ISSN 1846-6168 (Print), ISSN 1848-5588 (Online)
https://doi.org/10.31803/tg-20250502094727

Subject review
Received: 2025-05-02, Accepted: 2025-06-02

Global Logistics in a Changing Environment and Best Practices Implementation

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Abstract: The international economic interdependence and transnational organization of goods and services with global supply chains determine the economy, environment and working conditions in many countries around the world in numerous ways. The main risks in the supply chain are of an economic, ecological, political and ethical nature. The EU Supply Chain Act obliges companies to operate fairly and sustainably and to respect human rights and ecological protection in their supplier network. This contribution describes the effects of geopolitical hazards on the tactical level of the supplier network. Challenges include costs, disruption and regulatory and compliance issues. A case study of an automotive manufacturer shows supply security and resilient supply chains; risk management in purchasing, e.g. internal manufacturing, Innovations as a strategical competitive edge; digitalisation; social and environmental responsibility and carbon emissions.

Keywords: best practices; disruption; environment; global logistics; risk management; supplier

1 INTRODUCTION

For the first time since the end of the Cold War, Germany and Europe must again engage intensively with geopolitical risks and potential threats of war. Supply chains continue to be affected globally by unprecedented disruptions. Geopolitical instability and uncertain political climates increase the likelihood of sudden disruptions in supply. Supply chain resilience and sustainability help stakeholders to succeed throughout and after the interruption. A resilient supplier network provides to the sustainable competitive edge of the whole value stream [1, 2].

- Tactical risks: relate mainly to external issues with suppliers or customers: they include geopolitical supply chain risks, fires, quality problems, late deliveries, compliance issues, extreme weather phenomena caused by climate disasters and more.
- Operational Risks: involve mainly internal processes that the company has control over and that align with day-to-day front-line issues.

Geopolitical risks of the supply chain in focus in 2024 were, for example, the Russia-Ukraine war and Russia-Nato tensions and their global impact, the Israel-Hamas war, Red Sea crises, the US election, US-China tension, China-Taiwan tension, the advancement of climate change and environmental policies, the rise in global health challenges, protectionism and trade policy shifts, energy security and transition and demographic change. Allianz's Country Risk Atlas provides extensive overviews of the general policy, the macroeconomic and commercial situation and of the ecological aspects that influence default risk for companies in 84 countries [3]. How theoretical approaches from other fields can be used and practical research is presented in a variety of contexts in [4].

Logistics, as an accessory to and victim of the climate crisis, is among the biggest emitters of greenhouse gases, which demonstrates the need for environmental protection in logistics. Companies are not isolated in the supplay chain and relying on distant suppliers can be disastrous.

What significant role does managing resilience in operational and supply chains play in the transition to a more sustainable future [5]? To this end, the OECD policy toolkit provides pointers with regard to increasing supply chain resilience [6]. Limited sourcing options lengthen lead times and reduce flexibility, thus causing operational delays. As a result, companies are now adopting a ‘local for local’ concept with their suppliers and production networks. They collaborate with local suppliers to acquire parts near their manufacturing locations. The shortened transport distances reduce the carbon footprint of the parts. Furthermore, in times of extensive unstable supply chains, this localisation also allows for a greater level of flexibility and robustness in maintaining the supply of manufacturing facilities.

Embedding human rights due diligence in the procurement process is a key element for effectively enforcing defined social and environmental standards. Manufacturers' requirements are a significant factor for suppliers in implementing measures that help to ensure respect for human rights and are also considered by rating agencies. The "Act on Corporate Due Diligence in Supply Chains" came into effect on January 1, 2023. The legislation governs the accountability of German companies for compliance with human rights in worldwide supplier networks [7]. For the customer, the consideration of sustainability aspects and human rights is now playing an increasingly important role in purchasing decisions in addition to quality.

The aim of this article is to show how the network of a resilient supply chain is secured in the face of geostrategic aspects and that to establish a more resilient and flexible supply chain, it is necessary prioritize risk management in purchasing, strive to achieve in-house production as a means of gaining a strategic competitive advantage, seek collaboration with technology partners to implement innovations and develop a digitalization strategy. This must also include the execution of social and environmental responsibilities and acting with due diligence, for example, regarding carbon emissions in the supplier network.

