

## SUPPLY CHAIN RESILIENCY, EFFICIENCY, AND VISIBILITY IN THE POST PANDEMIC ERA

**Dr. Uma Shankar**

Professor, Catholic University in Erbil, Iraq, Email id: [uskapila@gmail.com](mailto:uskapila@gmail.com)

### **Abstract**

People rely upon supply chains to carry essential necessities like food and medicine. Any breakdown of these conveyance pipelines rapidly undermines human existence. During a health-related crisis, store network execution can be the contrast between life and demise. For instance, clinical salvage helicopters can save lives by rapidly shipping mishap casualties to emergency clinics for crisis clinical treatment. During this pandemic when there was a deficiency of medicines, oxygen, and gear important for treatment it opened up to the patients because of amazing inventory network execution. Organizations can foster strength by expanding excess, building adaptability, and changing the corporate culture. Hypothetically, a versatile undertaking can be worked by making redundancies all through the store network. Organizations with resilient supply chains are ready to oversee change to their production network and tasks. They can flex and adjust rapidly to advancing examples of market interest. They utilize progressed information science to foresee disturbance and respond with certainty, at speed.

**Keywords:** Supply chain resilience, Maturity model, Artificial intelligence, Threat analysis, and Multi sourcing.

### **Introduction**

It is notable that supply chain management is a fundamental piece of most organizations and is vital for organization achievement and consumer loyalty [1]. Clients anticipate that the right products should be followed through on schedule [2]. Consumer loyalty lessens if items are conveyed late. Retailers rely upon supply chains to rapidly convey costly items to try not to hold expensive inventories in stores and it assists with diminishing buy costs [3-9]. Manufacturers rely upon supply chains to dependably convey materials to get together plants to stay away from material deficiencies that would close creation [10-18]. Effective inventory anchors empower a firm to be more serious in the commercial centre. Regardless of whether managing everyday item streams or managing a startling cataclysmic event, inventory network specialists focus on and get going [19-28]. They analyse issues, innovatively work around disturbances, and sort out some way to move fundamental items to individuals deprived as effectively as could be expected [29-38]. When there is a problem in supply chain management it affects human life. Calculated disappointment can rapidly bring about danger to human existence [39-48]. In 1998 in the East Coast ice storm electrical cables fell bringing about no power for 3,200,000 Montreal, Quebec inhabitants. 30 people passed away and 25% of all Quebec inhabitants ventured out from their homes to look for warm sanctuary. Likewise, monetary expenses included \$3 billion in lost business, \$1 billion in home harm, and \$1 billion in government consumption [49-51].

Transportation represents 30% of world energy use and 95% of worldwide oil utilization [52-55]. As planners of the organization, supply chain experts have the part of creating energy-proficient

stock chains that utilize fewer assets [56-59]. Modern bundling strategies, best-in-class reconnaissance cameras, worldwide situating frameworks, and radio-recurrence ID (RFID) stock following are a portion of the techniques used to stop fear mongers from getting to these indispensable coordination frameworks [60-67]. A supply chain management executive can improve the effectiveness of plants, stockrooms, and transportation vehicles. Income is straightforwardly expanded on the grounds that the conveyance of an item is in convenient way, and customers can buy their products [68-78]. With the development of contest in the current market situation, a proficient supply chain can give a business the edge that it needs [79-88].

### **Background**

Supply chains are encountering outrageous vulnerability, the Coronavirus infection impacts the accessibility of crude materials and items, growing assembling and conveyance time spans, and depleting stock cradles [89-95]. This interruption and turmoil uncovered organizations, governments, and shoppers to extortion and control. We see a critical ascent in the pervasiveness of fake clinical hardware and different items while conventional review estimates break down [96-101]. These, in any case, are indications of the difficulties that cutting-edge supply chains face today. Currently, this mind-boggling web of worldwide providers, contract producers, and outsider strategic accomplices is being tried as far as possible. While streamlined to react to typical elements, the current well-being emergency has clarified that we need more permeability than at any other time. The thought of needing to know where things are coming from and how things are made is a pattern that we see across businesses. Buyers are progressively worried about where their items come from - regardless of whether it's morally sourced espresso beans or bona fide drug medications and clinical gadgets.

We have seen on a worldwide scale the significance of supply chain permeability and flexibility. As organizations conform to the new typical, they should figure out how to explore quick-changing and dark inventory chains. They should have the option to adjust and react quicker to the inventory network elements. Having apparatuses and capacities to work proficiently in ordinary occasions just as adequately react and oversee interruptions in the event of any future emergencies is fundamental. To construct more strength, associations, all things considered, should hope to carry out new innovations like blockchain and incline toward their cloud accomplices and arrangement suppliers to help direct them through this excursion. The requirement for versatility has never been more prominent, and trust is the establishment. We need to work together across the inventory network biological system to assemble a reality where trust is natural in each part and product.

