Restructuring the Supply Chain in the Post Covid Era with Geopolitics in the Background

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***Abstract*— Over the last decade, the topic of supply chain disruptions has increasingly gained importance among scholars and professionals due to changing business dynamics and several developments on the geopolitical front. The U.S.-China trade war has developed an overall geopolitical trend in favor of nationalization followed by the recent COVID-19 pandemic, which altered the priorities of several supply chain leaders who now have to balance operational efficiency and cost alongside building greater resilience of the supply chain. Several articles and other literatures have been published in important journals and other public domains which form the basis of our study. The emphasis is on restructuring of supply chain in the post-Covid era in the backdrop of recent geopolitical mayhem. The Russian invasion of Ukraine and the resultant sanctions imposed on Russia and the recent Covid-19 lockdowns in China are latest events which have played havoc with the worldwide supply chains. Important studies on this subject, have been acknowledged and evaluated, based on reviews. Detailed evaluation of these studies scrutinized existing information regarding the various types of disruptions, their effect on supply chains, the flexibility in-built in supply chain design and the strategies for recovery, supported by cost-benefit calculations, are recommended by the studies. Research on supply chain in the context of COVID-19 is still in the nascent stages. This article contributes to the development of literature on the subject.**

***Keywords*—** *supply chain, restructuring, geopolitical, global supply chain, supply chain restructuring, digitization, automation.*

1. *Introduction*

Evolution of supply chains, at the global level, over the past few decades has been the outcome of the objective of businesses to maximize efficiency [1]. There has been a noteworthy transmutation in attitudes towards and tactics of international commerce, forced by such phenomena as increasing cost of labor in China [2] and growing protectionist inclinations all across the globe [3], especially in the US, which had already heightened the US-China strategic rivalry which has been aggravated and accelerated by the Covid-19 pandemic making it imperative for businesses to strive to restructure their supply chains on an urgent basis [4]. The occurrence of the global pandemic made the need for diversification of supply chains more ostensible. The US, EU and several other concurring countries agree that they need to terminate, or at least drastically reduce, their supply chain dependence on China now more than ever; even more than the times of the trade war between China and the US [5]

2. *Literature Review*

A supply chain handles the transformation of inputs or raw materials into outputs or finished goods along with the distribution of the finished products to the final users at the correct time and place [6] and incorporates every party that has direct or indirect involvement in the fulfilment of consumer demand [7]. For all sorts of businesses, supply chain has emerged as a key factor for gaining competitive advantage and supply chain management (SCM), or the active management of the activities that create the supply chain, is essential for the maximization of customer value and for achievement of competitive advantage that can be maintained over the long run [8].

2.1. Supply Chain & Its Evolution

In terms of both definition and scope, SCM has always been extremely dynamic [6]. A supply chain basically refers to a group of suppliers who are necessary for creating a particular product for a business, each acting as a link that creates value and adds to cost of the product [9,10].

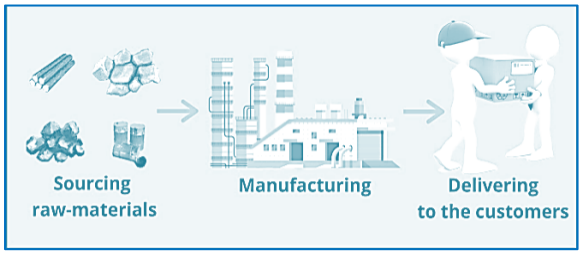


Figure 1: *A Typical Supply Chain*

International Journal of Supply Chain Management
IJSCM, ISSN: 2050-7399 (Online), 2051-3771 (Print)

Scholars and researchers reason that supply chain parameters such as, shape, size and the nature of transactions are ultimately governed by basic economic considerations [11]. The emergence of new supply chains generally occurs due to disruptions – natural or manmade. It could be a technological breakthrough, emergence of new markets or even shocks such as the recent global pandemic [12]. Just as new supply chains appear in response to development of demand or creation of new demand, they might also decline and finally disappear due to insufficient or no demand [13].

***Figure 2**: Supply chain management*

Business today is extremely fast paced, which makes it essential for entrepreneurs across dimension and industry to have access to relevant and useful information flowing through its physical network that can be leveraged completely using commercial integration. Coordination amongst diverse players can be achieved through such business integration which becomes instrumental in enhancing or augmenting the bottom line [9]. The complexity of business transactions has magnified manifold with the evolution of supply chains. Nevertheless, in terms of efficiency, contemporary business transactions are doing much better than ever before. Rapidly expanding infrastructure and implementing new processes within the supply chains have made it possible for supply chains all around the world to bring down costs significantly and effectively and at the same time enhance efficiencies [14].

Supply chain being the very backbone of business operation, its effective and active management is essential for augmenting customer experience and enlarging customer value while attaining a maintainable competitive advantage [15]. Supply chain management (SCM) refers to the assemblage of theories, procedures and practices which work in tandem towards keeping a supply chain functioning effectively and augmenting its efficiency in order to benefit maximum number of these links, if not all [16]. The process of supply chain management comprises of various different groups of players including retailers, producers, and suppliers who work towards providing goods and services to the final consumers, exclusively for creation and addition of value in the products they offer, not only in upstream but also in downstream, using certain channels that facilitate proper flow of resources and data [17].

