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Transformational Factors in the Development of Global Supply Chains

MARIIA SANDUL[1]

ANNOTATION. The article is devoted to the study of the relationship between the goals and plans of sustainable development, the problems of regulating the global economy, the trends of de-globalisation, the spread of protectionist policies and geopolitical conflicts, which contribute to the paradigm shift of global supply chains. The article provides a comprehensive overview of their evolution from traditional linear models to interconnected and flexible networks enabled by technological progress and deepening globalisation. The author outlines the current challenges and opportunities that are emerging in response to the changing dynamics of global trade caused by waves of de-globalisation, inflationary pressures and the resurgence of protectionist trade policies, in particular during the Covid-19 pandemic. The article shows how these challenges have necessitated a revision of traditional supply chain strategies and prompted the search for innovative risk management practices in a more uncertain economic environment, which is also characterised by trends in friend-shoring and the gradual completion of the stage of diversification of trading partners in supply chains in response to the growing disruption of global supply chains due to the pandemic. The aggravation of geopolitical conflict and the imperatives of sustainable development are identified as the main drivers of modern transformations of global supply chains. The article examines the issues of sustainable development and related legislative initiatives that necessitate the initiation and establishment of processes for responsible sourcing, minimisation of negative environmental impact and ensuring ethical labour practices throughout the supply chain. The author emphasises that in the practice of international business it is quite difficult to balance the desire for cost-effective supply chains with the need to meet increasingly stringent standards of sustainable development, which calls into question the possibility of achieving both goals simultaneously. At the same time, digital solutions are proving to be a promising way to overcome the problems caused by these challenges. The article explores the potential of technologies such as blockchain, artificial intelligence and data analytics to ensure transparency, traceability and risk mitigation in supply chains. The transformational role of digitalisation in increasing the resilience and responsiveness of supply chains is emphasised. The author describes the disproportionality of threats faced by developing countries in the global economic space. The author emphasises the critical importance of recalibrating strategies and promoting wider stakeholder engagement to overcome the challenges and specific vulnerabilities faced by less developed economies and to develop solutions that will contribute to economic stability and growth in countries with different levels of development.

KEYWORDS: global supply chains, international trade, international business, risk-based management, sustainable development, sustainable finance, digitalisation, industry 4.0, de-globalisation, protectionism, inflation, friend-shoring, near-sourcing.

[1] **Sandul Mariia Stanislavivna** – PhD **(**Economics), Associate Professor of the Department of International Trade and Marketing, Kyiv National Economic University named after Vadym Hetman (Kyiv, Ukraine). Scientific interests: international economics, sustainable development, international logistics, international trade, supply chains, sustainable finance, competitiveness of higher education systems, international competitiveness. E-mail: m.sandul@kneu.edu.ua ORCID: 0000-0001-6985-5179

Introduction

In recent years, the global trade landscape has undergone significant changes, prompting a critical analysis of the transformational factors that are influencing the development of global supply chains. As economies become increasingly interconnected and technological innovations are being developed and implemented at an unprecedented pace, shaping Industry 4.0, traditional approaches to supply chain management are undergoing significant changes. In this context, it is important to study the current state and prospects of global supply chains, given their key role in international trade and, more broadly, economic ecosystems. The study of the key drivers of supply chain transformation aims to outline the interrelationships between them and globalisation, technological innovation, sustainability imperatives and the evolution of consumer behaviour, and to emphasise the need to adequately adapt strategies, policies and practices to ensure the competitive advantage of international business.

A significant number of scientific publications have been devoted to the study of global supply chain transformations, especially since the beginning of the Covid-19 pandemic. In particular, G. Tullio[2] examines the relationship between international trade and protectionism in the long run, taking into account the impact of non-tariff barriers, and points out that protectionist trade policies still play a role in explaining the decline in the dependence of global trade dynamics on GDP. S. Khorana et al.[3] study the ratio of benefits and risks of a company's participation in global value chains associated with supply and demand shocks in the context of growing protectionism. D. Fjellstrцm et al.[4] pay attention to the practical aspects of internationalisation in the context of geopolitical tensions and note that under the pressure of such non-market factors, TNCs should focus on strengthening business ambidexterity and transactional competence, improving mechanisms for rapid response to and adaptation to changes, deepening and diversifying cooperation with partners in host markets in order to maintain competitive positions in global markets. On the other hand, A. Jane and M.Kroenig[5], while generally positive about the manifestations of de-globalisation that have resulted from increased geopolitical conflict, focus on identifying the main reasons for the expediency of reducing cooperation between the

[2] Gregori, Tullio. "Protectionism and international trade: A long-run view." *International Economics 165*, (2021): 1-13. https://doi.org/10.1016/j.inteco.2020.11.001.

[3] Khorana, Sangeeta, Hubert Escaith, Salamat Ali, Sushma Kumari, Quynh Do. "The Changing Contours of Global Value Chains Post-COVID: Evidence from the Commonwealth." *Journal of Business Research* 153 (2022): 75-86. ISSN 0148-2963. https://doi.org/10.1016/j.jbusres.2022.07.044.

[4] Fjellström, Daniella, Bai, Wensong, Oliveira, Luis, and Tony Fang. "Springboard internationalisation in times of geopolitical tensions." *International Business Review*, (2023): 102144. https://doi.org/10.1016/j.ibusrev.2023.102144.

[5] Jain, Ash, and Matthew Kroenig. "Ally Shoring: A New Tool of Economic Statecraft." *Orbis 67*, no. 1 (2023): 21-26. https://doi.org/10.1016/j.orbis.2022.12.005.

"democratic" and "non-democratic" blocs, emphasising that moving to "friendly" territories provides an economic justification for the existing network of security relations between democratic states and will help reduce strategic vulnerabilities.

P. Buckley[6], noting the significant flexibility of international corporations in the context of responding to numerous crises in the international environment, points out, however, that the breakdown of the global trade and investment system still causes serious damage to the international operations of transnational and multinational corporations, and identifies strategic guidelines for corporate governance in modern realities. The researcher emphasises the need for a corporate strategy concept involving a wider range of stakeholders in the context of growing nationalism.

In view of the emergence of Industry 4.0 and sustainable development priorities, G. Garcia-Reyes et al.[7] study the maturity of supply chains and propose a model for the phased integration of Industry 4.0 drivers in terms of three main aspects of their maturity: flexibility, resilience, and reliability. H. Rifke and D. Sandrem[8] study the maturity of supply chain management from the perspective of sustainable development. R. Yuan et al.[9] investigate the potential impact of the US-China trade war on greenhouse gas emissions, offering 4 scenarios and generally indicating a likely increase in emissions due to the relocation of international trade.

