



Data-Driven Sustainable Decision Models for Supply Chains in an Era of Deglobalisation

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ABSTRACT

One of the biggest changes in recent years is happening in global supply chains. In the last few years, things like wars, the covid-19 pandemic, and the ongoing climate crisis have shown how companies' planning and management of their production and sourcing are not perfect. These problems have led to a lot of talk about deglobalization, reshoring, and nearshoring. In this chapter, i examine how data-driven decision-making models can assist companies in re-evaluating their supply chains to ensure they are not only cost-efficient but also resilient and environmentally sustainable. This study uses real-world trade data, corporate sustainability reports, and optimization methods to show how companies can balance risk, efficiency, and carbon reduction. I use examples from electronics, textiles, pharmaceuticals, cars, and other fields to make things easier to understand.

Introduction

Overview globalization was hailed as the most effective approach to supply chain management for many years. Businesses operated on the straightforward tenet of finding the least expensive supplier, regardless of location, and depending on trade routes to deliver goods efficiently and economically. Production networks were able to span continents while retaining high efficiency and responsiveness to demand thanks to containerization, reduced fuel prices, trade liberalization, and advancements in logistics.

But this strategy has been seriously questioned in recent years. The covid-19 pandemic halted international transportation and manufacturing, exposing the vulnerability of supply chains that rely significantly on far-off suppliers. Shortages in everything from semiconductors to medical equipment brought to light the flaws in "just-in-time" strategies, which keep low inventories in order to cut



costs. Businesses were under immediate pressure to find substitute suppliers, shorten lead times, and control rapidly rising expenses as a result of disruptions.

Geopolitical tensions have made these issues worse. The us-china trade war, the russia-ukraine conflict, and brexit all resulted in tariffs, sanctions, and border delays that hindered trade flows. Protectionist policies, shifting alliances, and political unpredictability have increased the risks for businesses that depend on foreign sourcing. The urgent need to cut emissions from long-distance transportation and production processes as a result of climate change forces businesses to reevaluate their energy use, logistics, and material sourcing. In this context, deglobalization does not imply a halt to international trade. Rather, it represents a shift in supply chain architectures that seek to strike a balance between three crucial goals:

Cost efficiency is the ability to maintain competitive pricing in a setting that is changing quickly.

Supply chains should be able to withstand shocks from natural disasters, political upheavals, and pandemics.

Environmental sustainability includes reducing carbon emissions, implementing the ideas of the circular economy, and satisfying rising customer and regulatory demands.

Businesses now have to deal with complicated issues that extend beyond supply chain issues. Do regional energy sources affect carbon intensity, or does sourcing closer to end markets automatically reduce emissions? How can businesses develop resilience methodically without significantly raising expenses? Can cost-effectiveness and sustainability coexist, or do they need to be traded off? This chapter uses industry case studies, data-driven analysis, and useful frameworks to answer these questions. Data helps businesses anticipate disruptions and optimize for multiple goals at once by acting as a link between theoretical sustainability goals and practical supply chain decisions.

2. Literature background

2.1 Deglobalisation and supply chain reconfiguration

At one point, it seemed impossible to stop globalization. Baldwin (2016) explains that the "second unbundling" allowed businesses to split production across borders in order to take advantage of comparative advantages and cut costs. With components made in one nation, final assembly in another, and raw materials sourced in another, this model resulted in extensive worldwide supply networks. But by the middle of the 2010s, the growth of global trade started to slow down—a phenomenon known as



"slowbalization." this slowdown was caused in part by changing consumer preferences, environmental pressures, rising political tensions, and technological advancements. These trends were quickened by the covid-19 pandemic, which made businesses reevaluate the resilience and sustainability of remote supply chains.

Real world examples shows this shift:

- Apple moved part of its assembly from china to india and vietnam to reduce

Dependence on a single country.

- Intel invested in semiconductor fabrication facilities in the u.s. and europe to ensure

Critical supply security.

- Adidas trialled “speedfactories” in germany and the u.s. to reduce lead times by

Producing closer to key markets.

- European carmakers shifted some production back to domestic or nearby regional

Facilities to mitigate shipping delays and chip shortages.