Today's supply chain is very different from what it used to be a decade ago making it imperative for the companies to build agile and swift supply pipelines [18]. Due to the growing complexity of modern business environment, supply chain management has assumed the position of a critical success factor for today's businesses [19, 20]. The premeditated and deliberate configuration of end-to-end business processes in a manner that leads to maximum realization of both economic and market value is an indispensable part of today's supply change management [21]. It is as important as creating and maintaining competitive advantage over global and local business rivals through efficient SCM.

Trends in Supply Chain Management, like globalization of market economies, digitalization, less lengthier life cycles of products, and growing complexity of customers' expectations, in conjunction with such developments as insufficiency of resource, more stringent regulatory conditions, and higher emphasis on long-term objectives, have resulted in the development of highly intricate and complicated supply chains [22]. Today supply chain management has a more important role to play than earlier as it efficiently connects the front, middle and back offices in every contemporary organization [23] providing competitive edge to the business [24]. It is, therefore, understandable why an incompetent or uneconomical and poorly performing supply chain can be extremely damaging for every aspect of any business organization [25].

Lean SCM practices have gained significant popularity on the back of globalization of world markets and development of competitive business conditions [24, 26] that call for processing of nonstop flow of commodities with low volumes of inventory, aimed and non-fluctuating production, just-in-time production and correct scheduling of transport for cross-docking operations which results in supply chains with higher responsiveness and better cost efficiency [27]. In addition to this, there is significant

pressure to reduce costs which has resulted not only in outsourcing but also in offshoring of several activities including production, assembly and research and development (R&D) and more specifically procuring from countries that offer reasonably prices. Such changes and practices demand both environmental and operational stabilities but at the same time magnify their susceptibility to disruptions which in turn leads to much higher operational and financial consequences of disruptions in the supply chain [28].

2.2. Supply Chain Disruption

Supply chain disruptions refer to unexpected, unimagined and inadvertent occurrences or changes in the normal environment that disrupts the manner in which goods and services normally flow through a supply chain [29]. These are very real and are caused by both human and climate change factors [27], and the ones that happened recently continue to put significant drag on global trade and commercial activities. The key aspects pertinent to supply chain disruption are:

I. the restrictions on economic activities due to the global pandemic,
II. the problems and complexities in the transport and logistics segment,
III. the shortage of labor, and
IV. the semiconductor shortages [30].

It might look or feel uncanny how disruptions tend to transpire irrespective of the best efforts put forward by the managers, leading to sales losses, which result in large financial setbacks and have an adverse effect on Shareholders' wealth and the company's operating performance [31].

Over the last few decades, significant progresses have been witnessed in transportation, technology and various fields. Despite such advancements the occurrence of supply chain disruptions between 2020 and 2022 could not be prevented. Figure 3 illustrates the ways in which COVID-19 and trade wars impacted the supply chain by triggering off a series of events that created a roller coaster like situation for supply chain professionals to tackle, since they witnessed market ups and downs continuously. However, even with deliberate and cautious functioning there was no major improvements in the supply chain situation due to the dearth of data availability especially related to supplies, third-party suppliers and beyond which made it possible for choke points to occur at any and every point along every supply chain [32].

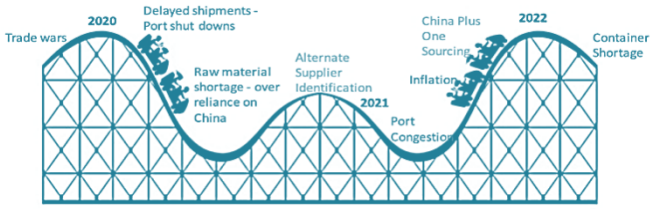


Figure 3: Impact of COVID-19 & Trade Wars on Supply Chains

2.2.1. Covid Disruption

The COVID-19 pandemic that broke out recently had significantly impacted every faction of the value chain, from procurement of raw material to the delivery of final product to the end customer. Every aspect For most companies around the world, the COVID pandemic tested their organizational strength, operational flexibility, financial resilience and commercial buoyancy [33]. Supply Chain disruptions were heightened due to the pandemic, with businesses constantly contending with persistent fluctuations in demand and supply, sudden and unforeseen outbreaks in various parts of the world and conjectures to find different routes to reduce dependence on China [34].

Beyond a doubt the global pandemic has been able to highlight the gaps that exist between the prevailing risks and the ability for several organizations to bounce back. This has pushed CEOs to actively look for innovative solutions to combat the challenges thrown by such disruptions, with 67% being affirmative about steadily scaling up investment in technologies and processes for detecting disruption detection and finding innovative solutions and responses [33]. This has also urged companies to look at restructuring their supply chains, balancing flexibility with efficacy and reducing overall expenditure – either initiated or fast-tracked because of the global pandemic [34].

Worldwide merchandise shipping has undergone severe disruption because of misplacement of containers and congestions at the ports riding caused by quick global economic recovery, alternation of consumption demand between services and goods and the resultant above average volumes of import, along with such events as port closures caused by allochronic and restricted outbreaks of the disease [35]. From the end of 2020 the cost of shipping, especially from prominent ports in Asia to the US and Europe have risen steeply. The COVID-19 pandemic flipped global supply chains over.