In general, given the potential benefits and threats of de-globalisation and decentralisation processes[10] for corporations, in the context of growing geopolitical tensions and protectionism, it is quite natural to expect further reconfiguration and fragmentation of global supply chains, especially in terms of production systems, with the gradual development of more localised value-added systems focused on the needs of consumer markets closer to them. The need to adapt management approaches to the new realities makes it important to study the key transformational factors in the development of global supply chains in the world trade system.

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[6] Buckley, Peter J. "Corporate reactions to the fracturing of the global economy." *International Business Review*, (2022): 102014. https://doi.org/10.1016/j.ibusrev.2022.102014.

[7] García-Reyes, Heriberto, Avilés-González, Jonnatan, and Sonia V. Avilés-Sacoto. "A Model to Become a Supply Chain 4.0 Based on a Digital Maturity Perspective." *Procedia Computer Science* 200, (2022): 1058-1067. https://doi.org/10.1016/j.procs.2022.01.305.

[8] Reefke, Hendrik, and David Sundaram. "Sustainable supply chain management: Decision models for transformation and maturity." *Decision Support Systems 113*, (2018): 56-72. https://doi.org/10.1016/j.dss.2018.07.002.

[9] Yuan, Rong, Rodrigues, João F., Wang, Juan, and Paul Behrens. "The short-term impact of the US-China trade war on global GHG emissions from the perspective of supply chain reallocation." *Environmental Impact Assessment Review 98*, (2023): 106980. https://doi.org/10.1016/j.eiar.2022.106980.

[10] Zinchenko, V.V. "Alterglobalism as a transformational model of sustainable development, internationalisation and effective transformation of society and education systems", *Philosophical Horizons of the Present. Collection of scientific papers* (2018). Kherson: SHEI "KhSAU", 2018. 324 p. (pp. 63-68).

Evolution of supply chains in the global trade system

The interconnections between international companies within value chains and supply chains received a significant impetus for growth, diversification and global networking in the 1970s and 1980s, when globalisation and liberalisation became the leading trends in international trade. Technological advances, particularly in transport and communications, contributed to the integration of economies around the world. Companies began to explore outsourcing opportunities and offshoring strategies, as the potential for cost savings, access to new markets and other economic and competitive advantages was undeniable. In this environment, driven primarily by economic motives and to some extent ignoring the potential risks of internationalisation and globalisation strategies, supply chains became increasingly global, spanning several countries and continents, as companies sought to optimise costs, often by moving production processes and facilities to other countries.

In the 1990s and early 2000s, trade liberalisation continued to increase due to the flourishing efforts of the World Trade Organisation (WTO) and regional trade agreements (e.g., the North American Free Trade Agreement (NAFTA), the European Union). The reduction of trade barriers, including tariffs and quotas, has contributed to the growth of international supply chains, with security aspects being largely ignored in favour of potential economic benefits. Businesses have taken advantage of these new opportunities by creating complex networks of suppliers and partners abroad. The rapid growth of emerging economies, especially in Asia, has further intensified the globalisation of supply chains.

In the 2000s and 2010s, supply chains became increasingly integrated and complex due to advances in information technology and logistics. Advances in enterprise resource planning (ERP) systems, supply chain management software and real-time tracking capabilities have improved coordination and visibility across global supply chains. It was during this period that the speed of material flows in global value chains became paramount to companies' competitiveness, as many of them adopted the popular concepts of just-in-time (JIT) and lean manufacturing, which are aimed at optimising efficiency and minimising inventory costs. This period was therefore characterised by a business focus on optimising processes, improving responsiveness and achieving cost savings through global sourcing and production.

However, the global financial crisis of 2008 marked the beginning of a trend towards de-globalisation. The late 2000s, and especially the next decade (2010-2020), showed the shortcomings and over-expectations of the established liberal trade system. Factors such as rising income

inequality, concerns about job displacement (the Rust Belt (or, more commonly, the "industrial" or "factory" belt in the United States), and anti-globalisation sentiment led countries to reassess their previously dominant approaches to trade policy. Against this backdrop, and with China increasingly using the principles of global trade liberalisation to build its own dominance, protectionist measures, including tariff increases, trade restrictions and renegotiations of trade agreements, have become widespread.

The Eastern partners' apparent rejection of the democratic and liberal values of the Global West has been manifested, among other things, through geopolitical conflicts, such as trade disputes between major economies, which have created further turbulence in global supply chains. While globalisation continues to shape supply chain strategies with opportunities for market expansion and cost optimisation, companies must simultaneously navigate the challenges of de-globalisation trends. Striking a balance involves considering geopolitical risks, regulatory complexities, trade uncertainty and the need for flexibility and adaptability to effectively manage global operations. In terms of material flow management, geopolitical conflicts have already led to a shift away from the just-in-time model, setting back decades of globalisation[11]. In addition, according to some researchers[12], the geopolitical conflict of our time is a manifestation of systemic crisis and civilisational contradictions, and will increase over time, leading to a significant redistribution of global influence. Given this, risk-based management models for global companies need to improve tools for taking into account additional risk factors, as well as formulating and testing complexes of adaptive and preventive actions to protect their competitive positions.

On the other hand, according to some researchers[13], the "slowdown" of globalisation does not automatically mean a mandatory defragmentation or a complete reconfiguration of supply chains. This is what is primarily driving companies to consider reviewing their supply chain strategies, focusing on strengthening its resilience. However, given that building resilience often requires bringing production closer to end users and significant supplier diversification, and given the geopolitical tensions and increasingly bipolar global trading system, supplier diversification is driven by security concerns and tends to create "friendly" supply chains, globalisation as a process is likely to undergo significant changes in the

[11] Colback, Lucy. "How Technology Can Help Redraw the Supply Chain Map." Financial Times, 2022. https://www.ft.com/content/3db177f2-d187-4632-b94d-268f9d2598eb.

[12] Kalchenko, T., Oliynyk, V. Geopolitical conflict in the context of global economic crisis, 2019. *International Economic Policy*, Issue 30, 2019. DOI: 10.3311/iep.2019.30.02

[13] KOF Swiss Economic Institute. "The KOF Globalisation Index." https://kof.ethz.ch/en/forecasts-and-indicators/indicators/kof-globalisation-index.html.

coming years. For example, some TNCs are even considering "bifurcating" their supply chains in an attempt to protect themselves from the escalation of the global trade war[14].

Despite these trends, global trade volumes have been most significantly affected over the past 5 years by the Covid-19 pandemic and global inflation. The focus on supply chain resilience and resilience has increased significantly as a result of the pandemic, which has exposed previously invisible vulnerabilities in global supply chains. At the same time, companies have become aware of the risks associated with over-reliance on single suppliers and lengthy supply chain processes. Consequently, more and more attention has been paid to building supply chain resilience, introducing redundancies, diversifying sources of supply, and improving supply chain visibility (transparency).

