Chapter 4. The digitalization of the supply chain

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Supply chain disruptions have emerged as a major challenge for the global economy in recent years.

The pandemic in 2019 disrupted global economic operations, causing unprecedented disruptions in supply chains and affecting both local and international trade. The difficulties were especially pronounced during the post-pandemic recovery phase when demand for commodities and goods exceeded their limited supply.

Factory closures (particularly in Asia), widespread lockdowns and mobility restrictions have caused bottlenecks in logistics networks. These disruptions have resulted in increased shipping costs and sea freight, longer delivery times and shortages of raw materials due to the subsequent race for available resources.

A number of bottlenecks have emerged in complex supply chains, impacting the global manufacturing process. Monitoring this process has become important not only from the perspective of businesses directly affected by the disruptions, but also for policymakers. It helps them assess potential imbalances between supply and demand and consequent inflationary pressures.

In view of these complex dynamics, the digitalization of the entire supply chain was considered more important than ever.

Supply chains have expanded significantlyin recent years, and this growth has been compounded by increased complexity. Customer needs, the competitive environment, and the standards of various industries have changed. Companies and entire supply chains have formed strategic alliances, engaged in mergers and acquisitions, outsourced functions to third parties, adopted new technologies, launched new products, and expanded their operations into new geographies with different time zones and markets.

In other words, the growth of supply chain complexity has accelerated dramatically with trends such as globalization, sustainability, personalization, outsourcing, and manufacturing innovation.

The events of recent years and in particular the Covid-19 pandemic and the outbreak of the Russian-Ukrainian war, as well as the Israeli-Palestinian conflict, have in fact led to a perfect storm with strong repercussions on all markets.

For instance, the microchip sector, energy and the main foodstuffs have all been significantly impacted.

Today, every business has to deal with the complexity of the supply chain, which encompassesstatic, dynamic and decision-making complexity. While static (structural) complexity describes the structure of the supply chain, the variety of its components, and the strengths of interactions; in contrast, dynamic (operational) complexity represents uncertainty in procurement and involves aspects of time and randomness.

Static structural complexity has existed for several years and, as we have pointed out, depends on factors such as globalization, sustainability and technological innovation of production.

Dynamic complexity, on the other hand, is linked more to unpredictable events, the so-called black swans, which now seem to be very widespread.

Decision-making complexity is an immediate consequence of the previous static and dynamic decisions as well as from the choices to be implemented.

The static-dynamic distinction has been used primarily to study complexity within production systems.

Today, we talk about supply chain resilience in reference to the complexities to be faced, the solutions that often lie in greater standardization of products and shipping methods, in the automation of decision-making processes through the management of business rules and, above all, in collaboration with supply chain partners.

In fact, supply networks are referred to as the optimization or redesign of supply networks, especially when they are characterized by a large number of suppliers and varieties of parts (complex products).

There has been a tendency to diversify suppliers and sub-suppliers by relocating them closer to the main production site through reshoring, nearshoring and regionalization of strategic supply chains. This approach aims to optimize time and costs by alternating the just-in-time model with that of increasing safety stocks and developing the logistics real estate market.

In making these decisions, the supply chain is increasingly a variable to be evaluated from a financial point of view, with impacts in terms of investments and ROI. Supply chain finance (SCF), in fact, has grown significantly in recent years thanks to the digitalization of supply chains, expressing the need leverage financial tools to enhance not only the efficiency of one's own company but also the broader supply chain, optimizing available financial resources. Yesterday's linear, global, and predictable supply chains - where suppliers were more or less the same, certified, qualified, and controllable - are increasingly rare. Today, supply chains are asymmetrical and variable due to geopolitical, economic and social factors.

Sudden variables such as embargoes, wars, internal revolutions, climate crises (like floods or earthquakes) and possible future pandemics can cause blockages

in the face of which valid alternatives will have to be identified in a very short time. Strategic suppliers or customers will have to be replaced to avoid production stoppages and consequent huge economic losses.

Additionally, trade routes - such as those from the Suez Canal to the Black Sea to the Baltic to the China Sea can be suddenly blocked, requiring rapid changes of strategy.

Climate change, particularly the melting of the ice, is expected to shift the focus toward the Arctic, opening new routes for international trade. The increasing congestion and vulnerability of the Suez Canal and the Panama Canal - as demonstrated by the Ever Given accident in the Suez Canal - require possible alternative routes. Additionally, the Arctic's vast natural resources, spanning approximately 8 million square kilometers, are becoming increasingly significant on a global scale.

The supply chain will therefore increasingly become a strategic variable to be analyzed on an ongoing basis and possible disruptions will have to be monitored as much as possible.

In fact, for some years there have been measures to assess them, such as the Fed's new indicator: the Global Supply Chain Pressure Index (GSCPI). This index integrates a series of data and indicators[9] to provide the most complete summary possible of the potential disruptions affecting global supply chains. More specifically, the index is based on data from seven interconnected countries[10] and a range of indicators from SMEs and transport costs.

The GSCPI could therefore be used as a monitoring tool to assess the conditions of the global supply chain, but also as a statistical model to understand trade flows between countries or price movements.

Even without disruptive events such as pandemics or wars, disruptions can arise within countries - such as build-up at ports or truck driver shortages - or they can spread to different countries, as in the case of a widespread container shortage.

The ongoing redesign of global value chains is crucial, especially considering the severe economic crises faced in recent years. The sector has a very high value, it is estimated to be worth up to 12% of the world's GDP for an absolute value of between 8 and 12 trillion dollars and growth forecasts for the coming years continue to be significant (Maiden, 2020).