Scarcity of labor at ports was observed as workers developed home sickness during the pandemic. Transport drivers and crews of cargo ships were not able to go overseas because of travel restrictions imposed due to public health constraints. A huge backlog of demand needed to be met as large stimulus packages got implemented during the extended shutdown of all public services and amenities. This caused a choking up of supply chains which were just not built for such a huge surge in consumer demand and the consequent demand for shipments. Other than the resultant delay in getting the goods delivered to end customers, there was a premium cost involved in getting the goods delivered [36].

Second half of 2020 witnessed an acute shortage of semiconductors and this was particularly noticeable in the automotive sector. Scarcity of workforce was not as prevalent and seemed more evident in certain economies such as the USA and the UK [30]. Supply shortages witnessed by the semiconductor industry, have reportedly contributed towards downstream industry disruptions all through the COVID-19 global outbreak. This might have been true for a number of downstream users but trade data shows a marked and rapid increase in overall trade of semiconductors. There has been a 11.5% year on year increase in the value of exports of 10 biggest exporters in 2020 and the figures recorded for Jan-Apr 2021 reflect a remarkable growth of 26.3% over the corresponding period in 2020. Only a handful of top suppliers saw a decline in growth rates in the beginning of 2020 but even these were turned around positively over the year [37].

2.3. Supply Chain Disruptions & Geopolitics

Across industries and firms, supply chains have expanded rapidly, crossing national and regional boundaries, which has heightened the risks and opportunities that accompany activities related to outsourcing and offshoring [38]. A supply chain geopolitical risk is the likelihood of a supply chain getting disrupted due to political, cultural or socioeconomic changes at the global level. This could include such events as trade controls, war, revolution, costs escalation due to tariff conflicts and could actually result in reduction of supply chain efficiency [39].

Disruptions on a global or even regional scale have the potential to generate significant volatility in the operational environments which can lead to increased costs, more complexity and less efficiency of the supply chains [40]. Tariff, quantitative restrictions, taxes, geopolitical sanctions on goods etc. can result in shortages caused by disruption in access to key raw materials. This demands further customization of the supply chains for adhering to the added regulatory compliances being laid down by newer rules and regulations. Regularly used shipping lanes may suddenly become clogged or unreachable due to military or political emergency, thus forcing organizations to look for alternate supply channels [41]. Certain natural geopolitical risks are always prevalent and these risks are extremely irregular and arbitrary making it nearly impossible for corporate planners to predict. It only needs one link in the supply chain to be affected by some catastrophic event to cause a full disruption. This volatility and uncertainness must be overcome by well renowned international companies who should keep a global outlook but also work at a local level while complying with codes of local traditions and culture [42].

Supply chain disruptions are not something new that global organizations have had to deal with and they were already fire-fighting to keep supply chains operational much before the advent of the COVID-19 pandemic [41]. In the past few years, several different supply chain disruptions have occurred quite often due to various reasons with natural calamities being the prime disruptor [39]. The PwC 25th Annual Global CEO Survey [43] has found 32% executives voting for geo political unrest as the prime candidate for stoppage of economic and industrial growth in this sector. The same report also cited that that 71% of the respondents claimed lower access to markets due to these disruptions would become a reality thus becoming a key impediment for the producers' ability to trade goods and services [43].

2.3.1. China- U.S. Trade War

US-China trade war that started out as the US's retaliation to unfair Chinese economic policies considered unfair by the US, has now steamrolled into an alleged cold war which has been further stoked by differing governance principles and philosophies [44]. The retaliatory tariffs were imposed on China and then followed up by strict control on China's access to state-of-the-art US tech products [45] as well as foreign investments which involve security concerns and accusations of unfair Chinese commercial practices [46]. These have been further amplified through strengthening of anti-China alliances and further restrictions on trade in Chinese goods in the recent past.

Deterioration of US-China relations could adversely impact supply chains as well as the global movement of data, population and capital. Both US and China are apprehensive about their supply chain security for goods that are important to each of the nations [47].