Without full control of the production network, manufacturers can confront significant dangers, they will be unable to meet severe guidelines, and thus, purchasers might be devouring food that doesn't coordinate with their own inclinations. It is more regrettable; to make them wiped out because of sullied fixings. Trend-setting innovations can assist with guaranteeing consistency across the store network organization, and in situations where quality issues emerge, have the option to proficiently execute item reviews. A clinical gadget producer works with another provider for one of the parts utilized in their gadget, they need to confide in the adequacy of that provider's item and guarantee that it satisfies quality guidelines and certificates.

The advancement in technology makes it simpler to build up recognisability, in any event, when there's no single wellspring of possession in the production network. The blockchain makers can approve and validate an item's starting point, which assists with fulfilling buyer needs for sourcing, addresses consistency needs, and expand trust. Collectively advanced stages help work between organization business measures just as give important data to the end clients in a simple to devour the way, for example, through versatile applications. Collaborative computerized stages are ideal to record the full chain of guardianship and other recognisability data important to guarantee quality and credibility and eventually alleviate vacation and security chances. They made it simpler for local new merchants and little and medium-sized providers.

The latest technology in the mechanical, clinical, and high innovation areas can help meet the consistence prerequisites and security needs. Guaranteeing that all parts and items that move through the supply chain satisfy those prerequisites needs a powerful and dexterous technique to safely confirm the uprightness of the actual parts and their related information. Synergistic stages can be utilized to guarantee that supply chain information can't be controlled or adjusted. Confirmation of the actual products and guaranteeing that supply chain information indeed is planned onto the genuine parts and is imparted to approve partners are key elements of an extensive arrangement.

With the virus still a live danger and various locales and economies in lockdown, while others arise into an altogether different world, the interruption to the supply chain keeps on being serious. As economies restart, the supply chain will be basic to providing labour and products rapidly, securely, and safely. Business pioneers should settle on fast choices, and make prompt moves to support business activities to serve their clients, customers, and networks, just as ensure and backing their workers. The repurposed and reshaped supply chains of things to come should be portrayed by both resilience and responsibility. These will assist networks with dealing with the transient emergency and empower organizations to work around their clients and help economies bounce back. Coronavirus is definitely not a run-of-the-mill hazard occasion. The size of its effect shrouds anything most production network pioneers will have seen previously. The speed of the heightening requires consistent start-to-finish appraisal, improvement, and observation.

### **Issues faced**

The size of its effect shrouds anything most supply chain pioneers will have seen previously. The speed of the heightening requires persistent start-to-finish evaluation, advancement, and observation. Distinguish the items that are generally basic for adjustment and development, shore up the related Supply chain, and accommodate basic abilities to meet close-to-term and future interests. Keep the trust of labour force by tending to their actual security yet in addition, their psychological prosperity and need to remain associated with collaborators. Settle on quick and exact choices on the capital speculation and exertion needed to redeploy underutilized resources or fabricate more prominent adaptability in current resources, for the time being, guaranteeing those choices don't restrain future development.

Supply chain hazards created problems like shortage of labour force requirements, material deficiencies, and liquidity problems, because of the slicing of production and future forecasts. The COVID-19 pandemic has exposed the long-standing weaknesses and dangers prowling in the company's supply chains. Sometimes, it has made organizations truly investigate their cycles and their plans of action. It has given the prospect for advancement, development, and the upper hand in the post-pandemic world. Generally, it has shown the force of interconnected, digital supply networks to empower associations to expect, sense, and react to unforeseen changes and limit their influences.