As for the impact of the pandemic on the dynamics of world trade, as of autumn 2020, its volumes declined significantly compared to the beginning of 2020, a decline that was even deeper than the fall in trade in 2008-2009[15]. The volume of international trade in goods in value terms decreased by about 5% in the first quarter of 2020 (Fig. 1). By the end of 2021, most industries saw a partial recovery in trade; according to UNCTAD, overall, global trade recovered from Covid-19 much faster than in previous recessions[16].

The economic challenges caused by COVID-19 have affected some industries much more than others. In the first quarter of 2020, trade in textile products (clothing) declined by almost 12%, while office equipment and automotive fell by about 8%. At the same time, the volume of international trade in the agri-food sector (in value terms) increased by about 2%. As of April 2020, there was a decline in most industries and a sharp decline in trade in energy and automotive products, by about -40% and -50%, respectively. Significant declines were also observed in the chemicals, machinery and precision instruments industries, which saw a drop of more than 10%. Conversely, trade in office equipment has picked up (as of April 2020), mainly due to positive exports from China. Trade in agricultural products has been the most stable during the pandemic (Figure 1).

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[14] Isaac, Anna. "Exclusive: Nokia and Ericsson Plan Emergency Break-up over Trade War and Security Fears." The Telegraph, 8 June 2019. https://www.telegraph.co.uk/business/2019/06/08/exclusive-nokia-andericsson-plan-emergency-break-up-trade-war/.

[15] UNCTAD. 2020. "Global Trade Update (June 2020)." https://unctad.org/publication/global-trade-update-june-2020.

[16] UNCTAD. 2021. "Global Trade Update (May 2021)." https://unctad.org/system/files/official-document/ditcinf2021d2_en.pdf.

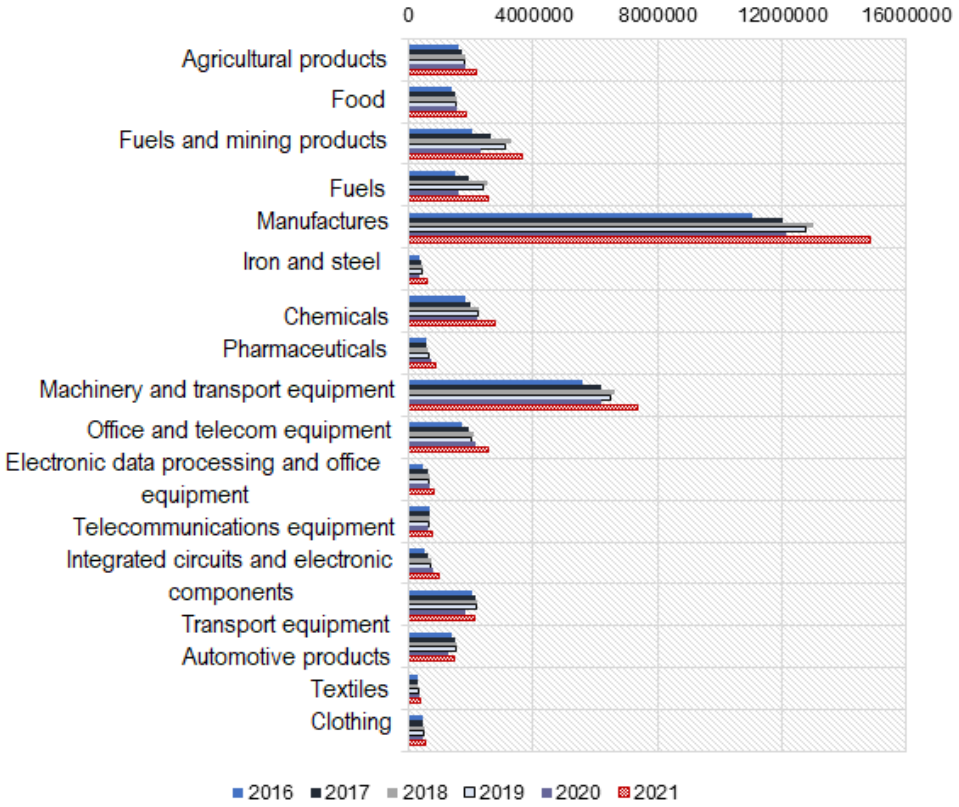

Fig. 1. Dynamics of world trade in goods by product groups, mln. USD million, 2016-2021[17]

In general, the divergence between sectors was driven by reduced demand and disruption to supply chains and global value chains due to COVID-19. However, by the end of the first quarter of 2021, UNCTAD noted that global trade continued to recover by about 10% annually, and by about 4% quarterly[18]. This recovery was largely driven by exports from East Asia. Trade in goods has already exceeded pre-pandemic levels, but trade in services has been much slower to recover.

In 2022, the main drivers of global trade were inflation (Figures 2 and 3) and rising commodity prices, so the growth in merchandise trade in 2022 was largely nominal.

[17] Compiled according to WTO data "Merchandise exports by product group – annual (Million US dollars)" https://stats.wto.org/ (data as of 15 May 2023).

[18] UNCTAD. 2021. "Global Trade Update (May 2021)." https://unctad.org/system/files/official-document/ditcinf2021d2_en.pdf.

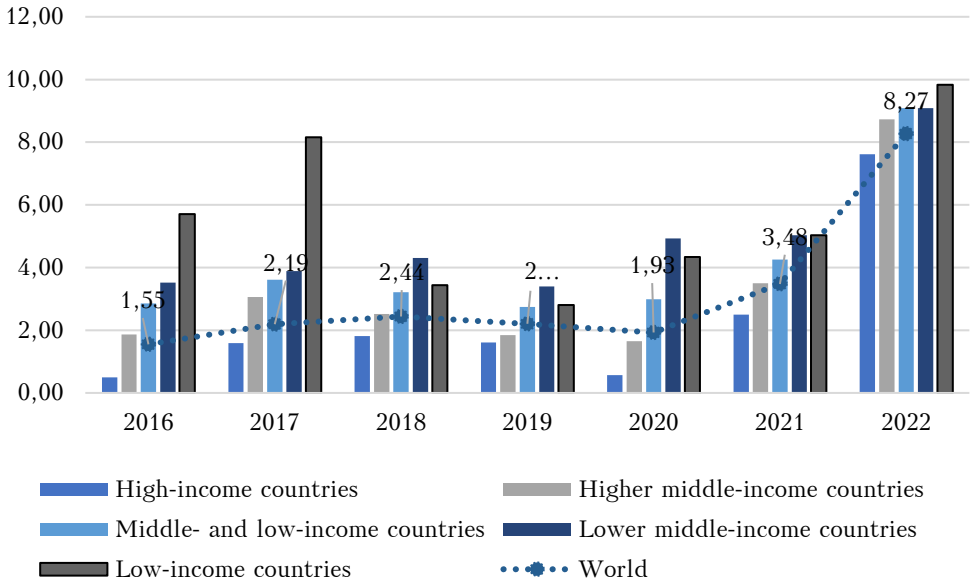

Figure 2. Inflation rates (by income group), 2016-2022[19]

