

FUNCTIONING OF SUPPLY CHAINS IN THE CONDITIONS OF MODERN CRISES

Galina V. Tretyakova,
gvtretyakova@fa.ru

Anna V. Orlova,
canbrecause@yandex.ru

Financial University under the Government of the Russian Federation,
49/2, Leningradsky avenue, Moscow, 125167, Russia

Galina V. Tretyakova, Cand. Sc., associate professor, Financial University under the Government of the Russian Federation.

Anna V. Orlova, student, Financial University under the Government of the Russian Federation.

*In recent times global supply chains have been undergoing significant changes under the influence of global economic crises, consequences of the COVID-19 pandemic, political decisions (regarding Russia and Ukraine), etc. As a result, the global supply chains can be disrupted and rebuilt «from the foundation», what often leads to a shortage of products or a change in the structure of consumption. Such changes may affect a significant part of the population, which determines the relevance of the research topic. **Objective:** to identify the current vector of global supply chains development and assess the consequences of their disruption during crises. **Methods:** a systematic review of the literature, a comparison method and correlation analysis tools to detect the degree of dependence between the indicators under consideration. **Results.** Based on the analysis, the key consequences arising from the disruption of global supply chains were identified: rising product prices and inflationary shocks, a temporary reduction in the volume of trade between partner countries, changes in their welfare and the restructuring of chains to find new participants and minimize risks, the transition to an integrated model of global supply chains management and the construction of its functioning scheme. **Scientific novelty.** Based on the analysis of many factors, the consequences of disruption of global supply chains on the modern functioning of the economies of countries were identified and evaluated. **Practical significance.** The main provisions and conclusions of the article can be used in scientific and managerial activities when considering the functioning and development of trade relations between states.*

Key words: global supply chains, management of global supply chains, global value chains, economic well-being, Global Supply Chain Pressure Index, digitalization, «Industry 4.0».

Introduction

In recent years, rising prices and periodic shortages of goods, even in countries with the largest economies, have forced us to focus on the functioning of supply chains, which usually work continuously in the «background» mode. Periodic long delays and supply constraints have become a motivating factor in the analysis of global supply chains (GSC): the causes of their violations and consequences.

The advent of the digital era of «Industry 4.0» has become the basis for the introduction of the concept of «Supply Chain 4.0», implying new views on the design, planning, distribution and operation of GSC. Based on it, modern management methods include: Internet of Things, 3D printing, «Big Data», augmented VR reality, robotics, cloud computing and algorithms, artificial intelligence (AI), the introduction of RFID tags, etc. However, despite the obvious advantages, digitalization raises the problem of increasing the «technological» gap

between developed and developing countries, which can not only rebuild GSC, but also have ambiguous consequences during a crisis.

Recent years have exposed GSC to many risks. The COVID-19 pandemic, trade rivalry between China and the United States, political aspects, have not only left a mark on the economy and trade dynamics of the countries, but also continue to influence the GSC, which forms the problem of the topic under study.

Literature review

Considering the point of view of the economists of the WTO, the World Bank Group, the OECD and consolidating the analytical calculations carried out [1], GSC, having experienced the external pressure of global crises and the vector of economic development, are characterized by a number of features:

1. The technological level of the production sector reflects the complexity of the value chain, increasing the number of links in the supply chain and their importance for the innovative and technological segment of the country's economy.
2. During favorable periods for the global economy (for example, the period 2000–2007, 2011–2019, etc.), GSC develop the largest topics in comparison with other components of GDP. However, with the onset of the crisis, they are among the first ones to identify a decline and slow down GDP growth.
3. At the present stage, as a result of digitalization and the transition to the «Supply Chain 4.0» model, the consequences are ambiguous: on the one hand, the length of the chains is decreasing, there is a «geographical» restructuring of industrial production and the involvement of developing countries in GSC is decreasing. On the other hand, by reducing coordination, the link is strengthened, supply costs are reduced and the chains become less exposed to risks.