These examples show that deglobalization is selective and strategic rather than absolute. Critical sectors and high-value sectors like semiconductors, defense, and healthcare tend to reshore or kneeshore the production, while the labor-intensive industries such as textiles continue to rely or depend on cost-effective production in asia. Companies make decisions of sourcing based on the risk, cost, and value, carefully weighing the trade-offs between global and regional supply chains.

2.2 Sustainability in modern supply chains

Sustainability has turned into a non-negotiable aspect of supply chain management. Investors, regulators, and consumers demand full visibility of environmental impact across all supply chain stages, including scope 1 (direct), scope 2 (indirect from energy), and scope 3 (indirect from supplier emissions).

Key points:

- Supply chain activities, such as production, logistics, and raw material extraction, Often account for more than 70% of a company’s total carbon footprint.



- Circular economy initiatives, such as recycling electronics, using reclaimed materials, And reducing packaging waste, help reduce reliance on virgin resources.
- Ethicalsourcing is closely tied to brand reputation. Fashion brands like h&m and zara face inspection over supplier labor standards, water usage, and chemical management.
- Low-carbon logistics, including electric trucks, rail freight, and biofuel shipping, are increasingly adopted to reduce emissions from transportation.

Sustainability offers financial and strategic advantages in addition to reducing negative effects on the environment. Businesses that use green supply chains can increase consumer trust and obtain sustainable financing, take advantage of tax breaks. Ignoring these factors puts one at risk for fines, financial losses, and damages one's reputation. Instead of being viewed as a purely compliance-related issue, sustainability is becoming more and more ingrained in business strategy. Businesses base their decisions about logistics, production, and procurement on sustainability performance metrics, supplier audits, and carbon auditing.

2.3 Data-driven decision models

Digitalisation and analytics have revolutionised the supply chain management. Companies now Use tools such as:

- Digitaltwins, which create virtual models of supply chains to simulate disruptions, Assess risk, and test alternative scenarios.
- Optimisation models, which balance multiple objectives, such as cost minimisation, Carbon footprint reduction, and resilience enhancement.
- Predective analytics, which forecast demand fluctuations, supplier performance, and Potential disruptions.

Complex supply chain management trade-offs are made more transparent through the data-driven decision-making. Managers can use it to evaluate how sourcing from nearby suppliers might lower emissions but raise costs, or how diversifying suppliers might improve resilience but make the logistics more difficult. When combined with the qualitative information from suppliers, industry professionals, and knowledge of regional laws, these analytical models work best. Although the data aids in quantifying



risks and benefits, decisions are kept realistic and sustainable by taking regulatory and human viewpoints into account.

3. Research questions and framework

- Since 2019, have supply chains become more regional?
- Do shorter supply chains really mean lower transport emissions?
- What are the true cost and carbon impacts of reshoring or nearshoring strategies?

To answer these questions, i use:

- Trade and emissions datasets from multiple global sources.
- Multi -objective optimisation models that consider cost, carbon emissions, and
- Resilience metrics.
- Industry case studies from electronics, textiles, pharmaceuticals, automotive, and food sectors

This method makes it possible to conduct an assessment that combines theoretical modeling with real-world, sector-relevant insights, offering a thorough picture of changing supply chain tactics.

4. Data sources

- UN comtrade: provides detailed international trade flows between countries from 2015 to 2024.
- World BANK WDI: contains transport-related CO₂ emissions data.
- Carbon disclosure project (cdp): offers corporate climate disclosures, including Scope 1–3 emissions.

Reshoring initiative: monitors reshoring and nearshoring patterns across industries.

- The OECD tiva helps measure the effect of supply chain decisions on national economies by providing value-added trade contributions.



A detailed examination of regionalization patterns, emissions, and the trade-offs between sustainability, resilience, and cost is made possible by these datasets.

5) Methodology

5.1 Empirical analysis

Regional versus global imports are the main focus of the empirical analysis. Imports that originate within 4,000 kilometers or less of the destination market are referred to as regional imports. Emissions from transportation are computed using:

$$Emissions_{ij} = Distance_{ij} \times Weight_{ij} \times EmissionFactor_{mode}$$

The energy source, mode of transportation, and shipment distance are used to calculate transport emissions. Indicators like these are used to evaluate supplier resilience: indexes of supplier concentration variability in lead time disruptions in the past.