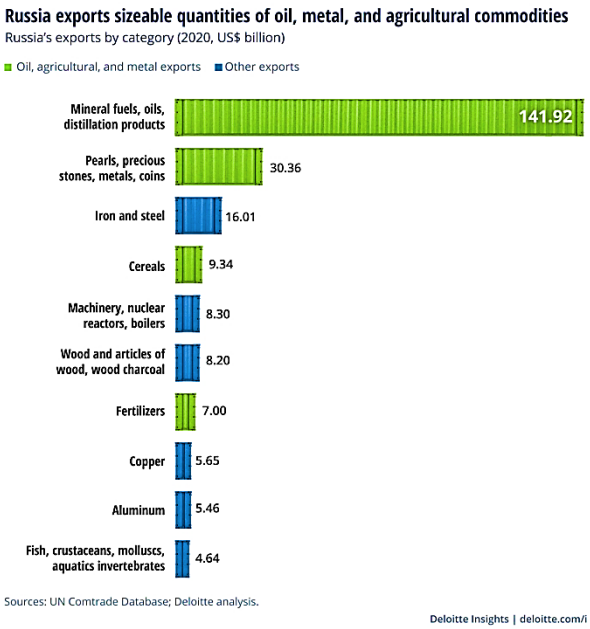
The US chiefly reduces its dependence on China by raising the cost of import of goods, from China, that are crucial to the nation, and simultaneously looking at other avenues for sourcing such goods [45]. Reasonable incentives are also being offered by the US, for organizations to shift operations from China to the US and additional export controls have also been implemented to prevent Chinese companies from acquiring US Intellectual property (IP) [48]. China meanwhile, continues to pursue its objective of moving production of critical components in-house thus reducing its dependence on foreign manufacturers and also prevent the USA from exerting greater control in the future and digitization and robotics is playing as large part in [49]. As manufacturing capability is enhanced locally, China is also sourcing critical inputs from other countries instead of USA as a stop gap arrangement [48]. China's association with other nations is also undergoing a significant change and a large amount of value is in the danger of being jeopardized depending on the level of engagement with China which makes it imperative for businesses to adjust their operations and supply chains [50].

US-China relationship has become more and more volatile leading to complications in key investment decisions leading to an ambiguous and unstable policy environment. This has been aggravated further by the onset of the global pandemic [51]. However, the assumptions and notions supporting the working principle of supply chains is based on comparative advantage which still remains very powerful. Competitive advantage is determined by the capacity of a country to manufacture certain products and provide certain services at higher efficiency and at lower cost compared to its competitors. This facilitates production of high-end goods requiring greater skills and technological prowess, in the developed countries, while labor centric assembly line manufacturing activities are done in developing countries where labor is still comparatively cheaper. Protective tariffs are levied to obstruct and dissuade against this principle of free market, and providing incentives so as to achieve political rather than economic, financial or commercial interests [46].

2.3.2. Russia-Ukraine conflict

In the post-COVID era, the Russia-Ukraine conflict poses major and immediate risk of affecting global supply chains should it escalate to a global level. It is argued that the economic sanctions and goods blockade against Russia has extraordinary consequences and needs to be promptly revisited since this is a tool of economic pressure during times of hostilities [52]

Presently Russia is one of the key exporters of wheat, oil, and other important products [53].



As stated by the United Nations Food and Agriculture Organization, Ukraine and Russia together contribute to over 25% of the global wheat trade and over 60% of global trade in sunflower oil and 30% of worldwide barley exports. Russia also accounts for a significant portion of global fertilizer exports, which implies that in case of restricted access or supply shortages, global crop yields could get seriously impacted [54]

The immediate impact of the Russia-Ukraine war on the global supply chain has been the sharp increase in the prices of a number of important commodities such as food products, fertilizers and oil and gas [55]. One of the most critical susceptibilities is Europe's excessive dependence on import of crude oil and natural gas from Russia, and its reliance on both Ukraine and Russia for major agricultural commodities [54].

The world today is a global village which makes it more integrated than ever before [53] but the Ukraine was has

led to severe economic consequences for Russia. These include multilateral financial restraints, economic sanctions, and export controls on several of the key Russian economic sectors including energy, defense, transportation, technology, and banking along with personal sanctions on oligarchs and the influential select few of the country [56]. As a result of globalization, worldwide economic effects of present-day sanctions are much larger than compared to anything witnessed so far and the magnitude of such impact should urge nations to reconsider the use of sanctions as a forceful policy tool that is capable of having significant economic implications, worldwide [52].

The disruptions caused in the global supply chains have significantly pushed up freight charges, produced dearth in container supply, and decreased the availability of space in warehouses [57]. These geopolitical shocks and resultant supply chain disruptions have the potential to agitate and destabilize socio-economic and political environment of nations across the world, waning the capability of the world as a whole to tackle its key long-term challenge at the moment, climate change [58]. Upstream suppliers in Ukraine and Russia have already started seeing disruptions in their supply chains, which in turn will further deteriorate global supply chains. An overview of this comprehensive supply chain network and its prospects would thus become imperative to meet potential challenges head-on [54].

In tandem with the US-China trade stand-off and other pandemic and climate-related disruptions, we see a definitive push by Western organizations to decrease their reliance on China for not only components but also finished products. Similarly, dependence on Russia for transportation and critical raw materials is also being lessened and parallelly more regional and local sourcing strategies are being employed. Should China decide to align with Russia, in the Ukraine conflict, this would add additional impetus to these measures and further delineate Russian and Chinese dependency [57].

2.3.3. Rise of Economic Nationalism

The world started to look decidedly different once the Covid-19 pandemic began to recede. The supply shocks began emanating from China in February 2020 which were followed by demand shocks as the global economy started grappling beneath pandemic induced lockdowns, which was instrumental in exposing the weaknesses that persisted in the manufacturing and distribution strategies as also supply chains of business organizations all around the globe [60]. Momentary restrictions on national and international trade and short-term shortages of several critical commodities such as pharmaceutical products and medical supplies, all the more underscored their vulnerabilities [61]. Along with these developments, the trade war between the U.S. and China, have stoked the fire of ‘economic nationalism’ [62].