2 CASE STUDY: SUPPLY CHAINS & SUPPLIER NETWORK

This part describes a case study of a premium automobile manufacturer, whose Procurement and Supply Organization is in charge worldwide for the sourcing and quality control of

manufacturing and raw materials, parts, assets and services as well as for the internal manufacturing of car parts.
The most important topics are, see [8]:

- Securing supply for the manufacturing site
- Extending robust supply channels
- Sourcing high-quality parts at favourable conditions
- Realisation of potential applications at an early phase
- Digitising the sourcing processes
- Integration of both social and environmental norms
- Integrating & improving the production of internal parts.

The case study is based on the author's many years of experience in the company in the fields of logistics, quality, risk and health management, environmental impact studies, with intensive access to internal documents and meetings, and in his activities as a consultant. More information was obtained and analysed through audits, expert interviews, questionnaires and data updated from the 2024 Company Report [8].

2.1 Supply Security and Resilient Supply Chains

Supply security: The year 2023 was shaped by enhanced supply robustness and by increasing commodity costs caused by raging global inflation. This led to higher expenses for the manufacturer, especially for commodities, and for energy and freight. The general supply conditions also continued to be difficult for specific technologies 2024 [8].

Natural hazards represent a further risk. As in 2023, there were bottlenecks in 2024 due to supply shortfalls resulting from the increase in severe weather conditions such as flooding and severe storms. The outlook for more severe climate impacts and increasing occurrences of severe weather conditions are also expected to complicate future planning. The company can reduce the impact of these unpredictable conditions thanks to its agile supplier ecosystem and thereby almost completely secure its capability to provide cars.

In order to reduce the effects of the war in Ukraine on its European sites, the manufacturer has taken extensive measures since 2022 to enable it to continue sourcing parts from western Ukraine [8]. Simultaneously, its partners have set up further manufacturing facilities outside Ukraine and supplies to the sites have largely returned to normal.

Expanding resilient supply chains: In 2023, the manufacturer was largely certain of the robustness of its supplier network due to the challenges imposed by geopolitical disasters and the unsecure availability of crucial commodities. The rise in costs on the world markets has also worsened to an even greater extent the tense procurement conditions. The manufacturer's RiskHub is a crucial part of improving the robustness of its worldwide supply network.

The RiskHub studies data from external, publicly available data sources concerning issues such as natural disasters and financial risks. It enables risks to be recognized at an early phase using artificial intelligence (AI) and data analytics [8]. The Catena-X Automotive Network (Catena-X) is a platform for the uniform transmission of information across its entire supply chain from the manufacturer to the SME suppliers and on to recycling businesses. Catena-X creates a collaborative, distributed information and service ecosystem. The Catena-X group consists of car manufacturers and suppliers, distributor societies and plant manufacturers [9].

The manufacturer applies a policy of sourcing car parts near to its manufacturing sites wherever possible. Local sourcing teams are therefore present in all major markets. Local risks and chances are therefore recognised fast and the company can respond quickly to the relevant market circumstances (Tab. 1). A robust supply chain strategy is becoming more important and the manufacturer is increasingly taking this into account when selecting its partners.

Table 1 Regional distribution, companies' purchased volumes [8]

Germany	33.1 %
Eastern Europe	19.6 %
North America	15.3 %
Other Western Europe	10.7 %
China	17.3 %
Other	4.0 %
Total:	96.1 billion € (2023)

2.2 Risk Management

Risk management in purchasing: A cross-linked risk management system is essential for the supply chain. It proactively steps in when appointing suppliers and responds quickly in recognising and analysing potential supply shortages. The manufacturer's RiskHub uses external, freely accessible data to analyse information on potential risks such as natural disasters or financial risks. State-of-the-art methods such as big data analytics and AI are also utilised [8]. Risk Data Hub is a platform that enhances the access and exchange of EU-wide maintained disaster risk data for Disaster Risk Management (DRM) related activities and forms the foundation of science-based information for DRM policies [10]. For chosen parts, the sites of sub-suppliers are also considered when evaluating the total risk [11].

To prevent cyber threats and efficiently manage the ever-growing number of supplier-related security threats, the manufacturer remains committed to certifying suppliers according to the vehicle standard Trusted Information Security Assessment Exchange (TISAX®). TISAX is an across-company assessment and exchange procedure for information relating to security in the automotive industry. It is concerned with the protection of data and its integrity as well as ensuring availability in the manufacturing process and in the operation of vehicles [12]. TISAX is an embedded feature of the sourcing process and an integral requirement of agreements with suppliers that fulfil the specified relevant criteria. The joint IT security analyses and the frequent exchange of information via a B2B portal makes the supplier network more resilient [8].

More and more trainings and information sessions are held both in-house and outside the company to increase awareness of the fast-increasing number of cyber threats.