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9 The Fed's index complements two well-known maritime indices, the Baltic Dry Index and the Harper Petersen Index of Container Rentals, to the Purchase Manager Index (PMI), the U.S. Bureau of Labor Statistics' Air Freight Cost Indexes, and many other economic datasets from the transportation and manufacturing sectors. The GSCPI is updated monthly on the fourth business day of each month.

10 The economies interconnected through global supply chains referred to are: China, Eurozone, Japan, Korea, Taiwan, United Kingdom and United States.

Digitalization and artificial intelligence are set to play an increasingly crucial role thanks to advanced e-procurement, an effective analysis and evaluation of new partners, and a total digitization of transport documentation that allows continuous tracking of the distribution network.

Today, during an expedition, information is shared and collaboration between the various components of the supply chain is the best solution to face the complexity of new challenges. The adoption of IT systems capable of synchronizing supply network data with collaborative planning, with defined processes and procedures helps minimize unforeseen events and disruptions.

Owning and rapidly processing digital data allows you to change decisions and strategies. After the appropriate collection of information and data, we proceed with their evaluation which, given the speed of the decisions required, can hardly be carried out in a coherent and fast way by a single human mind, even if it reasoned in a pool.

Increasing immediate support is being used by the most advanced technology, linked to business intelligence, analytics and artificial intelligence.

Highly efficient calculation algorithms, expertly configured, enable rapid adaptation to changes in critical indicators related to procurement, inventory, production, and distribution. These algorithms proactively suggest alternative solutions to address emerging issues and disruptions. The introduction of blockchain in logistics has also begun to allow for the authentication of certain steps in the supply chain. In a world where trust is constantly undermined by the destabilizing factors, there is a need for technological support that links the correct evaluation of the supply chain to guaranteed and unchangeable qualitative factors.

It is essential to have daily certainty of what you buy, where you buy it, who the partner really is and how they behave, how and where you transport the goods, the relative delivery and distribution times and the complete and reliable tracking of the commercial transaction in physical, economic and legal terms.

IoT systems and an effective TMS are the basis of all this, but a blockchain notarization system is crucial in convincing companies and their customers of the validity of a system that is constantly evolving and changing.

"Logistics 4.0" has profoundly transformed organizations and roles, pushing towards the demand for new skills especially for data analysis, automation and artificial intelligence.

However, supply chains are increasingly vulnerable to frequent cyberattacks, which can compromise the security of client companies.

The methods used to attack the supply chain are different and often unfortunately unknown. The Enisa (2021) report clearly illustrates a series of methodologies and cases of attacks that occurred between January 2020 and early July 2021. It proposes interesting conclusions that can make us reflect on the

need to develop adequate security models integrated into the supplier-customer supply chain.

Purchases on e-commerce platforms have grown exponentially with the acceleration of the Covid-19 pandemic, suggesting a consistent growth in the demand for logistics operators to prepare, transport and deliver purchase orders. This boom has highlighted the immense need for workers in the logistics sector. When analyzing future trends in logistics, it is impossible not to refer to the ongoing decarbonization process and therefore to the ecological transition of freight transport. The mission is one of the most arduous. First of all, the sector is characterized by an almost total dependence on fossil fuels and the adoption of low-emission technological solutions is progressing slowly, particularly in long-distance heavy transport. Secondly, the movement of products is set to more than double in the next three decades (ton kilometers will grow 2.6-fold between 2015 and 2050)[11] partly due to the increase in the world's population. This means that the reduction in emissions and average carbon intensity that current decarbonization policies will bring will be cancelled out by increased demand for transport. In addition, the assets used have a very long average life: ranging from 5-7 years for vehicles to 30 years for a ship and an aircraft (McKinnon, 2021). Finally, the stakeholders along the supply chains are numerous and the climate policy framework is not yet well defined and is fragmented into watertight compartments by type of carrier without an overall vision, not to mention the increase that this transition will entail on overall transport costs.

Reducing demand for freight transport is certainly one of the most politically sensitive issues. There was a close correlation between ton-kilometer growth, logistics performance and GDP growth. Governments are therefore concerned that limiting the growth of freight traffic could also inhibit future economic development. Despite the fact that the pursuit of the Net-zero goal may ultimately force policymakers to accept the fact that an infinite economic expansion is unsustainable for the climate, few governments are yet willing to pursue such measures.

The solutions being pursued are mainly at national and intra-continental level, where the goal is to move as many goods as possible from trucks to trains and ships. In fact, road freight accounts for 44% of all freight transport emissions, while maritime traffic only accounts for 20%, due to its high capacity and low carbon intensity.

Another measure is optimizingthe load capacity of freight transport, as available load capacity is seriously underutilized for all modes of transport.

Efforts are also being made to train hauliers in the conscious use of vehicles to limit fuel consumption. This includes strategies such as scheduling night departures to reduce traffic and improve fuel efficiency.

11 International Transport Forum (2021).

In Norway, the Norwegian Forum for Autonomous Ships has been established to promote the concept of unmanned navigation. Since 2021, the Norwegian fertilizer company Yara has been carrying out the first "pilot" project with an autonomous and electric container ship called Yara Birkeland, which has a capacity of 120 TEUs and has already been dubbed the "Tesla of the Seas". In 2024, at the end of the pilot project, the zero-emission ship could set the standard for the short sea shipping of the future. With no need for fuel and crew, the vessel will save up to 90% of annual operating costs compared to conventional vessels of similar size.

The future of logistics is already upon us, but the transition will not be painless in terms of upfront costs for all operators and the consequent impact on consumer goods.

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