The term economic nationalism is usually associated with government initiatives at encouraging the countrymen to ‘buy local’ or announcing any brazen ingenuity that works in favor of internal markets, manufacturers, or labors [63]. The most prevalent belief is that the ideology of nationalism must be opposed in no uncertain terms and the same treatment would need to be accorded to the related economic policies [64]. It is very evident that the rise of economic nationalism would challenge the custom of economic liberalism – what is called Globalization, and would dissuade cooperation, both political and economic, amongst countries. This rise of economic nationalism also pressurizes and jeopardizes rule-based trading which has been advocated by the USA since World War II [63].

The Covid-19 upheaval and the chaos in its aftermath has left us with many such examples. Emmanuel Macron has been pigeonholed as a nationalist for expressing his opinion in favor of the French dealing only in local goods [65]. In a similar manner, Germany were also being associated with the nationalism tag for creating a bailout funds that can help the struggling local firms during the pandemic and ensuing lockdowns [66]. The US is also being roped into this group; President Joe Biden while announcing the ‘American Rescue Plan’ was observed by liberals as having similarities to the economic nationalism style belonging to the Trump era from previous years which, in general, consisted of certain measures that can be broadly summarized as cancellation of a range of free trade agreements [67]. Commentators such as the economist Paul Krugman, who by and large concur with the policies implemented by Biden administration for strengthening local manufacturing, see a prolongation and persistence of economic nationalism, but this is expected to be in a more subtle manner [68].

Ramifications of this global tendency of economic nationalism has been the larger volume of political and competitive pressure on manufacturers, across the globe, to scale up domestic production, increase the level of domestic employment opportunities and diminish or even negate reliance on sources that are

understood to be undependable and uncertain [61]. These manufacturers will need to revisit their adoption and implementation of lean manufacturing policies that mostly means holding optimum amount of inventory within their international supply chains [61, 69]

3. *Post-Covid Supply Chain Management & Restructuring*

A significant change witnessed during the Covid-19 pandemic, was the restructuring of global supply chains based on geopolitical concerns rather than economic feasibility and productivity brought about by globalization [61]. This is a new and hitherto unique attempt. Various industries have seen their global supply chains evolve on the back of exclusive economic advantages offered by various countries while playing their diverse roles in a supply network. From being a raw material supplier, to provider of intermediate parts and components, to having the design and marketing proficiency were some of the advantages offered by each country. These advantages were exploited to the maximum by bringing together producers from various countries across the globe to maximize economic efficiencies of the supply chains, however this is now being challenged by recent geopolitical developments. Economic competence is no longer the sole driving factor for supply chains, and geopolitical concerns too are becoming major factors in the development and expansion of supply chain networks [39].

COVID-19 broke out into a world already going through major upheavals. Even before the advent of the pandemic, such was the vicissitude witnessed during these times that this period has come to be typically symbolized by uncertainty. Several concurrent changes were being witnessed in the global system. Rapidly deteriorating relations between China and the United States, a change in the patterns of global trade, an increase in false propaganda campaigns and sharp deterioration in democracy were some of the key factors influencing the European foreign policy which seemed to be shifting alarmingly and since these shifts were being brought about gradually, unswervingly, over a period of several years towards a particular direction, they can be termed as trends; design change by design [70].

Several factors including shortage of freight containers, congestion at the docks, inflation, steadily rising freight charges, and others have compelled majority of the industries to analyze their supply chains and if found necessary reorganize or restructure their supply chains and re-optimize their SCM processes. In this context, the year 2022 has assumed the position of a pivot in which greatest number of organizations have started to give attention to finding alternative and reliable procurement sources [32]. Corporates now plan to enhance resilience by bringing about physical transformations to their supply-chain trajectories [71].

A survey was conducted in February 2020 by Bank of America, that involved over three thousand companies which revealed that companies in 10 out of 12 global sectors planned to move one or more parts of their supply chains from their present existing locations [72]. Among the key reasons behind such shift, as cited by enterprises, are automation, national security and tariffs [73].

3.1. Planning Supply Chains

Assimilation of novel products, production procedures and processes, distribution and logistics are crucial for executing restructuring agendas. Integration of accounting systems and I.T. systems into the process is also necessary besides ensuring that the integration is culturally suitable for the organization and will not impede workforce coordination [74]. Supply chain plannings also factor in the cost inflation part of outsourcing products and services since this aspect has significant bearing on the pricing of the products or services produces and hence must be addressed at the time of planning and restructuring supply chain.

Planning is accompanied by monitoring. Real-time monitoring of status of the suppliers as also goods flow provides businesses superior cost control, lowers risks and makes best and more efficient use of throughput and at the same time is capable of achieving sustainability goals [75]. Planning helps to ensure lucidity in thought and transparency in action, which helps to carry out work smoothly with little or no interruptions as inept, inefficient and needless activities are reduced to the minimum or are completely eliminated.

The recent global pandemic has made it more evident that businesses across nations should develop themselves in a manner that they become better prepared to handle disruptions in the supply chain that might occur in the future, as a result of the possibility financial crises, acute weather conditions, probable terrorist activities, and imminent pandemics [76]. McKinsey Global Institute published a report recently that anticipates that on an average, companies across

the world may expect crucial disruptions in their supply chains, the ones that have a minimum duration of one month, to transpire every 3.7 years [77].