2.3 Internal Manufacturing and Innovations

The strategic benefits of internal manufacturing: The manufacturer periodically reviews its product program regarding profitability and strategic significance. The priorities of this assessment relates the areas of electromobility, digitalization and sustainability. In these central transformation

fields, the manufacturer is extending its internal know-how in relation to strategy-critical parts in a focused and lasting manner. Simultaneously, the capability to innovate must be increased and supply secured through internal manufacturing. The advantages of this solution are evident, for example, in the controller unit of the high-voltage battery and in the electrical powertrain system. The manufacturer also wants to reinforce its process expertise in the technological areas crucial to quality assurance and in the qualification of the supplier ecosystem. A commitment to quality for the customer provides a decisive competitive advantage and is a key factor in the manufacturer's long-term success.

Innovations: By collaborating with technological associates and establishing innovative networks, the manufacturer can apply innovations to its cars in the shortest possible time. The company works closely with the Startup Garage, which has assessed a total of 4,700 startups to date, of which 30 are now established as suppliers and service providers of the manufacturer and form an integral part of its network [8]. A collaboration of the company with iVentures in Silicon Valley reveals that investments have been made in startups in the fields of automation, manufacturing, robotics, logistics, and quality assurance [8].

The suppliers' results are regularly evaluated within the technology networks [8]. Suppliers contribute directly to the success of the manufacturer and, together with their employees, advance all their tasks via the partner portal, a worldwide platform for collaboration characterized by a mutual awareness of quality, security of supply, innovative capacity and the commitment to sustainability [13].

2.4 Digitisation of the Supply Network

A digitised transfer of data across the entire supply network is indispensable for the company. This is an absolute precondition for creating a more robust and agile supply network infrastructure.

Catena-X [9] is the car industry's frontrunner project for the digitisation of the supply network. This takes place between car producers, sub-suppliers, suppliers and, upcoming, recycling enterprises. The digital basis allows all parties in the supply network to overcome the obstacles within the sectors. This applies, for example, to improving robustness and fulfilling sustainability targets and legal regulations by means of digital cooperation. A beta test phase was effectively implemented in 2023 with the substantial involvement of the manufacturer as consortium leader. In cooperation with its component production, pilot projects have been implemented. This has generated useful knowledge that will help to encourage innovative IT processes in a manufacturing setting (Catena-X rollout phase since 10/2023) [9, 36].

The manufacturer concentrates primarily on the tracking of parts in the supply network, conducting collaborative root cause analyses to eliminate possible quality issues and gathering data of CO_2 emissions in the supply network. 2024 "use cases" with suppliers have been implemented and spread throughout the entire industrial sector. An important progress is the delivery of the Digital Product Passport (DDP) [14], which includes product-specific information for parts such as cells or complete cars. Data are available through Catena-X on the basis of information from n-tier suppliers. This contains information on the source and composition of the materials and on recycling.

In future, products must be aligned with the principles of the circular economy. Therefore, a knowledge of the preceding steps of the supply chain and the effect of the manufacturer's activities upon down-stream steps is essential. Here, DPP is a key enabler as it delivers the required data and networking opportunities. DPP's goal is to provide more traceability throughout the supply chain by digitally saving product-specific data (Ecodesign for Sustainable Products Regulation in force since 18.08.2024 [15]).

2.5 Ecological and Social Accountability

The manufacturer sees sustainable supplier management as an essential element of solid business management. The demands and anticipations it imposes on its vendors are defined in the manufacturer's "Supplier Code of Conduct" [11] and contractually binding as an essential element of the manufacturer's purchasing requirements [16].

In compliance with human rights, the social and environmental regulations of the complete supplier network form the basis for the permanent success of the manufacturer. This is defined in the manufacturer's "Supplier Code of Conduct". It obliges its Tier 1 suppliers to impose their demands on their upstream sub-suppliers [11].

A corporation-wide "Compliance Management System (CMS)" strengthens the behaviour of strict adherence and probity and minimises threats. Globally accredited standards for the safeguarding of human rights form the foundation for the company's entire supplier network. It considers these as to be special requirements for itself, its supplier's network and its other business partners [17], e.g. the Global Reporting Initiative (GRI) Content Index [18]. GRI is an independent, non-profit organisation that provides a comprehensive framework for sustainability reporting.