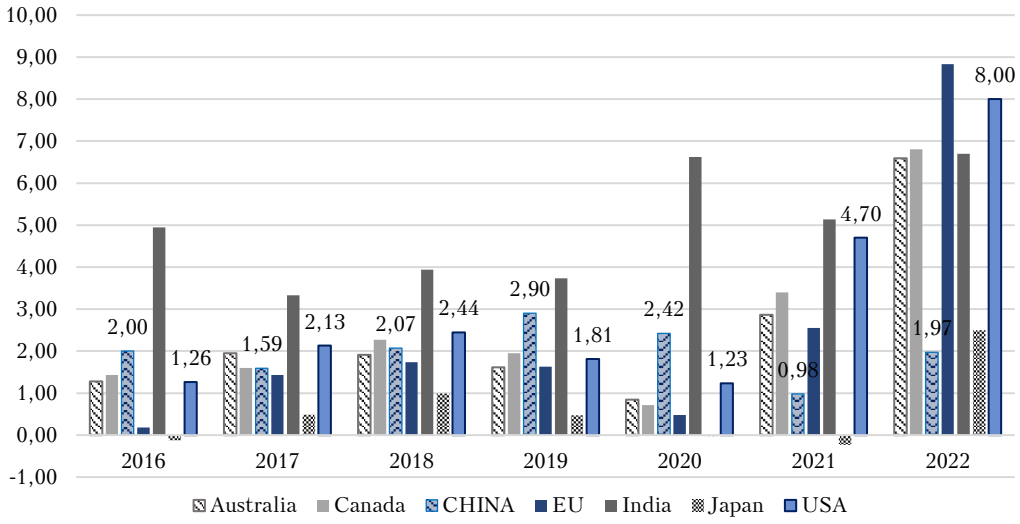

Figure 3. Inflation rates (some countries), 2016-2022[20]

[19] World Bank. 2023. "Inflation, consumer prices (annual %)". https://data.worldbank.org/indicator/FP.CPI.TOTL.ZG?end=2022&start=2016&type=shaded&view=chart.

[20] Ibid.

In value terms, global trade volumes increased in early 2022, with the value of global trade reaching a record high of around US$7.7 trillion (in the first quarter of 2022), up around US$1 trillion compared to the same period in 2021, and around US$250 million compared to the fourth quarter of 2021[21]. And compared to pre-pandemic levels, the value of trade was about 30 per cent higher in early 2022. In fact, in value terms, global trade was primarily fuelled by rising commodity prices, especially energy prices, while real trade volumes grew to a much lesser extent (by about 6 per cent). The war in Ukraine also has a significant impact on international trade, mainly through higher prices and their volatility. Geopolitical tensions and increased protectionism were the factors that significantly contributed to the decline in the value of global trade in the second half of 2022.

In response to Russia's invasion of Ukraine, the international political, legal and economic environment has imposed trade measures and restrictions[22], which have led to significant disruptions in global supply chains for essential commodities such as food, fertilisers and energy. As a result, these disruptions have increased economic unpredictability in global markets, exacerbating food security, especially for developing countries and least developed countries[23].

Despite the fact that global trade growth resumed in the first quarter of 2023, future prospects and forecasts, according to UNCTAD, remain unfavourable[24]. At the beginning of 2023, there were quite different trends in trade growth in the largest economies, with significant export growth observed in China and India. Experts note that the interdependence of trade between China and the United States has decreased due to global trends in friend-shoring. The services trade sector showed higher growth rates than trade in goods, but trade in information and communication technology goods continued to decline. Trade growth is expected to lose momentum in mid-2023, with the unfavourable outlook extending to the second half of the year, similar to 2022.

It is worth noting that based on the study of indicators of a) geographical proximity, which is based on the average geodetic distance of world trade, b) geopolitical proximity, which is measured by the similarity of foreign policy positions based on voting patterns at the UN General Assembly, and c) diversification of trading partners, based on the Herfindahl Concentration Index, UNCTAD researchers note a significant decline in the trends of trade

[21] UNCTAD. 2022. "Global Trade Update (July 2022)." https://unctad.org/system/files/official-document/ditcinf2022d2_en.pdf.

[22] Toh, Michelle, Junko Ogura, Hira Humayun, Isaac Yee, Eric Cheung, Sam Fossum, and Ramishah Maruf. "The List of Global Sanctions on Russia for the War in Ukraine." CNN, 25 February 2022. https://edition.cnn.com/2022/02/25/business/list-global-sanctions-russia-ukraine-war-intl-hnk/index.html.

[23] WTO. 2023. WTO Trade Monitoring Updates. "A Year of Turbulence on Food and Fertiliser Markets." 28/02/2023. https://www.wto.org/english/news_e/news23_e/trdev_02mar23_e.pdf.

[24] UNCTAD. 2023. "Global Trade Update (June 2023)." https://unctad.org/system/files/official-document/ditcinf2023d2_en.pdf.

partner diversification since the third quarter of 2022 (which indicates an increase in the concentration of international trade activities within key bilateral relations), as well as a significant increase in friend-shoring[25]. Thus, during 2022 and the first quarter of 2023, the geographical proximity of global trade centres, according to UNCTAD, showed a relatively stable picture. However, since the second half of 2022, there has been a noticeable surge in the alignment of political affiliation in trade dynamics. This shift underscores the tendency to reshape bilateral trade routes in supply chains, giving priority to countries with a common political ideology (friend-shoring). This trend is reflected, among other things, by a marked decline in trade interdependence (expressed as the share of bilateral trade (imports plus exports) in the total value of trade between the US and China) between the US and China (from 14.6% as of the first quarter of 2021 to 11.6% according to preliminary estimates for the second quarter of 2023)[26].

This trend is also reflected in the volume of trade in the European Union (Figure 4). Since 2020, the gap between the growth rates of trade between EU countries and non-EU countries has been growing significantly. And the deviation (decline) in the volume of exports of goods outside the EU is more significant compared to the dynamics of exports within the Union, which naturally reflects the deeper links in value chains between EU countries compared to those outside the EU.