It is worth noting that digitalization is currently pushing for a transition in supply chain management from a linear model (where instructions go from supplier to manufacturer, distributor, consumer (and back)) to the integrated model, which is also mentioned in the PwC study [2]. Such a model does not only unite each company with its direct suppliers and consumers, but also allows you to receive instructions on several streams. The accompanying analysis based on the data obtained has become an opportunity to increase sensitivity to the continuously changing consumer demand.

- However, functioning GSCs are still vulnerable due to a number of reasons:
- insufficient modernization of infrastructure [3] (transport, logistics networks, processing of information about received (shipped goods), employed labor, etc.);
- introduction of tariffs and restrictions caused by customs and legal regulation of trade relations between countries [4];
- political uncertainty in some countries regarding trade, value chains and investment prospects in the development of supply chains [5].

According to the IMF (International Monetary Fund), the most significant violations were caused in 2020–2022 by:

- restriction of the movement of sea transport and overloading of ports when delivering goods to target consumers [6];
- decrease in the volume of international trade in goods during the COVID-19 pandemic due to the introduction of restrictive state measures [7];
- temporary shutdown of factories or reduction of production in China, India and other countries;
- failures in logistics networks and lack of production capacity for the production of goods in parallel with the growing demand [8].

The functional consequences of violations in the period 2020–2022 can include:

- A) the increase in time for goods to pass through supply chains by an average of 25 % in the countries of the world [9]. And the costs for the projected additional days of goods in delivery are approximately equal to the ad valorem tariff of 1,0–3,1 %;
- B) the increase in transportation and delivery costs [10].

The consequence issue of disrupting GSCs has also been studied by World Bank economists [11]. They highlighted the main changes:

- interruptions in the production of goods and services due to a shortage of supplied resources, which leads to a shock to the aggregate supply curve;
- indirect negative consequences for participants further in the supply chain;
- growing unsatisfied demand for a number of goods and services, which leads to an increase in prices. It can also provoke a change in demand and prices for goods from related sectors (for example, related to raw materials).

Thus, the functioning of the GSC periodically changes and adapts to the conditions of the world economy. Determining and assessing the significance of the consequences of supply chain disruptions from global crises is still relevant. Identification of potential risks and bridging gaps can lead not only to the establishment of goods movement between countries, but also to the recovery of the world economies as a whole.

Research results

Taking into account the distribution and the level of production capacities in the countries all over the world, the formed GSCs can be conditionally consolidated into three main blocks of chains: Europe, Asia, North America. The share of their participation in value chains in the world has changed periodically: the improvement of management and the introduction of innovative technologies faced the onset of crises and supply disruptions.

The conditions for the implementation of deliveries in the countries are different and are characterized by logistics indicators (timeliness of delivery, efficiency of customs procedures, competitiveness of the delivery price, control and tracking of goods, quality of logistics infrastructure, etc.). Together, they form the LP index [12]. On its basis, it is possible to identify the main factors constraining development in 2022:

- «international transportation», reflecting the simplicity of organizing delivery at competitive prices;
- «customs procedures», complexity and often inefficiency.

This is often due to the «paper» declaration of goods, insufficient control of «gray» imports, the complexity of tracking the process of checking documents and, consequently, an increase in time, etc. (in a number of countries, customs inspection procedures are duplicated with inspections from tax authorities, which leads to excessive costs for the state and trade participants).

Considering the relationship between logistics indicators and trade dynamics, it is worth noting that countries with a higher level of economic development introduce higher and stricter standards in the field of logistics, which allows the country not only to occupy a high position in the rankings (for example, LPI leaders: Germany (4,20), Sweden (4,05), Belgium (4,04)), but also to create favorable conditions for the goods supply.

An analysis of GSC functioning shows that since the beginning of the COVID-19 pandemic in 2020, supply chains have begun to experience significant external pressure: periodic failures and disruptions have become a serious problem for the global economy. To assess the impact of the imposed restrictive measures, the Global Supply Chain Pressure Index (GSCPI) was considered [12]. The dynamics of the index is determined by indicators on transport

costs, freight indices, purchasing managers' indices (PMI), and other components within seven interacting economies: China, USA, EU countries, Japan, South Korea and Taiwan.