2.6 Due Diligence within the Supplier Network

The manufacturer's entrepreneurial accountability for social and environmental rights in the supplier network is institutionalized within the framework of a multiple-step due diligence procedure [19]. It primarily applies standards-based monitoring processes to fulfil the due diligence responsibilities anchored in its corporate procedures. The manufacturer works with campaigns and federations such as the "Responsible Business Alliance (RBA)" [20] and "Drive Sustainability" [21]. RBA represents the worldwide biggest industrial association. It is committed to sustainable corporate governance in worldwide supplier networks. Drive Sustainability is an automotive Partnership between 16 car manufacturers, facilitated by CSR Europe, which provides a Self-Assessment Questionnaire on Corporate Sustainability and Responsibility (CSR) for automotive sector suppliers. The manufacturer follows the principles created by the "German Automotive Industry Dialogue" for the five key aspects of human rights due diligence (risk analysis, policy statement, measures, grievance and reporting procedure) [22]. The manufacturer advocates the implementation of a cross-indus-

try complaints system [17]. For guidance on organising, implementing and evaluating complaint procedures, see the German Supply Chain Due Diligence Act [23].

Risk evaluation: The company reviews and evaluates the relevance of the risks of its suppliers at both prospective and already existing supplier locations. Different in-house and outside information channels, such as national and product-specific key figures and media reviews, are utilized to detect and evaluate human rights and ecological risks. The manufacturer employs standard ecological questions (see "Sustainability Code Database" [23]) and engages third-party on-spot audits to perform extensive risk evaluations of its Tier 1 suppliers. With the Sustainability Codex, the "German Council for Sustainable Development (RNE)" intends to encourage enduring corporate policies [24]. Illustrating the supply chains serves as the foundation for identifying the risks in supplier chains and the manufacturer is constantly striving to improve visibility in the whole supplier network [18].

Prevention and remediation: If risks are identified, suppliers are obliged to carry out the required prevention and monitoring tasks by a specified date before finalising the contract with the manufacturer. Suppliers are also required to demand these measures from their sub-suppliers, depending on the specific risks they pose. As a part of the procurement procedure, these activities are validated and assessed via the sector-wide Drive Sustainability Survey [21]. This is intended to overcome existing shortcomings and reduce possible risks. For GRI disclosures on the environmental assessment of applicable supplier sites, see also [18] and see SAQ Toolbox [25]. The on-line evaluation is carried out for providers of manufacturing and non-manufacturing products and services with a minimum order volume, based on market and product-specific hazards. Different modules are used and the deployment of each must be successfully finished before the launch of manufacturing. The extent of the preventive activities depends on the type and scale of the commercial operations, the possible threats and the scope of the supplier. Trainings on the topic of sustainability in the supplier network are offered by the company for internal insourcers. This is also applied to suppliers and process partners on an optional basis.

The manufacturer has set up further monitoring procedures for suppliers in critical locations or high-risk product categories. Tools consist for the audits of ecological and social requirements at supplier sites with the help of cross-sector assessment programs supplied by the "Responsible Business Alliance (RBA)" [20] and the "Responsible Supply Chain Initiative (RSCI)" [26, 27] of the VDA (Verband der Automobil Industrie). The RSCI association was launched in October 2021 by the VDA together with 14 other founding members, including both automotive manufacturers and suppliers.

The manufacturer's target is to fulfil local legal demands for both sustainability and international human rights standards for all assessed Tier 1 supplier locations.

2.7 Carbon Emissions in the Supply Chain

Logistics and transport accounts for approximately 24% of worldwide CO_2 emissions. Climate-neutral logistics is the future. The most important pollutants in terms of Greenhouse gases found in the global atmosphere are CO_2, nitrogen dioxide (N_2O), water vapour, methane (CH_4), and ozone. By 2050, the European Environment Agency expects that, without effective measures, global logistics will cause 40% of global carbon emissions [28]. Transport is responsible for around a fourth of all EU greenhouse gas emissions and is the cause of air and noise pollutants and for the fragmentation of living areas [29].

The manufacturer is committed to supporting the decarbonization of its supplier network and reducing carbon emissions from the supplier network, e.g. by 40% per vehicle by 2030 compared to 2019 [30, 31, 32]. It is therefore one of its procurement criteria that suppliers pledge to take decarbonisation measures. Measures include reducing carbon emissions by, for example, using green electricity, using secondary commodities, operating newer production processes for commodities and using innovative products and materials such as organic materials. Therefore, offsetting activities not covered. They specifically support their suppliers by offering online training, face-to-face partner workshops [18] via manufacturer's Partner Academy [33].