5.2 Optimisation model

It has three main objectives:

1. To minimize the cost while ensuring demand satisfaction.
2. Minimisation of carbon emissions while considering energy mix and transport mode,
3. To maximize resilience by mitigating potential disruptions and diversifying suppliers.

1. Minimise cost:

$$Z_1 = \sum (ProcurementCost + Tariffs + TransportCost)$$

2. Minimise emissions:

$$Z_2 = \sum (ProductionEmissions + TransportEmissions)$$



Supplier capacity, lead time restrictions, carbon budgets, and product-specific specifications are some examples of constraints. The model enables scenario testing, including assessing the effects of moving a supplier from a far-off, inexpensive location to a closer, more expensive, and lower-emission alternative.

6. Case studies

6.1 Electronics

The manufacturing of smartphones depends on a global network of suppliers. For instance, some businesses are moving their assembly to Mexico in order to serve the American market. Although these changes raise production costs by about 10%, there are significant advantages. Transportation-related emissions are reduced by about 25% and the supply chain is made about 30% more resilient to interruptions. In an effort to lessen their reliance on China, many businesses are also diversifying their suppliers in India and Vietnam. There is a trade-off. Though as production emissions may increase, coal is the primary source of electricity in all these nations. This demonstrates that when designing the supply chains, businesses need to consider not only transportation distances but also the energy sources used in production.

6.2 Pharmaceuticals

The pharmaceutical industry heavily depends on active pharmaceutical ingredients, (APIs) which are sourced from China and India. Hybrid sourcing strategies, which combines the local backups with international suppliers, are being tested by some companies. This approach more effectively balances the supply chains, resilience, and costs than reshoring everything. The importance of credit-driven decision-making is highlighted by the fact that completely reshoring pharmaceutical production can lead to a significant cost increase of 15-40%.

6.3 Automotive

Automobiles are made up of the components like chips, to batteries, to metal parts from 15 to 20 countries. Reducing batteries and chips regionally can increase the costs by 8 to 12 percent but it cuts the risk of disruptions by about half. Nearshoring critical components also helps the manufacturers to improve delivery times and reduce lead time variability. It makes it easier to manage production schedules and respond to changes in demand.



6.4 Food

Shorter supply chains in the food industry have clear advantages. They reduce the spoilage and improves freshness. Combining the local production with low carbon transport methods can lower the emissions by 15 to 25 percent. Companies also find that diversifying suppliers and keeping the inventory small buffers and improves resilience without adding much cost. This shows that operational flexibility and sustainability can go hand in hand. We don't always have to choose between environmental responsibility and efficiency.

7. Discussion

7.1 Key findings

A few important things stand out from the analysis. First, it's clear that regionalization is on the rise, especially in high-value or strategic areas like pharmaceuticals, cars, and electronics. Companies are moving production closer to their main markets and getting supplies from more than one place to lower their risks. Second, shorter supply chains don't always mean a smaller carbon footprint. The energy sources used in the production area also have a big effect on the environment. Moving production closer to Europe, for instance, might cut down on emissions from transportation, but if the factories depend heavily on coal, the overall carbon footprint could still be high. Third, there are always trade-offs between cost, durability, and long-term viability. A business might pay a little more to have backup suppliers or suppliers in different parts of the country.

7.2 Geopolitics

Supply chains are significantly impacted by political events. Companies are reluctant to rely solely on one nation due to tensions such as the Russia-Ukraine war, Brexit, and the U.S.-China relationship.

These days, a lot of businesses are using suppliers from different areas and using predictive analytics to foresee possible interruptions. For example, businesses can take action before their operations are impacted by a conflict or a sudden increase in tariffs, as opposed to rushing to address issues after the fact.

7.3 Technology

Modern supply chains now heavily depend on technology. Businesses can track shipments in real-time and model various crisis situations, such as pandemics, natural disasters, or abrupt political tensions,



using tools like ai, digital twins, and blockchain. Before putting alternative sourcing strategies into practice, businesses can even test them virtually, which lowers the possibility of making expensive errors. For instance, a business can plan an alternative route or supplier right away after observing what happens if a major supplier halts production.

