



PERSPECTIVES

August 8, 2022 / TACKLING THE CHALLENGES OF SUPPLY CHAINS

Supply chains under pressure: How can data science help?

THIERRY WARIN

Full professor, department of international affairs, HEC Montreal

Chercheur et Fellow CIRANO

Responsable du Pôle CIRANO en science des données pour les échanges commerciaux et le transport intermodal

The world has changed and companies are facing a perfect storm, with catastrophic risks that have a low probability of occurrence but high impact, especially on global supply chains. In a complex geopolitical context, some companies are considering repatriating some of their activities within national borders. Is this the right solution? In this paper, the author argues that solutions to complex supply problems must themselves be complex.

The Biden administration proposed a semiconductor stimulus package in 2021, which the U.S. Congress endorsed in July 2022. The U.S. president has repeatedly stressed that runaway inflation in the U.S. is directly linked to supply chain problems worldwide and is urging U.S. manufacturers to bring semiconductor production back to the U.S. The "CHIPS for America Act" authorizes \$54 million in financial support to promote semiconductor manufacturing in the United States, including support for research and development.

Why semiconductors? Semiconductors are essential for manufacturing cars, smartphones, or even medical equipment. Taiwan Semiconductor Manufacturing Co is the largest foundry in the world, with 55% of the global market share (Trendforce, 2021). Taiwan produces 63% of the world's semiconductors. China's move to reunify with the island of Taiwan is raising serious concerns.

Another concern is that the war in Ukraine is impacting global supply chains already constrained by the COVID-19 pandemic. According to Moody's Analytics, Ukraine is responsible for about 70% of the world's neon, and Russia controls 44% of the world's palladium supply, which is critical because of their importance as inputs in the semiconductor production process.

In this complex geopolitical context, some companies are considering nearshoring or reshoring, i.e., the repatriation of specific activities within national or regional borders. Is this the right solution or not?

Binary thinking is very rarely the right way to think when it comes to complex issues like this. The complexity of the issues requires a multidisciplinary approach and a variety of methodologies. Can data science help us think in complex terms about these international trade issues?

Vulnerability of global value chains

From the acquisition of raw materials to the production and delivery of the finished product, the production process is increasingly fragmented so that each activity that adds value to it can be performed wherever the necessary inputs are available at a competitive cost. This is what we call global value chains. Global value chains are supply chains characterized by a segmentation of production activities across multiple locations and countries that maximizes a company's competitive advantage.

Corporate decisions about global value chains and supply chains are based on local comparative advantages. These comparative advantages are often measured by tangible data such as the return on investment in a given location, but other factors may come into play.

ESG criteria are more relevant than ever

Environmental, social, and governance (ESG) criteria are increasingly used to select investments and encourage companies to act responsibly. Thus, issues of climate change, human rights, corruption, and social impact on local communities are now part of the equation. In the context of climate change, the issues of local pollution, international waste trade, and emissions from transportation are more relevant than ever. These elements are often intangible. (Bernard et al., 2014 et Dudoit et al., 2021)

After the 2008 recession, several scientific articles have focused on the renewed interest in reshoring (Delis et al., 2017, Gereffi, 2020, Gereffi et al., 2022, Panwar et al., 2022 et Sutch et al., 2022). The future of global supply chains in a post-pandemic world, their vulnerabilities, and the need for better risk management are all issues

that have been addressed recently in the literature on the subject. The issues of vulnerabilities in global value chains in the production of medical supplies were examined more specifically.

The question of risk is therefore essential, but how to conceive risk? In his essay *The Black Swan*, the statistician Nassim N. Taleb argues that the future is less predictable and that extreme events (black swans) should be seen as a starting point rather than an exception. "*Our world is dominated by the extreme, the unknown, and the very improbable (improbable according to our current knowledge), and all the while we spend our time engaged in small talk, focusing on the known and the repeated.*" (Taleb, 2010, traduction libre).

In the post-pandemic era, the world has changed, and companies are facing a perfect storm, with catastrophic risks that have a low probability of occurrence but for which the consequences are enormous. We are facing an unprecedented increase in central bank reserves to deal with the pandemic, a massive transformation of the world of work with what has been called the Great Resignation, and significant technological changes. And all at the same time!

Nearshoring and reshoring may be appropriate responses resulting from better risk planning. However, they should not be erected as a policy. A government that supports reshoring through its policies would likely dismantle global supply chains. This would require a radical overhaul of the global economic system.