Table- Challenges across the supply chain during the Pandemic

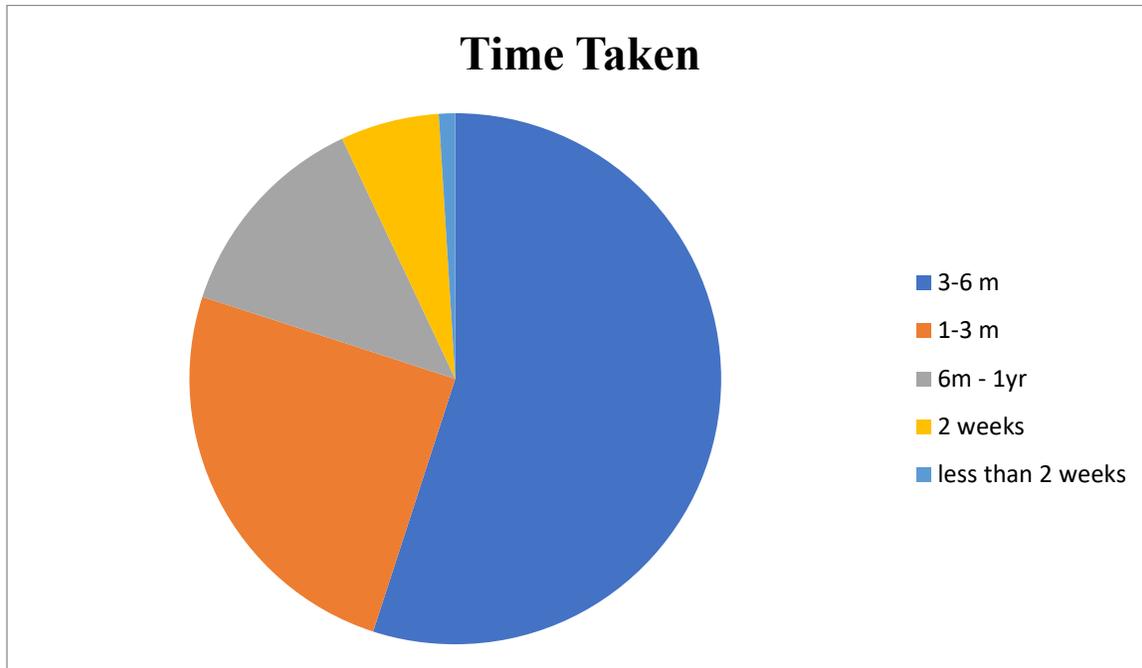
Planning	Sourcing	Production	Distribution	Sales
Difficulties in supply plan- lack information -69%	Shortage of materials-74%	Difficulties in rapidly scaling production-69%	Difficulties in balancing stock between warehouses-69%	Difficulties in switching to online channels-71%
Difficulties in demand planning due to lack of data- 68%	Delayed shipments – 74%	Difficulties in reconfiguring production lines-68%	Difficulties with products being held up in ports-68%	Lost sales due to stock outs -60%
Difficulties in end-to-end monitoring of supply chain - 72%	Difficulties in scaling workforce- 69%	Difficulties in controlling costs- 68%	Difficulties in maintaining healthy and safe working condition-60%	

Source: Capgemini Research Institute

The above table shows the high level of problems and challenges faced by organizations in each area. The sourcing of materials was affected much.

In a new worldwide overview, college students and Gen Z customers said that they will put forth an exceptional attempt to help organizations, more modest neighbourhood dealers after the pandemic, and they will not stop for a second to keep away from organizations whose expressed and rehearsed values don't coordinate with their own qualities. Further, a recent report by the Manufacturer's Alliance for Productivity and Innovation tracked down that 74% of makers anticipated that investigating environmental, social, and governance (ESG) objectives would become table stakes as ahead of schedule as within a year. Organizations' capacity to give confirmation of execution against these responsibilities may turn into a necessity. This would support the requirement for straightforwardness and reclassify the importance of trust and supportability in a supply chain.

**Figure - Organizations struggle to recover from supply chain disruptions**



It is observed from the above pie chart that 55 percentages of organizations took 3 to 6 months' time to recover from supply chain disruptions, 25 % of organizations took 1 to 3 months' time to recover from supply chain disruptions, 13% of organizations took 6 m to 1 yr time to recover from supply chain disruptions, 6 % organizations took 2 weeks to less than a months' time to recover from supply chain disruptions and 1 % organizations took less than 2 weeks' time to recover from supply chain disruptions. 68% of Organizations have taken more than three months to recover from supply chain disruptions caused by COVID-19

Not many organizations will be resistant to these movements. In reality, these assumptions are probably going to stretch out past business-to-purchaser organizations to incorporate the business-to-business world. While there will probably consistently be a few contrasts between how the two spaces work, research proposes that B2B clients will progressively expect a better business experience associated than the one they get in their own lives. Examples incorporate customized item/administration contributions, self-administration request entries, consistent request handling, charging shipment following, and no-bother returns.

Everything any supply chain association can manage or potentially trust for is to quickly and coherently bunch and refocus. This is fundamental to evaluate, decide, and act, to situate the firm to help, convey, and work together. This will guarantee that the impending impacts of the pandemic are overseen inside the current limit while rapidly fabricating short-term limits and capacity.

In India in the midst of reports of deficiency of oxygen supply for Covid-19 patients across a few expresses, the Indian Railways is good to go to work 'Oxygen Express' trains for the vehicle of fluid clinical oxygen and oxygen chambers. The Government has excluded all highway development of oxygen tankers from the enlistment of grants to empower simpler development. PM was educated that States and carriers have been approached to guarantee tankers move nonstop with drivers working

in movements to guarantee quicker turnaround and satisfactory ability to fulfill the flood in need. The Centre has likewise permitted modern chambers to be utilized for clinical oxygen after due cleansing. Nitrogen and argon tankers will be consequently permitted to be changed over to oxygen tankers to defeat the expected deficiency of tankers.

