Assessing Key Drivers of Supply Chain Vulnerability

As disruptions have become the norm in complex and tightly-coupled supply networks it is essential that firms mitigate risk and assess characteristics that drive supply chain vulnerability to protect their business. This article identifies global sourcing, supplier dependence and supplier concentration as key supply chain vulnerability drivers, and suggests three ways to reduce this vulnerability.

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1. Anticipating the vulnerability of supply chains

The vulnerability of supply chains has increased as supply networks have become more complex, volatile and tightly-coupled. A key issue is that firms are increasingly dependent upon each other, i.e., the interconnectedness of supply chain can cause significant disruptions, with a severe impact on a firm's operations. When the tsunami hit Japan in March 2011, it devastated among others a facility of Renesas Electronics near Tokyo. This Japanese supplier produces microcontrollers which function as the "brain" of an automobile, covering about 40 percent of the worldwide demand.[1] Renesas' breakdown caused a severe shortage in supply that became rapidly perceptible in automotive manufacturing plants not only in Japan, but also in the United States, as these highly individualized controllers are not easily substitutable.

Supply chain vulnerability is a critical issue for firms because it is indisputably linked to supply chain performance, which in turn, impacts a firm's financial bottom line. In the aftermath of the Japan tsunami, Toyota's U.S. division reported a significant drop in sales and market share. In total, the disruption's cost incurred by the natural disaster is estimated at $4.4

billion for Toyota.[2] In order to secure supply chain performance and profits, firms must recognize the vulnerability of their supply chains and understand the vulnerability drivers of this supply chain.

Supply chain vulnerability is the result of a supply chain's architecture, constituted by its supply chain vulnerability drivers that make the supply chain prone to various risks. Certain characteristics of the supply chain drive the probability, as well as the severity, of a supply chain disruption. A supply chain disruption, for example, the breakdown of a key supplier, is the trigger point for risks that may harm a firm's supply chain operations. However, the disruption as such is not the sole determinant of the firm's harm, e.g., financial loss. It is the susceptibility of the firm's supply chain to disruptions that must be taken into account.[3]

Supply chain vulnerability drivers leverage a firm's exposure to disruptions and their induced risks that impede the operations of the firm's upstream and downstream supply chain. As the vulnerability of a supply chain cannot be observed directly, one must assess the supply chain's drivers of vulnerability. Our investigation portrays the current situation of the vulnerability of firms' supply chains. Two questions are raised: (1) Which of the key supply chain vulnerability drivers are the most prevalent, and as a consequence, (2) what is the overall vulnerability firms' supply chains are exposed to?

We identified five essential drivers of supply chain vulnerability (global sourcing, supplier concentration, supplier dependence, single sourcing, and customer dependence3) and conducted a large-scale survey among purchasing professionals. We asked our respondents how extensively their firms have implemented global sourcing and how strongly have their firms been affected by supplier concentration, supplier dependence, single sourcing, and customer dependence.

2. Assessing key drivers of supply chain vulnerability

A driver of supply chain vulnerability can be any characteristic of the supply chain that either impacts the probability and/or the impact of supply chain risks:

• GLOBAL SOURCING "involves setting up production operations in different countries to serve various markets, or buying and assembling components, parts or finished products worldwide."[4] The benefits of global sourcing depend on the target country, the type of product purchased, or how the product is transported.[3] Generally, global sourcing is associated with higher uncertainty, i.e., it is less controllable and less transparent compared to sourcing from domestic sources, for example, due to different market conditions, the geographic distance to a firm's home base, different cultures, and geo-political environments.

• **Supplier concentration** is a "scenario where the buying firm only has a small number of suppliers."[3] Recently, firms are tending to reduce their supply base to realize improved product performance or better relationships.[3] The resulting trade-offs associated with fewer suppliers involve higher supply chain vulnerability. Having fewer supplier decreases complexity, however, the concentration on a small number of specialized suppliers limits the buying firm's ability to quickly switch to other suppliers in case of emergency.

• **Single sourcing** is an extreme case of supplier concentration. It is a strategy where one supplier is entirely responsible for the supply of a specific item or service as there is no substitute available. Hence, if there is only one supplier for certain procurement flows in the product line, the dependence on that particular supplier is at maximum which equals to very high vulnerability for the supply chain.

• **Supplier dependence** is a form of supplier concentration; however, in this situation the supplier is *dominant* and can substantially exercise power over the buying firm. Supplier dependence can be induced by logistical indispensability, the need for the supplier's technological expertise, the absence of alternative suppliers, or high switching costs from the buying firm's perspective.