Nor should nearshoring and reshoring be seen as strategies that will necessarily make supply chains more resilient. It may even be riskier to relocate some activities than not to relocate in cases where the local economy is more vulnerable to risks of labor or capital shortages, for example. Recall that at the height of the pandemic, masks and other medical equipment were mass-produced abroad through global value chains and global supply chains, not through the leverage of local economies. (Panwar et al., 2022).

Nevertheless, it is not a question of blindly trusting the market economy to mitigate risks. The way the market works means that prices rise when specific resources are scarce, and this price mechanism creates incentives to address shortages. However, markets are imperfect, and these adjustments are made ex-post. Futures markets, where they exist, are a mechanism for mitigating ex-post adjustment problems, with futures prices acting as useful indicators for firms to anticipate risks.

Data science makes it possible to go even further and faster in getting the most out of data. This is not a complete overhaul of the global trading system but rather an adaptation to a new technological paradigm: artificial intelligence and data science. (Ivanov et al., 2019).

Data science as a tool for resilience

Broadly speaking, data science combines statistics, computer science, and domain-specific knowledge to analyze data. Data science can be useful in the context of "TradeTech," i.e., advanced technologies to reduce processing times and improve the efficiency of cross-border trade and movement. Data science can also help companies organize their operations to improve production processes and diagnose and mitigate global risks. (Aubert et al., 2021).

This is the first time in human history that we have access to massive amounts of data - both structured and unstructured - as well as the computing power and new analytical methods, the whole machine learning toolbox. Both multinationals and governments can now use augmented intelligence in their decision-making. (Jablokov et Warin, 2022).

Data science helps diagnose and mitigate risks. Its arsenal of techniques allows it to see through the fog of war with predictive models based on real-time, geo-located data. Not only are the data real-time, but the models are also real-time, based on deductive

approaches such as neural networks. Data science allows us to build models that can establish cause-and-effect relationships, models that help make ex-ante decisions so that risks can be mitigated more effectively. (de Marcellis-Warin et al., 2020a, de Marcellis-Warin et al., 2020b et de Marcellis-Warin et Warin, 2020).

Data science allows for accurate mapping of global value chains and global supply chains. A multinational company that is aware of the vulnerabilities of its first-, second-, and third-tier suppliers and its customers can integrate political, environmental, human, and technological risks into its enterprise risk management framework. It can then develop a better strategy to avoid potential bottlenecks. Armed with the correct real-time, geo-located data and the best machine learning models and methods, a multinational company can better anticipate the benefits of greater diversification among its suppliers or customers. We are talking about going even further than the already very useful business strategy of *Redistributed Manufacturing* (RdM). (Srai et al., 2016).

Data science helps internalize negative externalities. The internalization of negative externalities can refer to pricing carbon emissions from freight transport. Most of the world's trade in goods by volume is done by ship, mostly using cheap oil, which further increases carbon emissions. Pricing is one way to take advantage of the market economy as an incentive mechanism for responsible behavior. Internalizing negative externalities can also refer to mechanisms that address child labor or human rights violations. By leveraging data science techniques to track these elements automatically, we can better align the cost of international trade with its true value. Not internalizing these externalities means that the entire planet, particularly the populations most vulnerable to the non-respect of their rights, artificially subsidizes world trade.

In short, data science can mitigate operational, financial, and even reputational risks. This is globalization 5.0.

Conclusion

Our global capitalism is a clever mix of market economics, government policies, and international regulations, creating a very complex map of different comparative advantages across industries and locations. It is not surprising that the state of global capitalism is being questioned once again. Furthermore, it is even healthy to do so.

As the saying goes, "every cloud has a silver lining", or as Winston Churchill said, "never let a good crisis go to waste." (Mutter, 2016). The current context of great global insecurity is an unprecedented opportunity to put in place the best international trade policies to create the most efficient system based on advanced technologies. We cannot settle for an improved market economy, as the inherent ex-post nature of the market is not satisfactory for mitigating global risks. The industrial revolution 4.0 is not science fiction. This is already a reality in many areas. We need to take advantage of what technology has to offer. There is no more time to lose.

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To cite this article

Warin, T. (2022). *Chaînes logistiques sous pression : Comment la science des données peut-elle aider ?*, PERSPECTIVES Journal, 2022PJ-06, CIRANO. <https://doi.org/10.54932/NJYX4623>

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ISSN 2563-7258 (version en ligne)

Directrice de la publication :

Nathalie de Marcellis-Warin, Présidente-directrice générale

Rédactrice en chef :

Carole Vincent, Directrice de la mobilisation des connaissances

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