Planning helps to gain visibility. Visibility through the length and breadth of the supply chain comprises of the competence to foresee or recognize demand-supply trends, opportunities for collaborating with vendors and suppliers, changes in customer profiles and behaviors and the ways for real-time judgement and evaluation of supplier risk [75].

Business organizations are becoming increasingly conscious about the fact that it is becoming imperative for supply chains to be more elastic and agile [78]. Organizational culture, administrative tradition along with the absence of a general supply chain vision are likely to be key impediments or obstacles while handling the process of change [79]. In today's world, a highly robust network is characterized by decent visibility and the flexibility to transfer or move around its procurement, production and distribution endeavors with relatively higher ease and speed [80].

Data integration will be the key differentiator. Supply chain processes across different departments can be optimized through the use of systems that can make data sharing as well as process automation possible [81]. While improving operating efficiencies, these systems also help to provide best possible customer experience. The integrated data also helps the supply chain professionals to reach better decisions based on the precise depiction of supply chain activities across the organization.

Among these activities are procurement, production, storage and warehousing, packaging transportation, sales, marketing, product lifecycle management and finance. It is neither new nor unheard about, for companies to end up providing over-attention to serving certain customers while other, high-volume customers, are provided service that is considered less than satisfactory. In such circumstances, data integration has the capacity to help establish supply chain systems in accordance to the service level agreement reached with the customers, which means offering the highest possible value utilizing the lowest possible outlay [82].

4. Investment in Supply Chain Technologies

Most business establishments intend to rethink and modify their corporate strategies pertaining to supply chain in order to turn themselves more resilient and cooperative, having stronger and much better network involving consumers, suppliers, and other stakeholders. This will entail additional investments in supply chain technologies such as artificial intelligence (AI) and robotic process automation (RPA) but at the same time will need to avoid retrenchment of workers [75].

4.1. Digitization

The crisis created by the global pandemic has acted as a facilitator for broader digitization of the processes of end-to-end supply-chain management. A large majority of corporates have already invested significantly in digital supply-chain technologies throughout the past year and majority of them have a present investment outlay that exceeded their original budget and planning to invest even more heavily [71]. COVID-19 was instrumental in accelerating the acceptance and implementation of digital supply chains [83].

It is a common matter for companies to drastically reduce their investments in technology to a dribble at times of uncertainty and amidst challenging economic environments. However, a study of 200 senior-level supply chain executives by EY in late 2020 revealed that through the period of the COVID-19 pandemic, 92% of the participants did not stop investing in technology which speaks volumes about the worth of a digital supply chain in assisting companies to tide over disruptive influences and act faster in response to unstable and unpredictable demand and supply shocks [75].

Enterprises have been using a computer-generated model of the physical supply chain, a digital twin, that helps to generate models of what-if scenarios employing a large number of variables in supposed operating environments that can be of tremendous aid to supply chain leaders. Digital twins allow to make wise and intelligent instantaneous decisions that can help in supply chain optimization throughout regular operations and has the capacity to function as a formula for continuity planning should a crisis appear [75].

Adidas has already turned to digitalization of footwear production for accelerating the pace of reaching the market, improving customization, and augment flexibility alongside superior automation by means of its project, SPEEDFACTORY [84].

4.2. Internet of Things (IoT) & Artificial Intelligence (AI)

In the context of supply chain and logistics, employment of solutions based on AI technology entails a process in which smart machines have the capacity to perform tasks that are meant for solving problems. This is an automated process of industrial production done intelligently through judicial use of Industrial Internet of Things (IIoT), and is perfectly capable of driving a whole supply chain completely, even with no human intervention [85]. At present, supply chain businesses are competing in demand planning (an area that has been modernized by both machine learning and data analytics), inventory management on a real-time basis which is regulated by IoT and associated systems, and AI-based solution driven overall optimization of dynamic margins within the industry of supply chain [86].

Being powered by data itself, AI enlarges the data collection potential which is extremely necessary, especially now, in the aftermath of the coronavirus pandemic, when the markets across countries, products and services are facing strong fluctuations. Multinational companies' (MNC's) saw that their supply chains were not able to cope with the challenges that emerged during and following the global pandemic [87]. It has become imperative for contemporary businesses to restructure supply chains using insights generated from the data collected, in order to for risk alleviation. Restructuring efforts consist of the use of AI for automating processes and keep the businesses informed by means of predictive analytics [88]. Beyond a doubt, data collection and sharing on a real-time basis will not only enhance efficiencies but also provide better visibility across the whole supply chain, and at the same time reinforce manufacturer-supplier relationships for making wise decisions [87].

Integration of AI into the production and distribution network intricacies, or the supply chain, has an economic impact that is larger than impact of any other technology application, influencing a greater number of businesses. According to McKinsey estimates, companies are likely to receive yearly economic value in the range of $1.3trn-$2trn from AI-enabled supply chains and production. Several firms like Nike & Adidas are already using machine learning powered robots for improving their daily factory and warehouse operations [89].

