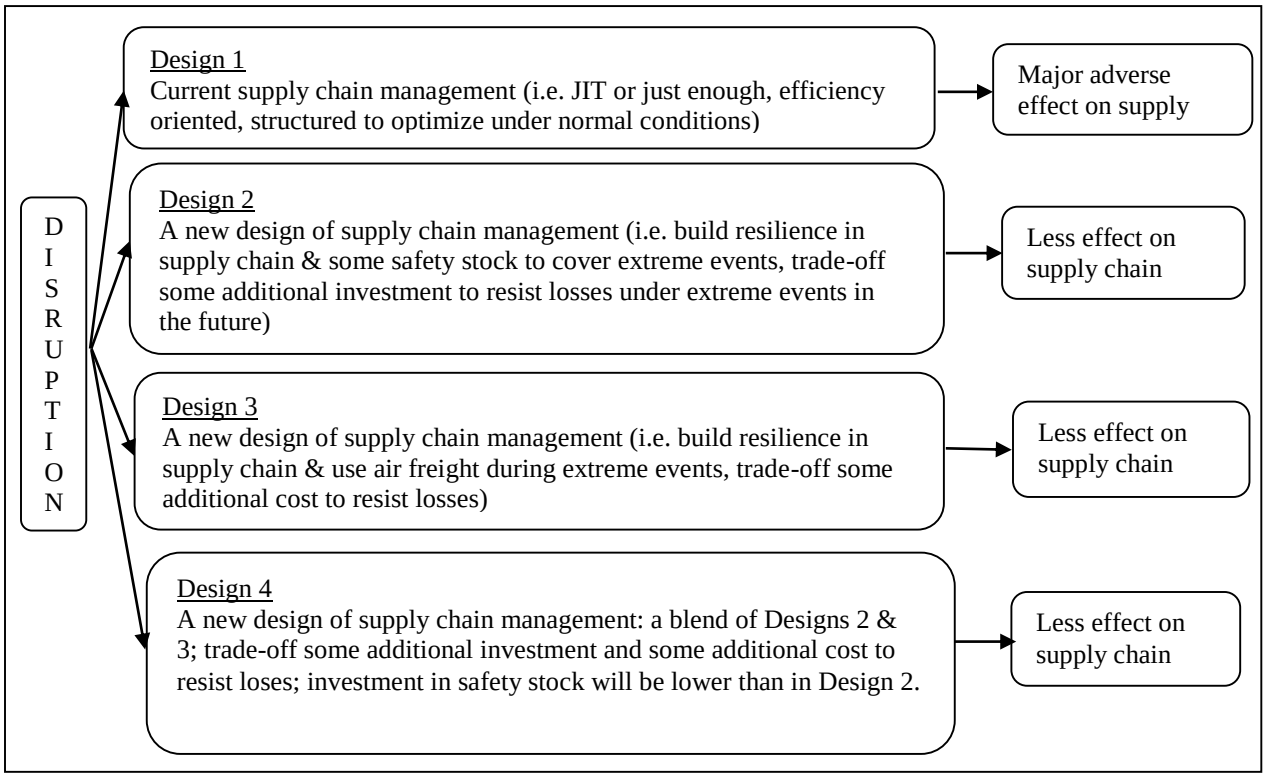

Figure 9. New designs of supply chain management

Governments can help with quick disaster recovery so that impacts are not spread throughout the global supply chain. Some specific measures include financial support, protecting and promoting employment (if applicable), and facilitating business rehabilitation and maintenance. Governments can play a fundamental role in building supply chain resilience through development plans for disaster-resilient supply chains. Measures include insurance, strengthening physical assets, issuing extreme-weather warnings, and sharing information on disaster risks and risk reduction strategies. There are additional considerations for governments and businesses, but due to lack of space, these cannot be covered in this paper.

Examples of Disruptions and Role for New Design of Supply Chain Management

Application of supply chain management design described in this paper could reduce the impacts of disruptions such as the ones noted here on Canadian stakeholders and the economy. Two are major nature-induced disruptions and the other two are labour disputes. (1) Japan earthquake-tsunami. (2) Floods of Thailand. (3) Labour disputes at US West Coast ports. (4) CP Rail strike.

In March 2011, three low probability high impact events occurred (Punter 2013, Ye and Abbe 2012): a major earthquake in East Japan, tsunami, nuclear power plant radiation leak. As a result of these events transportation links in the supply chain were disrupted, and industries in Japan and elsewhere around the world were affected.

In 2011, severe floods caused heavy damage in a number of Southeast Asian countries, including Thailand. This resulted in heavy damages and losses to transportation and infrastructure. Also, it affected the manufacturing capacity of Thailand and the ripple effects in the global supply chains extended to many countries.

The automotive industry was heavily affected because imported parts and vehicles could not be delivered. However, due to the advance warning of the potential disruption in the supply chain, mitigating actions were taken by some manufacturers. Although lost production was ultimately regained, extra costs were incurred in the form of expensive air freight, added storage and handling costs, and substantial worker overtime. Canadian supply chains were affected.

The U.S. West Coast Ports Labour Disruptions occurred in 2002 and again in 2014-15. In 2002, U.S West Coast dockworkers initiated a strike which resulted in 29 ports to decline service to business for 10 days. The main impact was suffered by U.S. automobile manufacturers and retailers. Also, facilities owned by foreign companies (Toyota, Nissan, Honda, and other manufacturers) located in the USA and Canada experienced losses.

