CASE STUDY: GVC VULNERABILITY TO DISRUPTION

Introduction

Despite the benefits of modularization and highly-interconnected GVC, recent natural disasters have provided evidence that global supply chains can be quite vulnerable to interruptions. Risks in supply chains leading to interruption are not limited to natural disasters and can include fires and financial ruin (see Natarajarathinam et al., 2009). Simchi-Levi et al. (2014) have recently suggested it is the low end commodity producers that expose higher-value system integrators to the greatest risks. For example, the Thai floods in 2011 disrupted electronics and auto supply chains across the globe – particularly affecting hard drive supplies (Tibken, 2011). Likewise, the Japanese earthquake in 2011 disrupted auto production from Japan to North America to Sweden (Glinton, 2011), as discussed in a National Public Radio interview between Glinton (interviewer) and Handler (auto industry expert).

- *"GLINTON: So what's happens when one piece of that chain is gone?*
- *Ms. HANDLER: You end up with nothing. In order to build a car, you have to have every piece. There is not one piece that you can say well, I'll add that later.*
- *GLINTON: Not one piece. But there are factories all over the world making car parts.*
- *Ms. HANDLER: If you have a part that is not being made due to a factory being down or something being down, you can't just go to the factory next door and say hey can you make this widget."*
  (Glinton, 2011)

We start with examining the inputs to each industry and assess their vulnerability to disruptions in the supply of six types of input:

(i) Technologies: all transport, machinery and electronics industry classifications
(ii) Chemicals: chemicals, coke and petroleum, rubber and plastics etc.
(iii) Commodities: agriculture, mining and wood
(iv) Metals: iron, steel and non-ferrous
(v) Semi-processed: food, beverages and tobacco etc.
(vi) Services: all service sectors
(vii) Self: intra-industry sourcing, separately accounted for from the above

For each industry, we can then plot the relative proportion of these types of imports, as visualized in Figure 1, with the industries listed in order of their SPE, types input as per columns and colour coding, and the percentage of inputs as per the magnitude of the coloured bar and noted percentage. Multiple factors are immediately evident from Figure 1. Industries are highly dependent on suppliers within the same industry, as represented by the "self" column, with an average proportion of 40.9% of their value-add coming from within the same industry. Vice-versa, inter-industry sourcing is also substantial: on average, ~60% of value-add is sourced across other industry complexes.