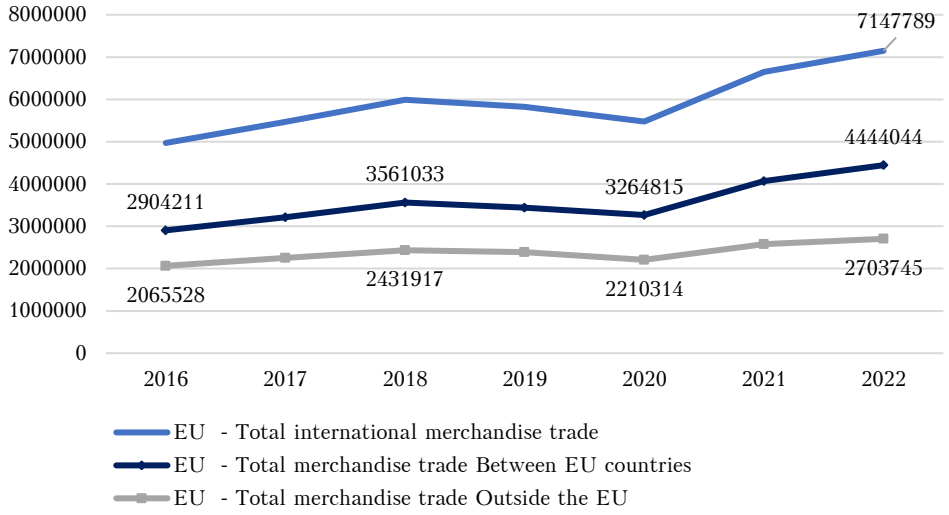

Figure 4. Trade dynamics of the European Union, USD million, 2016–2022[27]

[25] Ibid, p. 6.
[26] Ibid.
[27] Compiled according to WTO data "Merchandise exports by product group – annual (Million US dollars)" https://stats.wto.org/ (data as of 15 May 2023).

Thus, as geopolitical tensions escalate, the impact of non-market factors on global supply chains is becoming increasingly noticeable, and in response, they are becoming more fragmented and continue to be adjusted to take into account an increasing number of nuances and risks. To summarise, international supply chains have evolved significantly since the 1970s, driven by the forces of globalisation and de-globalisation. While globalisation has led to the integration of global supply chains, de-globalisation trends have prompted companies to significantly rethink their development, expansion and supply chain partner selection strategies. Navigating this dual reality requires a thorough assessment of risks, opportunities and the development of flexible supply chain development strategies.

Sustainability imperatives for global supply chains

In parallel with globalisation and de-globalisation processes, sustainability issues and related legislative initiatives have become particularly important for corporate governance in recent years, leading to the need to improve the processes of responsible sourcing, minimising negative environmental impact and ensuring ethical labour practices throughout the supply chain. This transition is driven by the increasing attention paid to attempts to take into account those aspects of the global economic system that have not been properly addressed by the market and/or the state for decades and have led to numerous negative externalities. In general, externalities arise when the actions of one entity have an unintended effect (positive or negative, often negative) on unrelated entities or individuals, but in the event of an externality, the potential costs of eliminating its effect (consequences) on unrelated parties are not borne by the entity that committed such actions. In theory, governments can internalise externalities by pricing them to fully reflect the external costs (or benefits) of an entity's actions.

To date, most of the activity in the area of promoting sustainable development has been in the European Union, with the main responsibility and regulatory pressure in this regard resting with the financial and banking sector as the one that can help redirect financial flows to activities that are identified as more environmentally friendly and discourage the financing of those that are identified as environmentally unfriendly. An important step forward was the adoption of the EU Taxonomy, a classification system and framework designed to promote sustainable investment. The Taxonomy is intended to provide clarity in defining which activities are considered environmentally sustainable and to help finance the transition towards achieving environmental sustainability goals. The Taxonomy should also

help to prevent greenwashing[28], for example, in the use of carbon offsets, which is currently a significant risk for companies due to the criminalisation of liability if found. Greenwashing, as defined in the Taxonomy, is the practice of gaining an unfair competitive advantage by marketing a financial product as environmentally friendly when in fact basic environmental standards have not been met. In general, in practice it can be difficult to determine whether a particular instrument meets the declared characteristics, so one of the recommendations to mitigate this risk is to avoid making loud statements about a company's actions aimed at achieving sustainability goals[29].

Sustainable finance requirements and regulations will lead to the widespread integration of environmental, social and corporate governance (ESG) criteria into supply chain practices. Companies will be required to assess and disclose their ESG performance, including carbon emissions, resource use, labour conditions, etc., including with respect to their own suppliers. Suppliers who fail to comply may face consequences such as restricted access to finance or loss of business opportunities. Furthermore, the strengthening of sustainability regulations as a response to global warming should have a global application. In particular, in some cases, the implementation of sustainability requirements and regulations may lead to unintended consequences that adversely affect developing countries. For example, attempts to reduce carbon emissions by global companies may backfire, at least for a period of time, if production with significant negative environmental impacts is relocated to countries with less stringent regulations (typically in developing countries) – potentially increasing overall global greenhouse gas emissions and adversely affecting developing economies.

Thus, the gradual improvement of corporate practices towards sustainable development is imperative, and regulatory requirements are becoming increasingly clear. In particular, in February 2022, the European Commission adopted a proposal for the EU Corporate Sustainability Due Diligence Directive (CSDDD)[30], which will require companies from the European Union and non-EU countries operating in the EU to take responsibility for both their own environmental and human rights impacts and those of their suppliers throughout the global supply chain. The Directive is part of the European Green Deal, a series of policy initiatives by the European Commission aimed at reducing greenhouse gas emissions and achieving

[28] European Commission. 2022. "EU Taxonomy for Sustainable Activities." https://finance.ec.europa.eu/sustainable-finance/tools-and-standards/eu-taxonomy-sustainable-activities_en.

[29] Loyens & Loeff. 2023. "ESG Key legal considerations". https://www.loyensloeff.com/esg-litigation-new-version--february-2023---print.pdf.

[30] European Commission. 2022. "Proposal for a DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on Corporate Sustainability Due Diligence and amending Directive (EU) 2019/1937https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52022PC0071.

climate neutrality by 2050. The proposal for the Directive is undergoing legislative procedures in the EU, and at this stage, inter-institutional negotiations on the Directive between the European Parliament, the European Council and the European Commission are expected. Once the CSDDD is formally adopted, which is expected no earlier than 2024, Member States will have two years to transpose the Directive into national law[31] .