During the period under study since 1998, GSCPI has shown significant fluctuations in 2020–2022, by now the movement of the index is approaching the balance level. In 2022, the main negative factors in the disruption of supply chains were restrictions that caused an increase in the delivery time of goods in trade with China, an increase in the cost of air transportation between Asian countries and the United States, an increase in the cost of transportation in EU countries, etc. They are based not only on quarantine measures to prevent the spread of COVID-19 in China [13], but also on the impact of the conflict between Russia and Ukraine on the supply chain [14] in Europe.

More than 500 foreign companies involved in GSCs have announced the suspension of activities in Russia. As a result, the balance of cargo turnover is disrupted: for example, when cargo turnover in the port of St. Petersburg is reduced by 85 % compared to 2021, and the ports of the Far East are overloaded. In general, in 2022, the physical volume of imports decreased by 16 %, exports – by 6,9 % (with a parallel increase in value by 17,5 %). Such an effect is mainly associated with an increase in the price of energy carriers due to an increase in the cost of supplies. Now the share of supplies, for example, Urals crude oil to the EU countries has decreased from 85 to 24 % by the end of 2022. The focus shifted to trade with India, Turkey, and China.

The conflict led to the disruption of transport lines between Europe and China. Ukraine, as a link between countries in the supply of chips, car components, metals, etc., has become a limiting factor in the development of GCS. It is worth noting that the volume of its trade has also significantly decreased: imports decreased by 23,6 %, and exports – by 1/3 compared to the previous year.

By this moment, the GSCI level has declined after a historic high (Fig. 1), but tensions in the GSCs and the risk of worsening trade conditions remain.

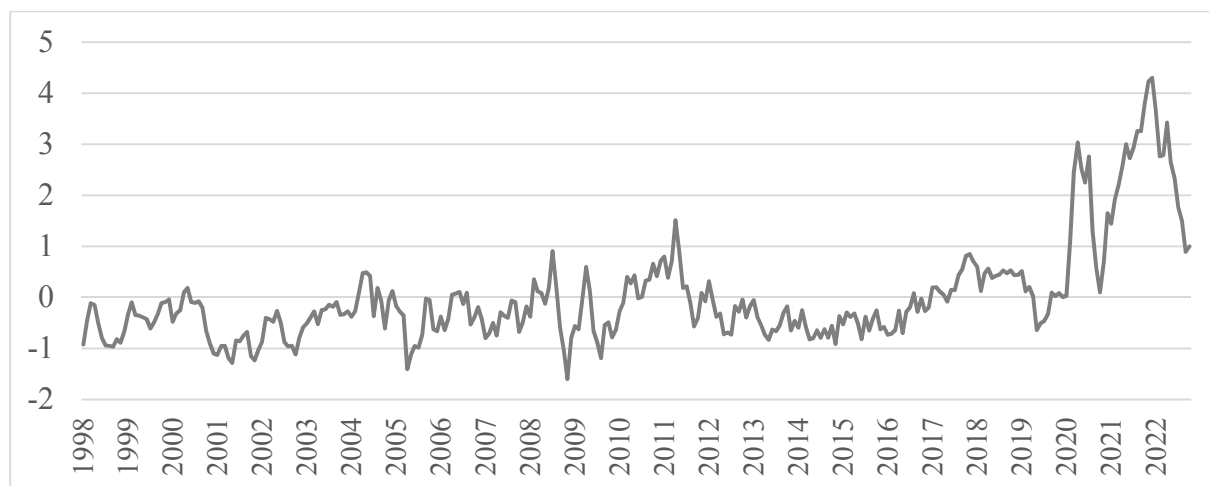


Fig. 1. GSCPI dynamics due to violations and recoveries of GSC

Рис. 1. Динамика GSCPI (глобальный индекс давления в цепи поставок) вследствие нарушений и восстановлений GSC (глобальные цепи поставок)

As a result of the supply chains disruption, many phenomena were provoked:

1. Rising commodity prices and inflationary shocks. The disruption of production and logistics chains led to the restriction and even complete shutdown of production [15]. For example, the computer, smartphone, and automotive manufacturing sectors experienced

a shortage in the supply of microchips and many parts in 2021 due to trade restrictions with China, the container shipping crisis, etc., which led to a reduction in production by companies. So, in the automotive industry Ford, Volkswagen, Hyundai, Volvo, etc. the companies restricted their activities, as a result of which the volume of sales in the industry decreased by \$ 61 billion in 2021 [16].