The Indian Railways has been one of the vital supporters of the country's battle against the COVID-19 emergency. The remarkable flood in Corona infections contaminations has squeezed India's medical care framework abandoning a great many patients for emergency clinic beds, prescriptions, and most life-saving oxygen. The continuous and opportune stock of clinical oxygen is pivotal to forestalling COVID-19 passing because of the lack. Rail lines have moved almost 490 tons of oxygen across 6 states and 10 urban communities within 10 days. 4,000 COVID care mentors with 64,000 beds have been situated at different railroad stations of which, some have been recently utilized for the detachment of patients during the main rush of the pandemic. These mentors altered for Covid patients have been partitioned into eight straights or 'lodges' with each having 16 beds. 200 mentors are being utilized by states and urban areas to concede reasonably indicative Corona infection patients.

### **Supply chain risk**

Supply chains are viewed as the organization of associations required through linkages to perform various exercises that makes it worth to the end customers as goods and services. Supply chains are sorted into (i) effective inventory chains (ii) hazard-supporting supply chains (iii) reactive supply chains (iv) alert supply chains. Risks are frequently deciphered as inconsistent and questionable assets making inventory chain interferences while vulnerabilities are identified with organic market confounds in supply chain measures. The result of the risk and assumption for its sources are the key determinants of it. On the off chance that the result of an occasion isn't sure and the most pessimistic scenarios are known, it's anything but risk and surprisingly the most pessimistic scenarios are not realized it becomes a vulnerability. Risks are frequently deciphered as questionable and unsure assets making supply chain interferences while vulnerabilities are identified with organic market confounds in production network measures.

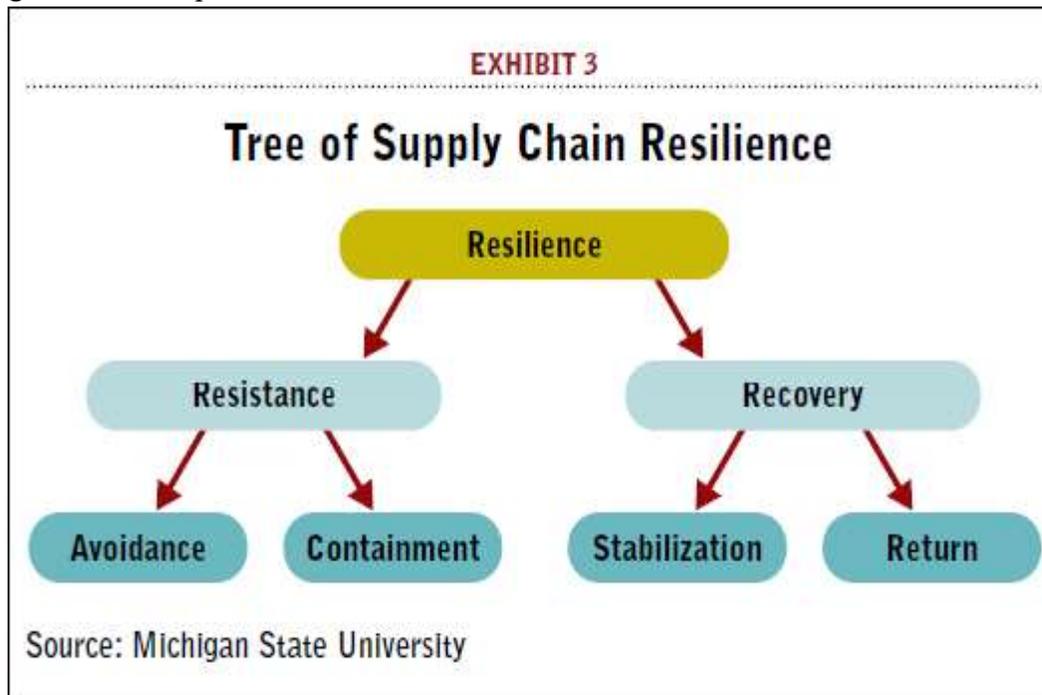
Supply chain hazard can be viewed as the impression of the specific arrangement of undesirable and unwanted results happening that influence the capacity of the supply chain to convey qualities to the client adequately and proficiently. Supply chain hazards fall into four significant classifications, for example, (I) supply hazards (ii) operational danger (iii) demand risk, and (iv) security hazards. Supply chances identify with any unfavourable occasion in the inbound supply causing disappointments from providers or the inventory market coming about in the failure of the central firm to satisfy the need inside the expected cost or time. Operation risk represents the chance of any unfavourable occasion influencing the inward capacity of the firm to create labour and products, keep up quality and timetables of creation, or the productivity of the organization. Operation risk is the dispersion of results identified with unfavourable occasions inside the firm influencing the inward capacity of the firm to create labour and products and to earn profit.

Demand risk is the probability of the event of any antagonistic occasion in the outbound streams influencing the number of client orders, fluctuations in volume, and variety of item levels by the clients. Dangers of demand risk may change from postponed or unseemly new item presentations,

varieties sought after, and disorder in the framework. Security hazards regularly happen from an outsider party who wishes to take exclusive information or information and disturb the activities of the firm. The sources incorporate people inside the firm spilling data to contenders, framework programmers, and ill-advised firewalls of the supply chain. Supply chain risk management can be characterized as the recognizable proof and the board of dangers inside and outside the store network through an organized methodology among the individuals from the supply chain to diminish the general weaknesses.