Figure 1: Relative proportion of imported value-add by industry

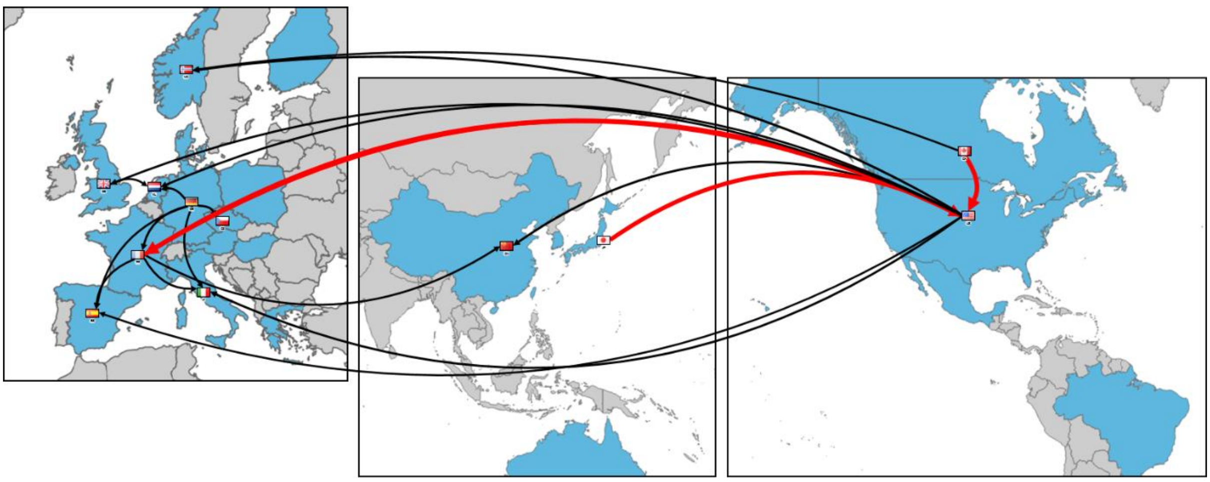
Rank (SPE)	SPE	Industry Complex ↓ \ Source Industries →	Technologies	Chemicals	Commodities	Metals	Semi-Processed	Services	Self
1	1.85	Aircraft and spacecraft	28.2	0.9	0.3	2.1	2.2	5.4	60.9
2	1.77	Office, accounting and computing machinery	62.1	1.8	0.2	0.6	0.8	2.0	32.4
3	1.69	Pharmaceuticals	1.6	39.6	2.5	2.0	5.4	5.5	43.4
4	1.57	Radio, television and communication equipment	37.9	4.4	0.8	2.2	1.4	2.9	50.3
5	1.53	Railroad equipment & transport equip nec	41.2	11.3	1.9	11.9	7.4	7.2	19.1
6	1.45	Electrical machinery and apparatus, nec	13.3	14.6	2.6	18.2	2.9	3.0	45.5
7	1.41	Medical, precision and optical instruments	54.0	6.4	2.7	5.2	4.9	4.0	22.8
8	1.41	Machinery and equip nec (aka industrial machinery)	23.1	7.2	1.2	18.3	7.6	4.5	38.0
9	1.36	Building & repairing of ships and boats	27.4	3.8	1.3	9.3	4.7	3.2	50.4
10	1.36	Motor vehicles, trailers and semi-trailers	17.0	8.4	1.3	8.4	5.3	2.9	56.7
11	1.23	Rubber and plastics products	5.4	65.4	5.0	1.3	6.3	2.9	13.7
12	1.09	Manufacturing nec; including Furniture	7.1	17.4	16.2	16.4	18.5	5.1	19.4
13	1.08	Non-ferrous metals	4.2	4.3	13.4	3.6	3.2	1.1	70.2
14	1.05	Fabricated metal products, except machinery and equip	12.3	8.6	2.7	56.3	1.0	4.5	14.6
15	1.00	Wood and products of wood and cork	5.5	14.0	17.1	1.6	7.1	3.9	50.7
16	1.00	Pulp, paper, paper products, printing and publishing	5.5	14.0	4.4	1.0	2.4	6.3	66.4
17	1.00	Chemicals excluding pharmaceuticals (Industrial & other)	4.1	12.7	5.8	1.1	3.3	5.3	67.6
18	1.00	Textiles, textile products, leather and footwear	3.5	17.6	6.3	0.1	3.8	3.0	65.7
19	0.95	Food products, beverages and tobacco	3.0	14.2	38.8	0.4	2.6	6.5	34.5
20	0.95	Other non-metallic mineral products	12.1	29.6	19.6	5.0	5.3	9.6	18.8
21	0.82	Coke, refined petroleum products and nuclear fuel	0.8	1.5	92.3	0.3	0.1	0.8	4.3
22	0.82	Iron and steel	8.4	6.8	21.6	3.4	2.3	2.9	54.6

Highly interconnected industries (e.g., SPE > 1.3) are highly reliant on inter-industry imports of ‘technologies,’ averaging 33.8% of their value-add being sourced from technology industries. In comparison, for less interconnected industries (e.g., SPE <1.3), sourced ‘technologies’ only represent 6% of value-add. These recursive intra- and inter-industry flows indicate that vulnerabilities may be of particular importance in industries that resemble global factories. Aerospace tops the SPE list and has surprisingly similar inter-industry sourcing patterns to shipbuilding, in that roughly 60% of the value-add from imported modules are intra-industry (e.g. fuselage sections, etc.), and the next most significant import type is technology at 28.2%.

Aerospace

Other than ICT related industries, aerospace is the only other trade complex that is a global factory, as visualised in Figure 2. The trade complex has proportionately more significant sourcing pathways per economy than other industries and has three significant bilateral pathways.

Figure 2: The global factory value architecture for the Aerospace trade complex



This structure evolved due to two trends in the aerospace industry, occuring around the mid- to late-1990s. On the one hand, the number of commercial aerospace production hubs contracted[1]. On the other hand, the remaining firms progressively outsourced. For example, between 1990 and 2000 the share of imports in the U.S. net output (i.e., the foreign value-added) for the aerospace trade complex rose from 9 per cent to 17 percent (see Wixted, 2009). The Boeing 777 entered into service in the mid-1990s and so provides a useful benchmark for a discussion of the supply chain for that time period, and is analyzed by Pritchard and MacPherson (2005). In their analysis, they find that 30 per cent of the build cost for the 777 was imports (ibid., p .3). The imports from Japan include substantial aircraft components (ibid., p. 6-7), including fuselage sections, wing sections and fairings, internal bulkheads, beams and ribs, and various external doors.

Furthermore, aerospace is witnessing what could be called super-modularity[2] in commercial aerospace. Wixted (2009) discussed the Airbus A380 super-jumbo where wings and other parts are moved across Europe and the globe. Boeing's 787 program (first commercial flight in 26 October 2011) outsourced even more of the airframe. Various publications reveal that of the main body of the aircraft, Boeing is now only building the tail, while large sections of the airframe come from Italy and the wings from Japan (Peterson, 2011, Lamba and Elahi, 2012). Japan alone is producing approximately 35 per cent of the value going into 787s (Pritchard and MacPherson, 2004). Aircraft engines also "account for up to a third of the value of a new jet" (The Economist, 2014), are usually sourced from GE (US), Pratt & Whitney (Canada), or Rolls Royce (Great Britain), and are themselves globally modularised products[3]. It is thus possible that the aerospace industry with its super-modularity is even more complex than the iconic iPhone production system and the electronics industry.