The figure for contracts with suppliers that defined decarbonization activities increased significantly in 2023. This increase includes activities that require the usage of recycled materials, bio-materials and de-carbonized steel. According to the manufacturer, the usage of green electricity has the biggest effect on decarbonisation of the supplier network, (internal production, directly procurement or "Energy Attribute Certificates" [34], for example proof of origin). The manufacturer has determined that the utilization of green electricity is a prerequisite for the allocation of orders for the procurement of carbon-intensive parts and commodities. This applies to suppliers (tier 1) and for energy-demanding processes of sub-suppliers (n-tier). The manufacturer has signed many call-off contracts with its largest suppliers for the utilization of green electricity since mid-2021. An initiative was created in 2023 to evaluate suppliers' schemes for the utilization of green electricity before the start of manufacturing.

In addition, the manufacturer continues to appoint an independent third-party contractor to perform an annual assessment of decarbonization efforts in mass manufacturing. The carbon dioxide emitted in the manufacturer's logistics and supply network is measured globally in in tons of CO_2 equivalent (tCO_2e) per vehicle produced. The result in terms of reducing the negative impact on the environment was a 78% reduction in carbon dioxide emissions per car manufactured from 2006 to 2020. The target is the reduction of average carbon dioxide emissions per car by a projected 80 % by 2030 in comparison to the base year 2019 [35]. The number of suppliers with contracts to reduce CO_2 emissions increased from 468 (2022) to 707 companies in 2023. The result was a saving of 1.7 million tonnes of carbon dioxide emissions [36]. The company further announced that it will avoid emissions of over 200 million tons of CO_2 by 2030 [30].

Scope 1 to Scope 3 emissions are founded on emissions from different sources [37]:

- Scope 1: immediate emissions resulting from the incineration of fossil fuels within a firm.
- Scope 2: indirect emissions generated using electricity and heating from outside energy supplies

- Scope 3: indirect emissions resulting from the downstream and upstream stages of the processes: downstream - utilisation of goods and services; upstream - in the supplier network

The manufacturer is committed to the research-based objective of lowering its Scope 1 and Scope 2 emissions by 80 percent and its upstream Scope 3 emissions by 22 percent per car by 2030 [37]. As expected, emissions from the fleet's supply chain will increase. It expects that the implemented CO_2-reduction activities will overturn the present rising tendency by 2026 at the very latest. The manufacturer still uses the "Carbon Disclosure Project (CDP) Supply Chain Programme" [38] for evaluation of the efficiency of its supplier network regarding its decarbonisation.

3 CONCLUSION

Can we provide an outlook and conclusion for the near future? For the Bavaria 2025 Raw Materials Report, the Bavarian Chambers of Industry and Commerce (BIHK) surveyed ca. 7,000 member companies in 2024 [39]. The results:

- Drastic price increases & supply bottlenecks predicted
- Continuing uncertainties on global markets expected
- 60% expect that the supply situation will worsen in the next 5 years
- It is expected that a tighter supply of local raw materials will lead to longer transport routes, higher transport costs & CO2 emissions
- Due to the political environment, 40% welcome the establishment and expansion of strategic partnerships in the raw materials sector
- Measures necessary to combat impending supply bottlenecks: optimise warehousing and manage inventories
- Diversification of raw material sources and long-term supply contracts is required.

Company adjustments to be made: optimise transport (86%), warehousing (67%), packaging (49%).

Expectations for the next five years of the companies surveyed:

- 60% predict a worsening of the supply situation
- 49% expect a deterioration due to the war in Ukraine
- 44% expect bottlenecks in international maritime trade
- 26% expect an impact from the inception of the "European Supply Chain Due Diligence Act".
- 25% expect an impact from China's actions regarding critical raw materials
- 39% expect an impact from the entry into force of the EU Critical Raw Materials Act.

Global supply chains will continue to be challenging and subject to increasing pressure from higher prices and costs, raw material shortages, natural disasters, geopolitical crises and extreme weather events. Logistics and transport accounts for approximately 24% of worldwide CO_2 emissions. Climate-neutral logistics and production are the future.

Respect for human rights, compliance with social standards and the reduction of CO_2 emissions are becoming more of a focus and are being demanded by the public, politicians, rating agencies, laws and regulations and especially by customers in their purchasing decisions.

Reducing CO_2e emissions from logistics challenges is a priority that goes beyond traditional risk management. Companies that proactively address these risks secure competitive advantages in a volatile global economy. A well-structured, resilient supply chain transforms potential challenges into opportunities for sustainable growth and risk reduction and it respects human rights, adheres to social standards and supports the supply chain in its decarbonisation.

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