High demand for goods, limited supply and significant production delays due to supply chains have led to further price increases.

2. A temporary reduction in the volume of trade between countries. As participants in the global value chain (GVC) (supply chain), the level of exports of countries is reduced due to a shortage of parts for the manufacturing new products. To identify such a trend, a correlation analysis of exports of goods from the European Union countries [17] and the values of the GSCPI in these countries (the level of change in percent compared to the previous year) was performed. The calculations used an «emission-free» sample for the period 1998–2021.

The resulting correlation value was 0,68, which indicates an average level of dependence. Of course, the volume of countries exports is influenced by many phenomena, but the efficiency of supply chains is one of the fundamental factors. According to the World Bank, GSCs are responsible for about 70 % [18] of the volume of trade in goods and services in the world.

3. Welfare changes in the countries participating in the chain. According to calculations, the ratio of the sum of total exports and imports to the sum of total production and use correlates with the value of welfare in the country at the level of 96 % [19], which indicates the presence of a strong relationship. As a result, the disruption or loss of one or more «links» in the GSC can not only reduce the import of intermediate and export of finished products by trade participants located further along the production chain, but also affect the well-being of the economy as a whole.

To confirm, a special example is considered – the COVID-19 pandemic in China. The disruption of supply chains led to a significant decline in welfare in 2020 (Fig. 2) in highly integrated EU countries (Luxembourg (–67,6 %), Malta (–54,1 %), Ireland (–47,3 %), etc.) and countries with high dependence on international trade (Taiwan (–21,3 %), Russia (–15,8 %), etc.). Countries with more closed economies for trade and a small number of intermediate links in production flows suffered less (USA, China, Brazil within –6,2 %).



Fig. 2. Impact of supply chain disruptions on the economies well-being [20]

Рис. 2. Влияние сбоев в цепочке поставок на благосостояние экономики [20]

It is worth noting that in a country focused on trade in final goods, the closure of the GVC will entail higher welfare costs than in an economy without trade in final goods. This indicates that commodity trading will be more valuable for a consumer focusing on trade in final goods, and vice versa. Thus, two types of trade (intermediate and final products) complement each other.

4. Restructuring of GSCs. During the onset of the crisis, many countries and multinational companies decide to rethink the previous model of functioning of GSCs: diversification of suppliers, relocation of part of production, reduction of transport leverage, etc.

Sometimes this leads to significant restructuring in the industry. For example, in the case of a trade standoff between the US and China in 2020, the US government imposed restrictions on a number of companies, including the Chinese manufacturer Semiconductor Manufacturing International (SMI). Since its share in the global market is about 5 % [21], the GSC in the production and sale of chips has been disrupted. The need of customer companies producing technological products has prompted cooperation with competitors from other countries (for example, Taiwan Semiconductor Manufacturing (TSM)). The result is a global restructuring of supply chains in the microchip market. Later, many organizations with «factory-free production» appeared among the market participants, who only develop the technology, and outsource the production itself.

The destructive effects of crises can become a motive for deglobalization [22] of supply chains to reduce potential risks in the future. However, in practice, eliminating dependence on foreign resources and suppliers and focusing on partners within the country or close ones geographically does not guarantee full stability.

This is due to the risks of emergency situations (for example, in the case of natural phenomena or factors causing a temporary shutdown of activities), possible increase in dependence on a limited number of market participants, risks of missed opportunities, etc.

5. Transition to more integrated supply chain models through digital solutions to minimize future vulnerabilities and accelerate the recovery of existing gaps. Such a model focuses on linking firms with their direct consumers and suppliers, rather than participants located further along the chain. The main reason is delays in receiving and processing information and potential distortions as a result of changes in the final demand for products that occur as information moves from the beginning to the end of the chain.