Challenge

The above analysis reveals that firms must not only consider where geographically they are sourcing their inputs from, but also which industries they are sourcing from. Suppliers can cease to be available due to business failure, logistical issues, or exclusive trade agreements with competitors. Picture yourself as the competitor to the newly formed GE-Safran Aircraft Engines joint venture, CFM. How would you react? Do you aim to form a similar joint venture and larger modules, in an attempt to gain more credibility and scale in the industry with the aim to secure larger deals with the final aircraft assembler and to attract better suppliers? Or, do you disaggregate your operations with the aim of supplying sub-modules to these suppliers of the final aircraft assemblers? Whichever way you decide, what risks do you face if your supply chain agreements are short-term or do not have an exclusivity clause? How can you manage secondary dependencies on your supplier's suppliers?

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[1] It is much harder to access data on military aircraft and so the literature typically focusses on commercial aviation.
[2] Super-modules are sub-assemblies of modules. The aircraft are now assembled much like a computer from a globally distributed supply system with some of these components physically massive.
[3] See pp. 14-15 of https://www.safran-aircraft-engines.com/sites/snecma/files/brochure_sae_-lessentiel_va_0.pdf

Solution and implementation steps

Following the above analysis, managers of supply chains can become more cognizant of potential risks of experiencing a shock to the supply chain, and how it might cascade through the entire global value chains or architectures of sourcing. Some of these supply chain risks can be managed by diversifying the supply chain to multiple competing suppliers. Alternatively, some supply chain risks can be disintermediated by creating your own organization at the next step in the supply chain (either becoming a super- or sub-module developer). Lastly, another strategy is to use new innovations in manufacturing methods to completely skip part of the supply chain, and source commodities and raw materials to 3D print into modules as GE did, simultaneous to investing in the manufacturers of the 3D printers (Kellner, 2017).

References

Glinton, S. 2011, 'Japan Disaster Breaks Auto Supply Chain. National Public Radio', *National Public Radio. https://www.npr.org/2011/03/22/134755634/Japan-Disaster-Breaks-Auto-Supply-Chain*

Kellner, T. 2017, 'An Epiphany Of Disruption: GE Additive Chief Explains How 3D Printing Will Upend Manufacturing', *GE Reports. https://www.ge.com/reports/epiphany-disruption-ge-additive-chief-explains-3d-printing-will-upend-manufacturing*

Lamba, N. & Elahi, E. 2012, 'When supply chain strategy does not match supply chain capabilities: Lessons that can be learnt from the supply chain of Boeing 787', *Cases on Supply Chain and Distribution Management: Issues and Principles*, IGI Global, pp. 159-77.

Natarajarathinam, M., Capar, I. & Narayanan, A. 2009, 'Managing supply chains in times of crisis: a review of literature and insights', *International Journal of Physical Distribution & Logistics Management*, vol. 39, no. 7, pp. 535-73.

Peterson, K. 2011, 'A wing and a prayer: outsourcing at Boeing', *Reuters. http://graphics.thomsonreuters.com/11/01/Boeing.pdf*

Pritchard, D. & MacPherson, A. 2004, 'Outsourcing US commercial aircraft technology and innovation: implications for the industry’s long term design and build capability', *Canda-United States Trade Center Occasional Paper No. 29. Department of Geography, Buffalo, NY*.

Pritchard, D. & MacPherson, A. 2005, 'Boeing’s diffusion of commercial aircraft design and manufacturing technology to Japan: Surrendering the US aircraft industry for foreign financial support', *Canada-United States Trade Center Occasional Paper No. 30. Department of Geography, Buffalo, NY*, p. 3.

Simchi-Levi, D., Schmidt, W. & Wei, Y. 2014, 'From superstorms to factory fires: Managing unpredictable supply chain disruptions', *Harvard Business Review*, vol. 92, no. 1-2, pp. 96-101.

The Economist 2014, 'Gearing up for a fight', *The Economist. https://www.economist.com/business/2014/01/25/gearing-up-for-a-fight*

Tibken, S. 2011, 'Thai Floods Jolt PC Supply Chain', *Wall Street Journal. https://www.wsj.com/articles/SB10001424052970203658804576636951367373290*

Wixted, B. 2009, *Innovation System Frontiers: Cluster Networks and Global Value*, Springer, Heidelberg, Germany.