In view of this, the movement of companies towards increasing transparency in supply chain operations will only intensify in the near future. Already, the ability to track the movement of goods to the very beginning of the value chain is becoming a new competitive advantage for virtually all companies developing such a supply chain. With the development and implementation of technologies that will automate the tracking of material flows, the largest companies that are already working to ensure compliance with ESG principles in their supply chains will have the opportunity to improve customer service, gain a significant positive image effect and increase the loyalty of partners and consumers. A general recommendation is to implement an environmental impact assessment of global supply chains, including factors such as carbon emissions, resource depletion, waste and pollution, and to periodically review which sustainability practices can be integrated into supply chains to minimise negative environmental impacts.

However, compliance and sustainability are only part of the challenge for companies to improve their brand perception and maintain or enhance their competitive advantage. An important task for businesses is to assess the resilience of global supply chains against a range of environmental, social and economic risks, and to look for opportunities, including in the area of sustainable finance, that can improve risk management strategies, including supplier diversification, localisation of production and increased resilience to climate change-related disruptions. From the perspective of risk management in supply chains, there is a need to consider both climate and transition risks in order to ensure resilience and business continuity in the chain, which requires two vectors of activity – adaptive actions (in response to changes that are already occurring and cannot be averted) and actions aimed at reducing risk (where possible). Therefore, the key challenge of risk management in this aspect is the inability to make assumptions based on historical models. In particular, with regard to climate risks, the climate change and climate events that global supply chain actors are currently facing are increasingly atypical for a particular location or too large to be included in existing management and forecasting models.

[31] Bosselaar, Marit, Bloemen, Irene, Pennink Sjoerd. "The Corporate Sustainability Due Diligence Directive (CSDDD): the position of the European Parliament and potential impact". *Loyens & Loeff*. ttps://www.loyensloeff.com/insights/news--events/news/the-corporate-sustainability-due-diligence-directive-csddd-the-position-of-the-european-parliament-and-the-impact/

Programmes and plans to adapt to or minimise the impact of atypical climate events, such as heat waves, remain rather fragmented and usually cover only one aspect of society. Thus, research on the impact of atypical weather/climatic or natural events primarily concerns the impact on humans[32], [33], [34]. In the EU, in particular, the EuroHEAT project aims to increase the preparedness of health systems and their response to protect health in the event of heat waves, and there are Heat Action Plans in Portugal, England, Austria, North Macedonia, and Germany[35]. However, given the current state of the problem, according to the researchers, there is an urgent need to "reassess and strengthen existing heatwave surveillance platforms, prevention plans and long-term adaptation strategies"[36].

Other existing plans for responding to and counteracting acute and chronic climate events in most areas, including infrastructure[37] (including electronic[38]), agriculture, or production systems, especially in the context of digitalisation and the development of Industry 4.0, can be described in a similar way. In most cases, adaptation actions and minimising the potential consequences of business disruption if such risks materialise will remain the responsibility of companies themselves, which will involve increasingly proactive risk assessment, diversification of suppliers, investment in climate-resilient infrastructure and incorporation of climate data into supply chain planning.

Financing in global supply chains

There are generally two perspectives on the concept of supply chain finance. The first, the finance-oriented perspective, focuses on short-term solutions provided by financial institutions for accounts payable and receivable, while the second, the supply chain-oriented perspective, focuses on optimising working capital within a company or for several/many chain participants.

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[32] Vanderplanken, Kirsten; van den Hazel, Peter; Marx, Michael et al. "Governing heatwaves in Europe: comparing health policies and practices to better understand roles, responsibilities and collaboration", *BioMed Central* (2021). DOI: 10.1186/s12961-020-00645-2 URL: https://www.preventionweb.net/quick/51537

[33] Kyprianou, Ioanna, Artopoulos, Georgios, Bonomolo, Anna, Brownlee, Timothy, Cachado, Rita Á., Camaioni, Chiara, Đokić, Vladan et al. "Mitigation and adaptation strategies to offset the impacts of climate change on urban health: A European perspective." *Building and Environment 238,* (2023): 110226. https://doi.org/10.1016/j.buildenv.2023.110226.

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[35] WHO Regional Office for Europe. "Heat health action plans", *Climate-ADAPT* (2020). URL: https://climate-adapt.eea.europa.eu/en/metadata/adaptation-options/heat-health-action-plans.

[36] Ballester, Joan, Méndez Turrubiates, Raúl F., Pegenaute, Ferran, Herrmann, François R., Robine, Jean M., Basagaña, Xavier, Tonne, Cathryn, Antó, Josep M., and Hicham Achebak. "Heat-related mortality in Europe during the summer of 2022." *Nature Medicine 29,* no. 7 (2023): 1857-1866. https://doi.org/10.1038/s41591-023-02419-z.

[37] Ampratwum, Godslove, Osei-Kyei, Robert, and Vivian W. Tam. "Exploring the concept of public-private partnership in building critical infrastructure resilience against unexpected events: A systematic review." *International Journal of Critical Infrastructure Protection 39,* (2022): 100556. https://doi.org/10.1016/j.ijcip.2022.100556.

[38] Zamuda, Craig D., Wall, Thomas, Guzowski, Leah, Bergerson, Joshua, Ford, Janet, Lewis, Lawrence P., Jeffers, Robert, and Sean DeRosa. "Resilience management practices for electric utilities and extreme weather." *The Electricity Journal 32,* no. 9 (2019): 106642. https://doi.org/10.1016/j.tej.2019.106642.

Supply chain finance, as a distinct type of financial activity, necessarily involves an agreement between exporters and importers involved in international trade, and allows for the management of invoice payment terms, liquidity and the free flow of money through supply chains. In most cases, these services are offered and implemented by intermediary financial institutions. The main categories of services offered here are the purchase of receivables, supply chain financing on the basis of a loan or advance. Export financing is also a fairly common instrument, usually with government support. For example, in Sweden, there is the Export Credit Agency (EKN) and the Swedish Export Credit Corporation (SEK), which can provide long-term financing to exporting companies and sometimes take on the role of arranger, usually in conjunction with one or more banks. EKN's mission is to promote Swedish exports and the internationalisation of companies by insuring export companies and banks against the risk of non-payment in export transactions, enabling them to conduct safer export operations. The activities of such institutions are usually financed by premiums from the guarantee holders.

In this regard, it is advisable to analyse the context of the functioning of financial institutions through which financial flows that ensure the movement of material flows in global supply chains pass in one way or another. First of all, it is worth noting that from the perspective of financial institutions, two groups of risks are considered in the context of sustainable development: climate-related risks (which may affect the banking system through credit and market risk channels) and transition risks related to climate (which may affect the profitability of companies through revenues and operating costs: for example, the price of emissions may increase operating costs and reduce profits of companies that pollute the environment).