The On-Road Integrated Optimization and Navigation (ORION) system of UPS, the shipping giant makes judicious use of AI – providing an efficient tool for crunching data pertaining to transportation, drivers, clienteles, and more so that the drivers can be provided real-time ideal routing information [90]. This results in substantial cost savings on account of lesser fuel usage and lower vehicle depreciation [91] saving about 100 million miles and 10 million gallons of fuel per year and further developments which are still in the process will significantly augment these results [90].

4.3. Robotics & Automation

Supply chain automation uses robotics and automation technologies as steps to reduce operational cost of products [92]. Robotic Process Automation (RPA) in Supply Chain helps in automation of processes that hitherto were carried out manually, thus reducing the scope for anomalies and errors to the minimum [93].

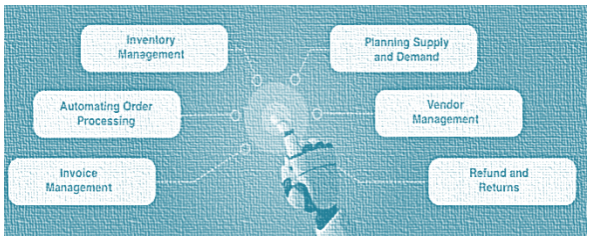


Figure 4: *Smarter Supply Chains Employing RPA*

Executable programs are installed on virtual servers that can be turned on and off based on user command or as scheduled tasks following a desired routine. RPA uses these pre-programmed robots to execute repetitive tasks through automation, thus freeing up the human work force for higher level brainstorming and problem-solving tasks. RPA can also be used to manage inventory specially to receive notification whenever the designated stock dips below the threshold limit set by the user/ organization - RPA can automatically execute the task of placing an order for the same product from a catalogue of items [94].

Both Nike and Adidas are expected to shift approximately 20% of their manufacturing to factories with higher automation by 2023 and several of them have the potential to become proprietary [95]. Nike's investment of $100,000 in Grabit's Stackit robots enables production of 300-600 pairs of shoes within a normal 8-hour shift [96, 97]. Nike's Chiba distribution center is served by goods-to-person robot series that has helped to cut costs while increasing warehousing efficiency and expediting order picking [96].

Along with reducing the requirement for outsourcing production implementation of RPA has the potential to provide businesses with the competitive advantage by

expediting the process of delivering the finished products to the end users or consumers [98]. This will also help in reducing the lead times by at least 66% in future supply chains, as a result of which products will be available more quickly [99]. Nike's decisive action to commence restructuring its supply chain using the power of digitization has already started bearing fruits as the company is able to deliver the right product to the right customer directly with higher speed even after prioritizing sustainability [100].

5. Building Inventories and Buffer Capacities

It has been argued by scholars that impacts of catastrophic events are of much higher severity compared to past years due to lower levels of inventory maintained within the supply chains [101]. Among the key indications of corporates shifting their stance from being efficient to being resilient, is the huge precautionary inventory build-up, with the largest 3,000 firms globally increasing their buffer stock to 9% of world GDP from 6% in 2016 [102].

Organizations are prompted by the necessity to develop supply chain resilience to stress on reducing their dependency on just-in-time inventory management and move over to the more flexible just-in-case inventory management which involves placing inventory buffers at specific points within the supply chain as safety stock that can be utilized at times of demand fluctuation occurring in future [103].

Buffer capacity is the least complex of the methods used to enhance supply chain resilience and agility, be it underutilized production facilities or inventory levels that exceed the stock levels required for safety [104]. Industry leaders generally use buffers that take the form of spill over or surge capacity used at the time of launching new products or developments into novel areas of growth. It is also possible for organizations to build buffer capacity by taking help of contract manufacturing deliberately to cater to their demand surges [80].

A huge issue is that buffers are costly and hence usually unsustainable, and supply chain leaders are likely to witness a hard time justifying them to the top management [103]. Additionally, the success depends on the ability to accurately estimate the carrying volume of the buffer stock, and ensuring that the stock is carried forward economically without compromising on the timeliness of catering to customers' orders [104].

6. Lessening Concentration & Dependence

With the issues of flexibility, over-reliance, resistance and buoyancy gaining higher significance so far as making decisions within global value chains is considered, a broad-based sourcing strategy and reduction in concentration levels have become essential [105]. An essential part of this strategy is reducing dependence on China by shifting to a network of non-Chinese suppliers who are dependable, thus limiting complications and obstacles associated with supply chains.

Thanks to a series of economic reforms, such as opening up of markets, introduced since 1970 and the abundance of inexpensive labor, China has turned into a global manufacturing hub [32, 106]. According to the statistics published by UNCTAD [107], China remained the world's largest exporter, contributing to approximately 15% of global trade, as of 2020 [107]. From clothing to children's toys, to electronics, to iron & steel used in civil engineering works, Chinese manufacturing leaves its imprint everywhere. All across the world physical products have some parts and component, however small that may be, which originated in China except maybe a miniscule percentage. Through such development, China has assumed the position of the second largest global economy with GDP standing at $14.72 trillion in 2020, which is contributed to more than 18% of the total global GDP [106].