### Supply chain resilience

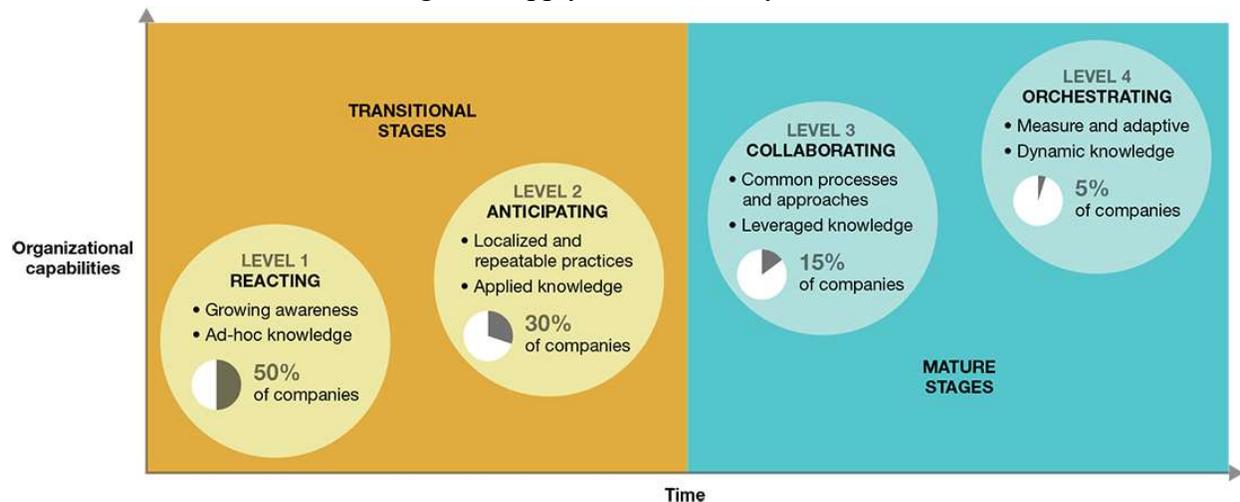
Dangers happen in the supply chain because of catastrophic events, mishaps, and Covid 19 which influenced worldwide stock chains, consistently contracting item lifecycles, and unstable and erratic business sectors. But since the numbers and kinds of dangers that can subvert the supply chain are currently more prominent than at any other time, resilience has taken on significantly more important in supply chain management. Therefore, pioneers in the control have attempted to all the more likely comprehend what makes a specific venture versatile, and consequently, there is a blossoming collection of information from which different organizations remain to profit. Store network strength no longer infers simply the capacity to oversee hazards. Supply chain resilience is the capacity to oversee hazards implies being preferred situated over contenders to manage and even increase advantage from interruptions.



Organisations like to have a high limit with respect to both resistance and recovery, but they have a blend of these characteristics. Specifically, given asset imperatives and serious components, firms may have to pick where it is best for them to contribute restricted assets. Supply chains showing low capacities with regard to both resistance and recovery would have low resistance. They would encounter disturbances to recover because of an absence of capacity to recover successfully. These supply chains are termed as fragile as opposed to delicate supply chains with low resistance; those

that show significant degrees of resistance can mitigate potential dangers all the more without any problem. At the point when they likewise have the limit with respect to viable recovery, they rapidly bounce back from those occasions that are unavoidable. Ex: GM motors supply chains are delegated as hardy. When interruptions got unavoidable, GM was sufficiently powerful to rapidly work through them and recover. The other centre position is portrayed by supply chains that display low resistance from troublesome occasions but rapidly conquer their effect. These supply chains are named as vulnerable but responsive. They have the ability to rapidly recover. Ex: Clothing producer/retailer Zara (6). The four stages of resilience are avoidance, containment, stabilization, and return. Nissan recovered and restarted operations and reclaimed lost market share more rapidly than Toyota. Nissan was able to attain this by accessing substitute suppliers, while Toyota remained with prevailing suppliers.

Figure- Supply chain Maturity model



Source: Gartner

As indicated by Gartner, at present, 80% percent of associations are at level 1 and level 2. Its supply chain development moves from a receptive mode to one that is proactive. Simultaneously, the store network moves from conditional to synergistic. Supply chain advances from siloed activities that work independently and at the time against one another to one that is coordinated, where tasks consequently stream starting with one activity and then onto the next in a consistent and liquid way. The steps the organization has to take to maintain a resilient and agile state are:

**End-to-end visibility:**

It is the capacity to have the option to track and follow material from the time it is requested to the time it is burned through, utilized, sold, and conveyed to the client or opposite end-client, from Tier 1 provider through Tier 1 client. Straightforwardness is an essential piece of start-to-finish perceivability.