Sustainable finance offers not only reputational benefits for banks, but with demand for green financial products on the rise, developing these types of products that meet the needs of customers offers an opportunity to increase revenues. This is true for almost all sectors of the economy. For example, sustainability-related loans in the real estate and construction sectors are in high demand, distinguishing financial institutions that offer them from competitors and at the same time providing added value to customers. According to various studies, the demand for such loans linked to long-term growth in the real estate and construction sectors will continue to grow. According to the IEA[39], the global building stock is expected to increase by 20% between 2021 and 2030, with 80% of this growth coming from emerging markets. And in 2021, the building sector accounted for 30% of total global

[39] IEA. 2022. "World Energy Investment 2022." Retrieved from: https://iea.blob.core.windows.net/assets/830fe099-5530-48f2-a7c1-11f35d510983/WorldEnergyOutlook2022.pdf..

final energy consumption[40]. Thus, as most economies are now recovering from the pandemic, we can expect a significant (and pent-up) demand for investment in zero carbon buildings. On the other hand, more mature markets are likely to experience greater demand for sustainable mortgage and retail lending (e.g. for retrofits, energy efficient appliances, electric vehicles, etc., which is partly funded by government programmes but also creates a huge potential for a sustainable lending market).

Sustainable finance is already expected to play a crucial role in channelling capital to sustainable supply chains. Green finance instruments, such as green bonds and loans linked to sustainability performance, will become more common. Investors will therefore prioritise companies with sustainable supply chains, encouraging greater transparency and accountability.

In the investment industry, a commitment to making investment portfolios carbon neutral is now an important part of an investment firm's reputation and competitiveness. Achieving carbon neutrality in investment portfolios means setting specific time-bound targets to reduce CO2 emissions for the entire portfolio to zero, both by aligning all financial activities with pathways that limit warming to 1.5 degrees Celsius and by neutralising residual emissions by investing in activities that remove an equivalent amount of atmospheric CO2[41]. Declarations by financial institutions to achieve carbon neutrality include setting and publishing interim targets for a roadmap to zero carbon emissions, measuring the carbon intensity of the portfolio (at regular intervals) and carbon offsets (if any), and redirecting investments from the brown to the green economy[42]. If these criteria are met, such statements can be considered sufficiently reliable, and this is the path followed by most of the world's leading financial and investment companies.

This process is challenging, as financial institutions need to revise their long-term strategies to make the targets achievable. The main challenges they face relate to: a) measuring the emissions financed so that the financial institution concerned can obtain an accurate "baseline" of emissions in their portfolios, and, b) understanding where the value will come from in climate change so that financial institutions can effectively attract and direct their clients' funds to investment products that are aligned with sustainable development and zero greenhouse gas emissions[43].

Thus, the current financial landscape shows a shift in the priority of efforts to reduce greenhouse gas emissions and achieve other sustainable development goals from the strategic to the operational plane, and in the

[40] Ibid, p. 150.

[41] SBT. 2022. "Foundations for Science-Based Net-Zero Target Setting in the Financial Sector. Version 1.0." Retrieved from: https://sciencebasedtargets.org/resources/files/SBTi-Finance-Net-Zero-Foundations-paper.pdf.

[42] Ibid, p. 10.

[43] Goossens, C. et al. 2022. "Banks' Great Carbon Challenge." Bain & Company. Retrieved from: https://www.bain.com/insights/banks-great-carbon-challenge/..

context of global supply chain development, this is another imperative to increase transparency of supply chain operations, implement measures to reduce greenhouse gas emissions, protect biodiversity, reduce waste and pollution, etc.

In addition to environmental impact indicators, given the potential dependence of the cost of external financing on the position of companies in ESG ratings, it is advisable to analyse the social impacts of global supply chains, such as labour conditions, respect for workers' rights and possible human rights issues. Businesses are already facing the challenge of developing appropriate indicators and reporting structures to assess the sustainability of global supply chains. MNCs are typically considering how to integrate environmental, social and governance (ESG) criteria with financial analysis and reporting, and assessing the role of sustainable finance in promoting transparency and accountability in supply chains. It is also advisable to target those sustainable finance opportunities that can contribute to fair labour practices, gender equality and social well-being throughout the supply chain. Companies will need to develop innovative business models to extend the life cycle of products, promote sharing and facilitate recycling, in line with the goals of a circular economy and increased business responsibility (and the emergence of Industry 5.0). In addition, given the regulatory requirements for both the financial sector and industry, businesses will need to investigate the origin of raw materials and components in their supply chains, the opportunities for transition to a circular economy in their supply chains, and how to integrate appropriate sustainable finance instruments to achieve better results. In addition, sustainable finance requirements and regulations will encourage the adoption of greener logistics and transport methods. Electric vehicles, alternative fuels and optimised route systems will help to reduce greenhouse gas emissions and the negative environmental impacts associated with transport in supply chains.

Digitalising supply chain management

In the face of today's challenges and transformational shifts in global supply chains, digital solutions have become important tools for effective supply chain management. These solutions use IT technologies to increase transparency, efficiency and responsiveness at all stages of the supply chain, and they play a key role in overcoming the challenges, uncertainties and demands of stakeholders and regulators that are driving the current dynamics of supply chain development and transformation.

Digital solutions provide real-time visibility into the various stages of the supply chain, enabling companies to control inventory levels, track shipments and identify potential bottlenecks. Advanced analytics help to

make data-driven decisions, optimise inventory levels and forecast demand. For example, Walmart uses its Retail Link system to collect data from suppliers and monitor inventory levels, ensuring, among other things, timely replenishment of goods[44].

In order to ensure transparency and traceability, it is important to create systems that guarantee the reliability and authenticity of data. Blockchain technology ensures transparency and traceability by recording every transaction in a secure and unalterable way. This is especially important in industries such as food and pharmaceuticals, where consumers are increasingly demanding transparency of product origin. For example, the IBM Food Trust platform[45] uses blockchain to track food from farm to table, while addressing issues related to the safety and authenticity of goods.

Traceability in supply chains is impossible without the use of Internet of Things (IoT) technology. IoT sensors provide real-time monitoring of goods, enabling companies to track temperature, humidity, location and other important conditions of transport and storage throughout the supply chain. This is vital for industries such as pharmaceuticals and perishables. For example, Maersk Line, a shipping company, uses IoT sensors to monitor the condition of containers and provide customers with real-time information about their cargo. In manufacturing, using sensors and data analytics, companies can predict when equipment is likely to fail and therefore perform proactive maintenance. This minimises downtime and prevents disruptions to the production process. For example, Caterpillar uses predictive maintenance for its heavy equipment, preventing costly breakdowns for its customers[46].