In 2014-15, due to an ongoing contract dispute involving dockworkers on the U.S. West Coast, seaports from Southern California to Washington were impacted. Disruptions led to significant port congestion and a backlog of imports and exports. As expected, this dockworker labour dispute had ripple effect on Canadian supply chain (Business Monday February 23, 2015). The U.S. West Coast congestion rippled through supply chains beyond the USA, and hampered shippers from Canada to Japan. (JOC.com 2015).

A nine-day CP Rail strike that started on May 23, 2012 disrupted its entire network. Although the strike lasted for 9 days, in effect it disrupted the supply chain for 11 days due to the extra time needed to start the logistics of moving freight. The pre-strike expected total transit time for the Shanghai-Toronto container traffic was 22.4 days and the standard deviation was 3.2 days. During the strike (days 1 to 11 conditions), the expected total transit time became 41.4 days and the standard deviation was 4.5 days. Following the strike, the transit days exhibited a downward profile (Figure 10). After 32 days, the transit time returned to the pre-strike level.

Implementation Considerations

The following considerations are advanced for reducing Canada's international supply chain vulnerabilities and enhancing resilience.

- A new design of supply chain management based on risk analysis is required that takes into account modifications to the "JIT" and "lean almost zero inventory" practices for enhancing resilience.

- Comprehensive planning of supply chains can address outsourcing and offshoring factors in association with safety stock and tradeoffs with higher cost modes/routes.
- A change in risk management agenda can balance efficiency with flexibility and adaptive resilience.
- Private and public sectors in Canada have roles to play in order to enhance the resilience of the supply chain for improving the competitive position of Canada. Also, private-public sectors can play joint roles.
- Governments of countries that engage in international trade can help with quick disaster recovery so that impacts are not spread throughout the global supply chain.
- Governments can play a fundamental role in building supply chain resilience through development plans for disaster-resilient supply chains.

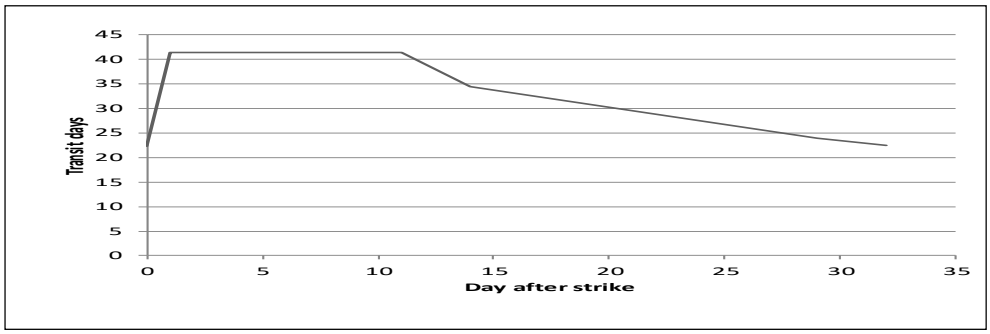

Figure 10. Temporal profile of fluidity of Shanghai-Toronto-Container Traffic (CP Rail Strike)

Acknowledgements
This paper is based on an Industry Canada-sponsored research study carried out at Carleton University on international supply chain vulnerabilities. We sincerely acknowledge cooperation of government and private sector personnel who provided information. The views expressed are not those of Industry Canada or of Carleton University.

References

Bakshi, Nitin (2015). Mitigating Cascades in Supply Networks. London Business School.

Business Monday February 23, 2015

CIPS Knowledge Works (2013). Supply Chain Vulnerability. Easton House, Easton on the Hill, Stamford, Lincolnshire, UK.

Iyer, A. Sridhar, S., and Vasher, R. (2009). Toyota Supply Chain Management: A Strategic Approach to Toyota's Renowned System. Kindle Edition. June 2009.

International Civil Aviation Organization (ICAO) (2014). Moving Air Cargo Globally, Air Cargo and Mail Secure Supply Chain and Facilitation Guidelines. Security and Facilitation. First Edition.

JOC Com (2015). Strong air freight demand to remain as US port backlog cleared. February 25, 2015.

Kahan, JH, AC Allen, and JK George (2009). An Operational Framework for Resilience. JHSEM, 6,1,83. Retrieved Online

Punter, A. (2013). Supply chain failures, A study of the nature, causes and complexity of supply chain disruptions. Report 2013. Airmic Technical.

Robinson, C.H. (2014). Global Freight Consolidation, Flexibility and Control Advantages. White Paper. 14701 Eden Prairie.

Schmidt, W., Simchi-Levi, D., Wei, Y., Zhang, P.Y., Combs, K., Ge, Y., Gusikin, O., Sanders, M., Zhang, D. (2014). Identifying Risks and Mitigating Disruptions in the Automotive Supply Chain. Ford and Massachusetts Institute of Technology, Duke University. Interfaces (Accepted)

Ye, L. and Abbe, M. (2012). The impacts of natural disasters on global supply chains. ARTNeT Working Paper Series No. 115/June 2012, Asia-PaCIFIC Research and Training Network on Trade.