**Unified Supply chain with Artificial intelligence:**

The framework should be completely coordinated, in such a way, that updates and changes can be reflected in totally influenced systems. Central to the framework is a production network execution framework with Artificial Intelligence ability, permitting the framework to settle on numerous

standard choices that are typically the work of people. Legitimate arranging, booking, acquisition of stock, and warehouse management are required.

**Constant development:**

Enhancements come in two structures, steady and leap forward. Gradual upgrades happen in little advances that form toward progress gradually. These upgrades are typically minimal expense and generally safe arrangements that are executed by representatives. A minimal-expense inventory network conveys worth to the association, its providers, and to its clients. Interaction enhancements additionally sway dexterity since they demonstrate an association's capacity to change rapidly and viably. Cost and process duration decrease utilized with measure improvement guarantee an association's capacity to get by in down cycles and flourish in up cycles. The most mainstream approaches utilized for consistent advancement programs are Lean/Six Sigma.

**Plan demand:**

Supply chain's motivation is to be the conductor for supply to fulfil needs, which is unsure. It's produced by clients. To decrease vulnerability, associations foster estimates, foreseeing future interest dependent on previous outcomes, current data sources, and patterns. Gauges are typically created utilizing refined PC programming. They additionally may not refresh their conjectures on a convenient premise, which prompts estimate mistakes paying little heed to the strategy utilized. The better option is to request arranging. Plans have the responsibility, estimates don't. Plans can proactively change as circumstances and markets change. Gauges, while inconsistent, is responsive in light of the fact that they are typically not changed until after the blunders happen and the harm has been finished.

**Subdivision of suppliers:**

The division is utilized to foster a general administration procedure. Supplier and client management incorporates creating fitting measurements, conveying those measurements, creating connections, making positive correspondence, and creating trust. At the point when suppliers and customers are appropriately overseen, both great and terrible news can be imparted in a positive and valuable manner and projects like collective arranging, anticipating and renewal, joint endeavours, shared new item plans, and cost investment funds developments are conceivable.

**Improve supply chain threat analysis:**

Numerous firms work in various supply chains. Each association needs a solitary supply chain hazard management strategy with the goal that the interests of the many exceed the interests of the trivial few. In the absence of such an arrangement, specialty units will consistently work from a place of personal responsibility, advancing danger inside their own range of command over the requirements of the whole association. The supply chain impacts the whole association, so fostering a solitary supply chain hazard in the management plan that applies to the whole association will profit everybody. Organizations can protect against such risks by taking insurance or by subscribing to third-party services to accept such risks as credit.

Making a straightforward perspective on a multitier Supply chain starts with deciding the basic parts of the tasks. The risk index for each bill of Materials item, in view of the uniqueness and area of providers, will help recognize those parts at the most noteworthy risk. Organizations would then

be able to evaluate the risk of a break from level two and forward providers. This phase of preparation ought to incorporate posing direct inquiries of level one associations about who and where their providers are and making data sharing arrangements to decide any interruption being looked at in level two and past associations. Producers ought to draw in the entirety of their providers, across all levels, to shape a progression of joint arrangements to screen lead times and stock levels as an early-notice framework for interference and set up a recuperation plan for basic providers by item. In the event that elective providers are inaccessible, organizations can work intimately with influenced level-one associations to address the risk cooperatively. Understanding the particular openness across the multitier supply chain ought to take into account a quick restart after the emergency.

### The changeover from Acquiring to Procurement and Collaboration

Associations using acquisition measures experience much preferable provider relations over the individuals who depend on conditional buying procedures. Obtainment experts foster associations with providers. All suppliers are treated with differences. Acquirement includes sourcing a thing or administration. Sourcing is the way toward qualifying reasonable providers of a thing, qualifying them, and working with them to get the best worth. The buying cycle is tied in with fostering an item or administration determination, setting up a Request for Proposal, offering the solicitation, and arranging a cost. Buying is tied in with purchasing a thing or administration; procurement is tied in with fostering a relationship with a certified and dependable provider.

### Implement Sales and Operations Planning:

It is the way toward adjusting demand and supply by giving the association one adaptation of reality as a solitary working arrangement for a particular time frame period, normally one month. A more drawn-out term plan of normally a year and a half to two years is grown all the while and set on a moving timetable. The length of the timetable is eventually controlled by the estimated thing with the longest lead time. This timetable diagrams the future necessities alongside the Sales advisory group's assurance of how best to fulfill requests dependent on limit and framework requirements. In this cycle, information is accumulated, based on which demand and supply are arranged, lastly meeting is directed to take a choice

### **Investment to overcome resilience**

Investment for discovery, information, designing, buffer, security, preparedness, and for operating flexibility has to be made as alternative investments during resilience and check their impact avoidance, containment, stabilization and return. Firms have to identify the problems in the supply chain and invest in forecasting, monitoring the performance of the supply chain, and demand detection. They must also invest in effective communication that improves the information flow quickly in the supply chain. Design supply chains that can be configured quickly with the changes in the environment. Organizations must have excess stock, operating capacity and safety lead time so that they can manage when a shortage arises. Change product specifications and arrange for alternate transportation during supply chain problems. Firms arrange for strengthened physical

systems to avoid theft and damage of stock. Plan for contingencies and offer proper training to employees as to what their responsibilities are, during supply chain problems. Organizations must also invest to sustain goodwill during supply chain problems by maintaining customer and supplier loyalty by maintaining good rapport with them.