• **Customer dependence** is similar to supplier dependence, but linked to the downstream relationship.[3] Following the same rationale, customer dependence refers to a situation in which a firm only has a limited number of purchasers for its product and services. A drop of a key customer might lead quickly to higher supply chain vulnerability, either in overall activity or with respect to a specific product line and its supply lines.

3. Benchmarking key supply chain vulnerability drivers

To assess which of the key drivers are the most prevalent and thereby examining the extent of firms' supply chain vulnerability, we surveyed 345 firms from Germany, Austria and Switzerland across five industry clusters. Our analysis is based on representative sample (see Table 1). The data were collected in Q2 and Q3 2011.

Sales (mUSD)	%	Industry cluster	%
1'000 and more	26.9	Process Industry	33.5
500 - under 1'000	8.7	Engineered Products	27.2
250 - under 500	20.9	Consumer Goods	18.5
100 - under 250	30.4	Automotive	11.3
Less than 100	6.1	Electrical Equipment	0.9
n.a.	7.0	Other	8.7
Position of informant	**%**	**Management level**	**%**
Accounting/Finance	44.2	C-level	5.7
Supply Chain Management/Logistics	24.6	2nd tier	30.4
Purchasing/Procurement	12.7	3rd tier	31.2
Production	5.8	4th tier	14.9
Strategy	4.6	Other	16.0
Other management positions	6.6	n.a.	1.7
n.a.	2.3		

Our respondents were asked to evaluate a set of statements on a five-point Likert-scale that correspond to the sources of vulnerability. In the assessment, the focus was upon a firm's main product line, that is, the product (and its variants) with the highest share in sales.

Results highlight that the top two supply chain vulnerability drivers are global sourcing and supplier dependence with an average of 77.3% and 72.5% respectively. Considering the pace of globalization over the last years, this seems logic.

Next, supplier concentration is ranked third among the key supply chain vulnerability drivers. Survey participants declare that they are affected strongly by supplier concentration, which scores an average of 68.2%. Single sourcing is ranked fourth (Ø 65.2%), followed by customer dependence (Ø 61.3%).

Overall, the results of our investigation reveal a clear hierarchy among the assessed supply chain vulnerability drivers.

Figure 3 highlights that all five supply chain characteristics that drive vulnerability are highly prevalent in firms' supply chains. The average of supply chain vulnerability across all industries yields 68.9 percent.

To derive industry specific insights, we also identified the top supply chain vulnerability driver per industry cluster. Interestingly, *global sourcing* is the most prevalent supply chain vulnerability driver in the electrical equipment (Ø 86.7%), consumer goods (Ø 74.6%), process (Ø 81.0%), and engineered products industry (Ø 77.9%). Only in the automotive industry, *supplier dependence* is the most prevalent supply chain vulnerability driver (Ø 80.9%). This is plausible since the degree of vertical integration in the automobile industry is remarkably low, i.e., in order to reduce costs, original equipment manufacturers have outsourced a large portion of the car manufacturing process and add today only about 30 percent of value in their own plants.

4. Decreasing the impact of supply chain vulnerability drivers

The significant exposure towards supply chain disruptions will, sooner or later, have a negative financial impact on firms. Consequently, firms must recognize and assess their supply chain vulnerability drivers to be able to mitigate the impact of disruptions. We propose three distinct steps that help firms to decrease the vulnerability of their supply chains:

• **Make supply chain vulnerability a top priority.** Firms that have recognized the importance and criticality of supply chain vulnerability make this issue a top priority on their management agenda. Top-level management attention is essential to mobilize necessary resources in terms of management capacity and financial support in order to benchmark and to compare risk management practices with industry peers, and to optimize the firm's supply chain management in terms of risk prevention and risk mitigation.

Regrettably, not all globally-operating firms actively manage their supply chain risks. Firms take notice of supply chain risks after disruptions have occurred. Even if supply chain risk management is formally implemented, it remains ineffective unless there are committed