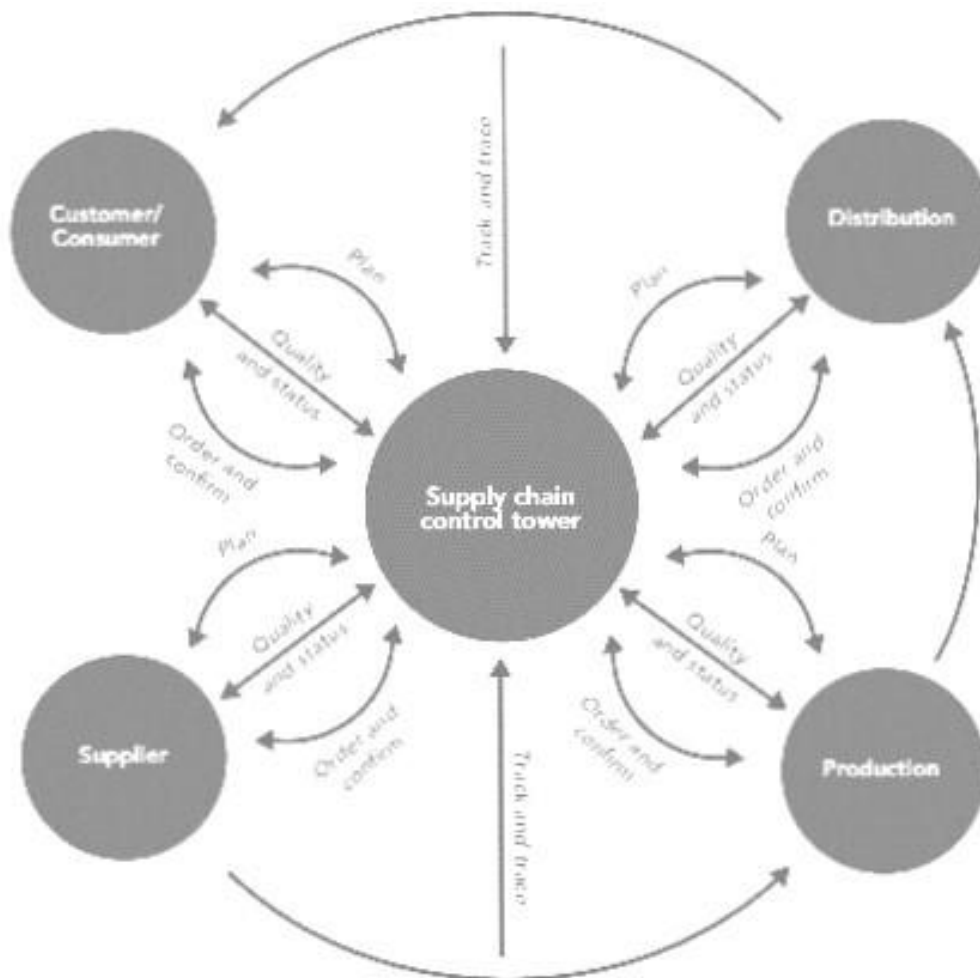
The integrated model for rapid assessment and decision-making due to changes in consumer demand already uses technologies based on the Internet of Things (IoT), combined with RFID (Radio frequency identification), Bluetooth and GSM (Global system for mobile communication) [23], which also characterize the global transition to «Industry 4.0». Communications and stages of trade relations between the participants of the GSC – a supplier and a consumer, can be illustrated as in Fig. 3.

Tracking each step throughout the supply chain allows not only quickly identifying potential risks and disruptions of the chain, but also effectively expanding activities by adding new participants to diversify suppliers and consumers.

In the context of the functioning of the Russian economy, in order to improve the previous model of GSC, we can also recommend: diversification of suppliers (increasing the number of suppliers of key elements of production), transfer of part of production, reducing the distance or strengthening logistics links between companies-links in the production chain, taking measures to reduce the transport load, increasing the volume of reserve stocks, etc. Such actions will contribute to the implementation of risk reduction tactics.