Indirect investment to maintain brand value and client steadfastness can likewise affect resilience. While these ventures are not cantered straight on improving the resilience of supply chain frameworks, they offer abilities that the firm can attract to manage unforeseen breakdowns in its systems. Indirect interests in brand value and associations with clients empowered Proctor and Gamble to recuperate from creation issues when it presented its Tide Pods item.

**EXHIBIT 6**

**Alternative Investments in Resilience and Their Impact on Avoidance, Containment, Stabilization, and Return**

Strategies	Avoidance	Containment	Stabilization	Return
Indirect Investment	0	++	0	0
Discovery	++	0	0	0
Information	++	+	+	+
Supply Chain Design	+	++	++	+
Buffers	+	++	++	0
Operating Flexibility	0	++	++	++
Security	++	++	0	0
Preparedness	++	++	++	++

Source: Michigan State University

From the above table, it is understood that the strength of the impact is indicated by the greenness of the shading - a moderate impact is denoted by + and yellow shading; a strong impact is denoted by ++ and green shading

When the impending risk to the production network has been recognized, pioneers should then plan a strong supply chain for what's to come. More grounded provider coordinated effort can in like manner build up a whole provider environment for more prominent resilience. Digitizing the supply chain improves the speed, precision, and adaptability of supply risk management. Associations should construct monetary models that size the effect of different stun situations and choose how much insurance to purchase through the relief of explicit holes, for example, by setting up double stock sources or migrating creation. The logical underpinnings of this danger examination are surely known in different areas, like the monetary area right now is an ideal opportunity to apply them to supply chains. As the Covid pandemic dies down, the errands will

fixate on improving and fortifying inventory network abilities to get ready for the unavoidable next stun. By acting deliberately throughout the following while, organizations and governments can raise out of this emergency more ready for the following one.

### **Controversies**

The pandemic has uncovered one of the critical shortcomings of some minimal-expense supply chains, the failure to respond to unexpected huge-scope interruptions, particularly in medical care, life sciences, and food ventures. China has been building its assembling framework throughout the previous 40 years, they have established government appropriations, which minimize expenses, which numerous US makers won't rival. The most ideal approach to guarantee a strong supply chain is, to begin with, an investigation of your most significant items. What is most significant is to have a reasonable comprehension of where the supply chain is powerless and begin making moderating moves. A few activities incorporate having stock inclusion in different phases of work in measure close shore or on-shore, having various causes of supply, having gear, and changing parts that can be effectively sent to other creation resources or destinations.

In the present progressively unique world, the supply chain assumes an undeniably more significant part, various occasions happen that take steps to disturb activities and endanger the capacity to perform viably and effectively. These occasions incorporate normal and man-made catastrophes like gear disappointments, pandemics like COVID-19, work questions, political shakiness, and psychological oppressor attacks. Such disturbances did not just influence production network tasks; they bring about monetary harm past the prompt operational effects. Resilience occurs by plan and not unintentionally. It requires a limit with respect to resistance and recovery. Resistance characterizes the production network's capacity to defer a disturbance and decrease the effect once the interruption happens. Recovery characterizes the supply chain's capacity to recuperate from an interruption.

Resilience is a capacity that should fit the particular requirements of each firm. Resilience is a receptive ability that happens after a shock has occurred. Others consider versatility to be more proactive endeavours toward assisting the firm with setting up a disturbance. Considering these different perceptions, it isn't astonishing that there is disarray encompassing this key concept. Resistance limit is the capacity of a framework to limit the effect of an interruption by dodging it totally or by limiting the time between the disturbance beginning and the beginning of recovery from that interruption. The recovery limit is the capacity of a framework to get back to usefulness once an interruption has happened. The cycle of framework recovery is portrayed by an adjustment stage after which a re-visitation of a consistent condition of execution can be sought after. The last accomplished consistent state execution might reacquire unique execution levels, and is reliant upon numerous disturbance and contender factors.

### **Problems faced**

During the post-pandemic period, there is transitory exchange limitations and deficiencies of drugs, basic clinical supplies, and different items featured their shortcomings. Those turns of events joined with the U.S. - China exchange war, have set off an ascent in monetary patriotism. As a result of this, makers overall are under more noteworthy political and cutthroat pressing

factors to expand their homegrown creation, develop work in their nations of origin, decrease or even wipe out their reliance on sources that are seen as hazardous, and reconsider their utilization of lean assembling procedures that include limiting the measure of stock held in their worldwide inventory chains. Buyers will keep on needing low costs, and firms will not have the option to charge all the more since they fabricate in greater expense home business sectors. The test for organizations will be to make their supply chains stronger without debilitating their intensity.