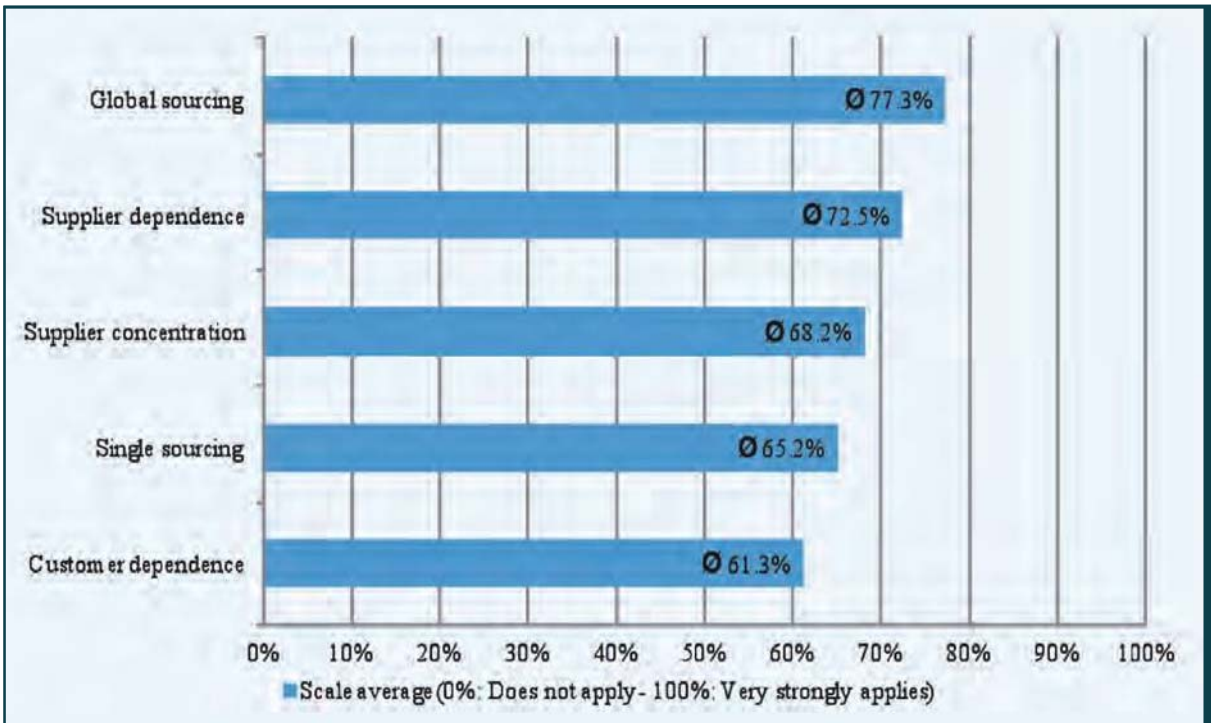

Figure 3: Ranking of supply chain vulnerability drivers

Note: Y-axis shows the supply chain vulnerability drivers, X-axis shows five-point Likert-scale converted into percentage (n=345).

employees that manage the risks. In this context, top management attention takes a very important role as it supports the employees involved in risk management.

• **Increase transparency in upstream and downstream relationships.** Firms that increase transparency in their upstream and downstream relationships decrease supply chain vulnerability. Transparency is centered around the availability of critical information. For the focal firm this means that it needs to gather information about the condition and actions of its customers and suppliers. Transparency is key to understanding and raising awareness of supply chain vulnerability, its drivers and the necessary managerial actions.

The steps towards increasing transparency involve identifying the vulnerability drivers that are embedded in a firm's supply chain, gathering critical information about the drivers, and subsequently, assigning responsibilities to monitor, prevent and mitigate risks. Additionally, it is important for a firm to regularly assess and re-evaluate its supply base.

• **Implement an early warning system.** Firms that sustain a comprehensive approach to decrease their supply chain vulnerability have implemented an early warning system. Vulnerability cannot be completely eliminated because its drivers are an inherent part of the supply chain itself. The purpose of an early warning system is to systematically acquire and process information concerning supply chain vulnerability and its drivers, e.g., regular financial health checks of suppliers on which the buying firm highly depends on, monitoring service levels, and quality.

Early warning systems increase awareness of possible future events to provide them with preparation time to react accordingly and implement appropriate preventive measures in case of a supply chain disruption. By having all critical information at hand and maintaining an active risk management, firms can do their best to anticipate and respond to supply chain disruptions.

Recognizing and assessing supply chain vulnerability and its drivers help firms to understand the extent to which their supply chains are exposed to disruptive events and to manage the consequential impacts a priori. Our results provide insights into the key drivers that increase supply chain vulnerability and show that this is an important concept that firms have to deal with. All firms and their supply chains are vulnerable. Thus, firms must begin in a staggered approach to decrease their supply chain vulnerability. At the end, supply chains with low vulnerability are more robust and will withstand future disruptions significantly better than fragile supply chains.

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