The recent aggravation in the risk of supply certainty, has compelled business organizations to search sources other than China as alternatives. This is not to state that all operations in China will cease for these companies entirely. For the businesses who are scouting for an alternative inexpensive backup source, the China Plus One approach has now become a very popular approach. Southeast Asian countries other than China viz. Thailand, the Philippines, Vietnams and Singapore are being considered as top candidates who are being evaluated as potential manufacturing hubs for replacing China [32].

Food businesses such as Kellogg Co. decided to move away from distributing bulk volumes to restaurants and schools. Instead, it started catering to people working from home, especially during the lockdown, who suddenly started finding time and scope for breakfast [108] The challenge was to procure adequate material for packaging for boxes of cereals. Packaging bottleneck was created due to Korean supplier in the

area running into shortages as a consequence of delays in shipping instigated by the COVID-19 pandemic [77]. The main issue is not engendering the raw materials necessary to manufacture goods, but delivering or receiving these materials at the precise location where they are required [108]. Kellogg's procurement team had to sweep through the globe in search of an alternative source of paperboard to arrive at New Zealand where the search concluded. The higher paperboard cost witnessed in New Zealand was offset by lower cost of transportation [77].

6.1. Nearshoring

Beyond multiple sourcing, a number of companies are interested in reducing their geographic reliance on their international networks and reduce the finished products cycle times. To avoid the supply chain crisis created during the pandemic mainly due to excessive dependency on China and the absence of adequate of inadequate buffer stocks, several industries are taking up nearshoring as a method to restructure their supply chains. Nearshoring refers to manufacturers or service providers moving whole or a portion of their business to a geographical location different than its home country, generally closer to the organization's area [109]. This helps to move the manufacturing efforts closer to home thus enabling the merchandises to travel a relatively short distance for reaching their target market for sale, this abridging the supply chain and facilitating logistics [110].

Associated typically with manufacturing such as apparel, medical devices, electronics, automotive components, and pharmaceuticals, nearshoring is now being adopted by services including software and systems design, IT services and business processes [109]. In 2020 Boeing, an American aerospace company, nearshored to Mexico a part of their aircraft production, outsourcing assembly of aircraft interior to Safran, a leading supplier for the US aerospace [111]. As of 2020, for the Boeing 787 Dreamliner, Safran produces 95% of the wiring, along with finishing wiring for various aerospace firms including Airbus [112].

Despite the fact that regional or local supply chains are costlier due to addition of higher number of players and more intricacies to the ecosystem, they offer greater control of inventory moving the product nearer to the final consumer [80]. For enlarging and expediting its distribution network, Nike moved to its new local service centers across USA and Europe [100].

7. Challenges in Restructuring Supply Chain

The Covid-19 pandemic along with the Ukraine war has set off a unique re-envisioning of international boardroom capitalism and governments [113]. Rebalancing productivity and flexibility will be an extremely challenging task. More often than not, higher resilience comes at additional prices. However, the price to be paid for refraining from doing anything can be substantial and even higher [80].

Restructuring entails huge costs. In the aftermath of the COVID-19 pandemic adopting restructuring strategies such as building buffer stock and maintaining excess capacity might entail prohibitory investment outlays. This will also put a question mark on the sustainability of the products. The resources committed will also have to be justified to keep the stakeholders satisfied. In case of outsourcing, quality control and the cost inflation are two important challenges that have to be constantly taken into consideration.

At the global level, the challenges of supply chain restructuring take a different form. It is necessary for governments and corporates to keep in mind that diversification is the key to resilience, not concentration at home. The autocracies around choke-points control just about 10% of the volume of global trade, depending upon how much share of the export market they command, which has to be at least one-tenth, and whether easily obtainable close substitutes exist for their products [102].

However, a reasonable pursuit of security can be potentially dangerous due to high possibility of being morphed into widespread protectionism, jobs conspiracies and huge amounts being spent on subsidizing industries [114]. The near-term consequence of this would be higher volatility and disintegration pushing prices even higher as is evident from US President Joe Biden's contemplation regarding new tariffs to be levied on solar panels, that had to be paused due to shortages. The long-run consequences of wastefulness arising from indiscriminately imitating supply chains would be huge. Trying to duplicate 25% of all multinational activity would entail the additional yearly operating and financial expenses that could exceed 2% of global GDP [102].

8. Conclusion & Recommendation

Supply chain restructuring is the need of the hour. Diversification of the supply chain is a continuous trend and the key strategy to reduce dependency on conventional resources, procurement sources and operational locations. It is evident from the recent supply chain crisis that resilience is essential along with the ability to respond quickly to external shocks which can be built through measurers such as buffer stocks and capacities. Planning can offer some amount of preparedness but global shocks like the COVID-19 pandemic demand maintaining minimum human intervention to ensure that production and distribution doesn't come to a standstill – hence the need for applying RPA. However, all these come at a significant cost. For small businesses such costs may be prohibitive. Digital transformation is necessary for sustainability. Government needs to play a positive role in this transition. Government policies that incentivize digitization and restructuring of supply chain ca come to the rescue. Offering inexpensive loans and financial subsidies can be tremendously helpful.

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