Another critical task in global supply chains is demand forecasting, which is crucial for the efficiency of operational planning of all key logistics functions, from procurement to sales and marketing activities. This is where big data solutions come in, such as artificial intelligence (AI) algorithms that can analyse historical data and market trends to more accurately predict future demand. Together with expert opinion, this is already helping many well-known companies optimise production schedules and reduce excess inventory.

Improving data exchange between supply chain partners in today's environment can be achieved through digital platforms that facilitate collaboration and communication (as well as financial transactions) between suppliers and manufacturers, improving coordination and reducing lead times. Supplier Relationship Management (SRM) software enables

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[44] SupplierWiki. 2020. "Retail Link – How Does It Help?" Retrieved from: https://supplierwiki.supplypike.com/articles/retail-link-how-does-it-help

[45] IBM. 2022. "IBM Supply Chain Intelligence Suite: Food Trust". Retrieved from: https://www.ibm.com/products/supply-chain-intelligence-suite/food-trust.

[46] Marr, B. 2017. "IoT And Big Data At Caterpillar: How Predictive Maintenance Saves Millions Of Dollars." *Forbes*. Retrieved from: https://www.forbes.com/sites/bernardmarr/2017/02/07/iot-and-big-data-at-caterpillar-how-predictive-maintenance-saves-millions-of-dollars/?sh=7c53e8e57240

organisations to manage supplier relationships, negotiate contracts and track performance and quality metrics.

Traditionally, supply chains have been linear, with discrete progression through design, planning, procurement, manufacturing and delivery of final products to customers. However, many supply chains are now evolving from a stable sequence of processes to a dynamic, interconnected system, connected to a digital supply network. According to Deloitte[47], this change is laying the foundation for how companies will compete in the future. Digital supply networks (DSNs) integrate information from many different sources and locations to manage the physical act of production and distribution. Using both traditional and emerging data sets, DSNs provide an integrated view of the supply chain and rapid response to changing environmental factors in a use case-by-use manner.

Also, given the challenges of risk management, there are solutions designed to simplify this activity at least to some extent. For example, the PRISM (Proactive Risk Intelligence in Supply Management) system developed by Kearney is a technology advisory solution for comprehensive supplier risk management. PRISM uses external market data, internal supplier performance and Kearney's analytical capabilities to "provide visibility into hidden risks, determine value at risk, and recommend risk mitigation strategies to clients"[48].

In summary, digital solutions are playing a transformative role in modern supply chain management. They improve transparency, streamline processes and enable proactive decision-making, helping companies navigate the complexities of today's global supply chains and maintain a competitive edge. The main challenges in this context, in addition to data security and system integration considerations, are the high investment requirements for implementing the latest digital solutions, as well as the difficulty of achieving a measurable return on such investments.

Uneven global impact of the transformational factors of the modern business environment

The projected global transformation of supply chains, driven by the requirements for increased sustainability, climate neutrality, sustainable finance, best corporate governance practices and production technologies, etc., may lead to positive changes in terms of global sustainable development goals, but they may also have a negative impact, especially on the economies and

[47] Bradley, R., Alderman, M. 2018. "Forget fail fast. How a customised and adaptive strategy can drive your digital supply network. *Deloitte*. Retrieved from: https://www2.deloitte.com/content/dam/Deloitte/ch/Documents/innovation/ch-en-consulting-%20how-a-customized-and-adaptive-strategy-can-drive-your-digital-supply-network.pdf.

[48] Kearney. 2022. "PRISM: Proactive Risk Intelligence in Supply Management". Retrieved from: https://www.kearney.com/service/operations-performance/proactive-risk-intelligence-in-supply-management.

societies of developing countries. The introduction of new sustainability requirements and regulations may create economic challenges for such countries that are heavily dependent on traditional industries or resource-intensive sectors.

The costs of regulatory compliance, technology upgrades and infrastructure investments may place an excessive burden on businesses, especially small and medium-sized enterprises (SMEs), leading to potential job losses and economic disruption. Small farmers or workers in traditional industries may also face difficulties in meeting new sustainability standards, potentially leading to income inequality and job losses. Developing countries may face difficulties in accessing sustainable finance due to factors such as weak financial infrastructure, limited awareness and complex regulatory environments. This can create an uneven playing field, as companies in these countries may find it difficult to attract investment and access the necessary financing to implement environmental practices. In addition, less developed economies may become increasingly dependent on external assistance, including technical expertise and financial support, to comply with sustainability requirements and regulations. This dependence may affect their autonomy and decision-making capacity, potentially perpetuating a cycle of dependency and unequal power dynamics in global supply chains.

The potential impact of sustainability and ESG regulations on the reconfiguration of global supply chains requires further research, including through the lens of non-tariff protectionism. Stricter sustainability requirements and regulations may create barriers to global market access for developing countries trying to meet these standards. Limited financial resources and technological capabilities may hinder their ability to meet complex sustainability criteria, reducing their competitiveness in global supply chains. This, in turn, could lead to reduced export opportunities and economic growth in those economies that fail to adopt Industry 4.0 and 5.0 technologies in time to avoid these consequences.

Thus, the transition of developed countries and TNCs to sustainable supply chain practices can lead to negative social impacts and exacerbate existing inequalities in developing countries. It is important to prevent these negative social impacts by finding and implementing innovative approaches to farming, inclusive policies and financial support mechanisms. Addressing potential negative impacts requires a holistic approach that balances sustainable development goals with the specific needs and capacities of developing countries. It is crucial to provide inclusive policies, innovation capacity building initiatives, technology transfer and financial support mechanisms to ensure their transition to sustainable supply chains while minimising adverse impacts. Cooperation among stakeholders, including governments, companies, investors, academia, civil society organisations and local communities, is also essential to overcome these challenges and promote sustainable development in a balanced and equitable manner.

Conclusions

The main drivers of the current transformations of global supply chains are the escalation of geopolitical conflict and the imperatives of sustainable development, which, in turn, are believed to be the consequences of previous market and state failures and the systemic global crisis, as well as the actualisation of civilisational contradictions. The perceived need for a global response to climate change is shaping new regulatory and partnership requirements for global businesses and supply chains, in particular in the context of increasing transparency and accountability for compliance and a gradual, but timely, transition to sustainable practices, sustainable finance and social responsibility.

Geopolitical tensions, on the other hand, are shaping trends towards increased protectionism and neo-protectionism in global trade, and the need to address the issue of a more balanced selection of "friendly" partners in the supply chain, taking into account more clearly defined policies and criteria, including those related to security (including information security). In the context of increasing climate, geopolitical, financial and other risks, innovative technological and digital solutions allow leading companies to maintain and increase their competitive advantages in today's turbulent environment, however, modern models of global supply chain management should take into account more and more non-market factors to maintain supply chain resilience, adaptability and ability to withstand crises of various scales.

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