7.4 Equity considerations

Re-generalization, de-globalization may strengthen the supply chains, but they also have social impacts. As companies or businesses relocate their production closer to their home, the developing nations that rely on manufacturing jobs may also see a decline in their employment opportunities. The inclusivity and fairness of these transitions must be guaranteed by the authorities and government. Economic assistance should be provided to the impacted areas like society, social safety nets, and re-skilling initiatives. Long-term economic instability and social unrest are risks in the absence of these steps. Workers in southeast asia, for instance, require assistance and new skills to find work if the textile factories shut down as a result of nearshoring, otherwise the entire community may suffer.

8. Conclusion and policy recommendations

I think that the era of de-globalization is lesser about closing off the trade and more about being intelligent about how we run the supply chains. Over the past decade, we have suffered pandemics, political unrest, natural disasters, and climate problems, which shakes things up. These events taught us that supply chains should not just be built for speed and low cost, which can break down easily, but companies now need supply chains that are flexible, environment-friendly, and strong enough to handle unforeseen situations without delaying deliveries or financial losses.

One of the things that really stands out for me is the power of the data-driven decision-making. When the companies understand their supply chains properly, they can make better choices and decisions instead of waiting for the problems to come up. For example, moving a supplier closer to their home, we call it near-shoring. It might cost a little more, but it can be reduced during delivery delays, low carbon emissions, and protect against sudden disruptions like political conflicts or transport strikes. Similarly, using sustainable methods like renewable energy, eco-friendly transport, or recycling materials. It doesn't only help the environment but also builds trust with customers and prepares the company for stricter rules in the future.



Sustainability and resilience are no longer extra things that the company can ignore, they are the essentials. If a company ignores them, it can face delays, fines, or even damages to its reputation. On the other hand, companies that focus on sustainability and resilience are much better prepared to handle crisis, retain loyal to their customers, and stay ahead of their competitors. Resilience, efficiency, and sustainability don't compete with each other, they can actually work together if decisions are made carefully, mindfully, and based on good information.

For companies:

For companies, investment in data tools, businesses should use software and models to understand their supply chains better. For example, a company can test if a supplier suddenly stops shipping. This helps plan ahead instead of reacting after things going wrong. Make sustainability part of every decision.

Sustainability should not just be a marketing point, it should guide the companies how to source materials, produce products, and deliver them. For example, a clothing brand using recycled fabrics does not only help the planet but also attracts environmentally conscious customers.

Plan for disruptions: companies should regularly test their supply chains for problems like natural disasters, political issues, or pandemics. This means keeping an extra stock, finding backup suppliers, or checking alternative shipping routes.

For government:

For governments, the government should encourage businesses to use renewable energy by giving them subsidies or tax breaks. This does not only reduce emissions but also makes the businesses more sustainable for the economy.

Invest in infrastructure: the government should get good transport networks, ports, and internet connectivity to make local supply chains more reliable and reduce dependency.

Encourage nearshoring and reshoring: governments should help the companies to move the production closer to their home in eco-friendly ways. They could do this by providing money, guidance, or easier regulations. This supports the economy and the environment.

Future research directions



Even though the chapter covers a lot, there is still more to explore. The supply chains are changing really fast because of technology, politics, and climate. The future studies could help the companies and the government to make smarter decisions, impact on developing countries. If the production house is moved closer to bigger markets, it may reduce exports from developing countries. Industries could look at how the jobs, wages, and growth are affected, which will help the government to support local economies better. Comparing industries, different industries face different problems. Food, electronics, textiles, and pharmaceuticals all work differently. Comparing the industries could show the best ways to balance cost, sustainability, and resilience. Using new technologies, blockchain, iot, ai, and analytics can make the supply chains smarter and greener. Studies could help to explore how companies use these tools, what problems do they face, and how do they combine them with older systems.

In short, future research should help us to see supply chains as a whole where efficiency, resilience, sustainability, and social responsibility, all the factors matter together. This way, the companies, government, and researchers can build supply chains that work well for the world that is complex, uncertain and changing.

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