In particular, it is necessary to focus on the implementation of a policy of strengthening and increasing the sustainability of supply chains within the country. Stress testing of supply

chains, attracting investments in the development of logistics networks forming infrastructure and ecosystems, support for local production of key components and materials will help in achieving the goals of stable development of the country's economy.



Compiled by the author based on PWC data [24].

Составлено автором на основе данных PWC [24].

Fig. 3. Integrated control model of the GSC
Рис. 3. Интегральная модель управления ГСК

In general, the development of supply chains is inextricably linked with the welfare of the people: the availability of high-quality goods and at a competitive price contribute to improving the population standards of life. In times of crisis, there are many negative factors (inflation, limited production, reduced flows of goods transportation, etc.) that worsen the situation of social and economic segments. However, at present, the welfare indicator reflects positive dynamics in relation to the gradual restoration of supply chains.

Conclusions

The identified consequences of disruptions and disruptions of supply chains on a global scale allowed not only identifying vulnerabilities, but also assessing the relationship with the economic component of countries. An analysis of the development of trade relations between countries, the activities of individual companies and macroeconomic indicators has identified

the cumulative effects in the GSC and logistics networks, revealing both negative aspects and positive sides as potential points of development.

It is worth noting that the transition to «Industry 4.0» and the introduction of digital technologies in the supply chain can open up significant advantages in terms of inclusive growth models, innovation and entrepreneurial opportunities. However, this does not negate the possible risks. The transition to an integrated management model can minimize them and become the basis for further, more sustainable functioning of supply chains in crisis conditions.

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ФУНКЦИОНИРОВАНИЕ ЦЕПЕЙ ПОСТАВОК В УСЛОВИЯХ СОВРЕМЕННЫХ КРИЗИСОВ

Третьякова Галина Викторовна,
gvtretyakova@fa.ru

Орлова Анна Викторовна,
canbrecause@yandex.ru

Финансовый университет при Правительстве РФ,
Россия, 125167, г. Москва, пр. Ленинградский, 49/2

Третьякова Галина Викторовна, кандидат педагогических наук, доцент Департамента иностранных языков и межкультурной коммуникации Факультета международных экономических отношений, Финансовый университет при Правительстве РФ.

Орлова Анна Викторовна, магистрант факультета международных экономических отношений Финансового университета при Правительстве РФ.

*В последнее время глобальные цепи поставок подвергаются значительным изменениям под влиянием мировых экономических кризисов, последствий пандемии COVID-19, политических решений (касательно России и Украины) и пр. В результате глобальные цепи поставок могут быть нарушены и перестроены «с фундамента», что зачастую приводит к дефициту продукции или изменению структуры потребления. Подобные изменения могут затронуть значительную часть населения, что обуславливает актуальность темы исследования. **Цель:** выявление современного вектора развития глобальных цепей поставок и оценка последствий их нарушения в период кризисов. **Методы:** систематический обзор литературы, метод сравнения и инструменты корреляционного анализа для обнаружения степени зависимости между рассматриваемыми показателями. **Результаты.** На основе анализа были определены ключевые последствия, возникающие вследствие нарушения глобальных цепей поставок: рост цен на продукцию и инфляционные шоки, временное сокращение объема торговли между странами-партнерами, изменение их благосостояния и перестройка цепей для поиска новых участников и минимизации рисков, переход к интегрированной модели управления глобальными цепями поставок и построение схемы ее функционирования. **Научная новизна.** На основе анализа множества факторов были выявлены и оценены последствия нарушения глобальных цепей поставок на современное функционирование экономик стран. **Практическая значимость.** Основные положения и выводы статьи могут быть использованы в научной и управленческой деятельности при рассмотрении вопросов о функционировании и развитии торговых отношений между государствами.*

Ключевые слова: глобальные цепочки поставок, управление глобальными цепочками поставок, глобальные цепочки создания стоимости, благосостояние экономики, глобальный индекс давления в цепочке поставок, цифровизация, «Индустрия 4.0».

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