The client is presently at the focal point of all Supply chain choices. The shortfall of coordinated and constant dynamics can bring about agonizing production network problem areas like underutilization of assets, imperfect plans, missed conveyance SLAs, and significant expense of failures, among others. The outcome disappointed clients. Unanticipated occasions are to be constantly anticipated. The size of the occasion may fluctuate, yet these occurrences have far-reaching influences on supply chains and put the focus on the requirement for granular permeability and organization plan. Brands need to have frameworks set up to respond to such occasions to diminish the effect and rapidly recuperate. Manual methods for overseeing production network activities are not, at this point reasonable. Technology answers for various pieces of the supply chain are as of now common however frequently work in silos. Give start-to-finish permeability and empower undertakings to improve their operational effectiveness by reining costs, smoothing out the client experience, and lessening the ecological effect.

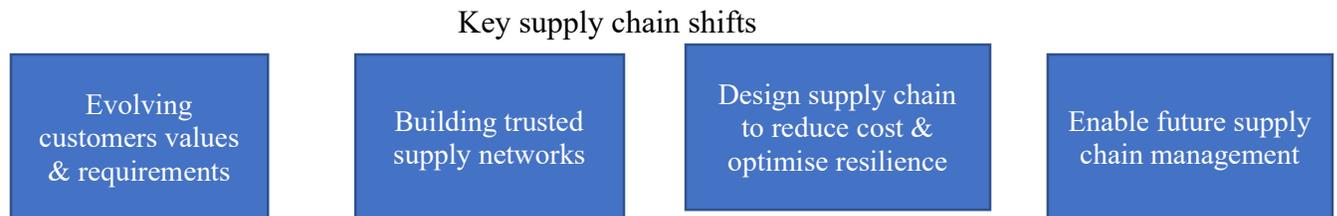
With activities in more than 25 urban areas and over 18,000 items, Big Basket selling grocery through online in India was hoping to drive down logistics costs, accomplish a significant level of consumer loyalty, and oversee tasks at scale. Locus one of the logistics planning software boosted volume use and orders per vehicle, and limited distance voyaged, guaranteeing on-time conveyance prompting improved client satisfaction.

Accenture worked with a global customer merchandise organization that had an extremely decentralized and siloed hierarchical arrangement. During COVID-19 it hit different topographies hard; obviously, the organization saw both demand and supply instability increments forcefully. It was fundamental that they keep their items streaming to the ideal spots. They understood rapidly that their decentralized siloes made quick, shrewd dynamics troublesome. To cure the circumstance, they incorporated organization information and made computerized twin abilities. This permitted the organization's production network and task pioneers to improve the dynamic at the operational hub to help with market difficulties. It's anything but a significant instrument to adjust choices across the organization. Working from information that is totally reality-based, their choices would now be able to be quicker, focused on, and incorporated.

Organizations confronted huge difficulties across the production network in the wake of the emergency. Numerous interruptions occasions were noticed like individual defensive gear and different supplies deficiencies in clinics, void racks in stores due to the absence of different food varieties and individual cleanliness items, and surprisingly electronic items not just in the actual channels but just as on the web-based shopping stages. Numerous issues identified with the production network of the board, particularly connected to sourcing procedures have caused huge disturbances in various supply chains. This incorporates the absence of the board as far as

appropriately overseeing hazards, reception of single-sourcing systems, conveyance coming up short from providers, and the absence of straightforwardness and visibility. During the COVID-19 pandemic, a worldwide review report showed how the level of reactions affected big data analytics (86%), IoT (78.7%), cloud computing (82.7 %), robotics (73.3%), added substance producing (59.3%) and blockchain (60.1%) due to interruptions in supply chain cycles and afterward on the limit of the store network reaction.

In a Supply Chain 4.0 setting, problematic advancements assume a focal part in the improvement of supply measures which may upgrade the limit of supply chains' reaction. In execution of Supply Chain 4.0's technique, it considers the administrative abilities of supporters, innovation switches, supply chain cycles' exhibition necessities, and key results. Though the problematic advancements assume the most vital part in a Supply Chain 4.0's drive, issues identified with individuals, IT foundation, initiative, coordination and undertaking the executives and vital direction are the platform to get a fruitful innovation switches execution and afterward get their advantages. Supply chain process presentation necessities may be improved as far as straightforwardness, proficiency, adaptability, responsiveness, coordinated effort, and interaction estimation. The advancement improvement of these presentations ascribes gets principal with the intention to make a more responsive supply chain, leaving it more ready to perform during unforeseen events.



Source: Deloitte analysis

### **Solutions and Recommendations**

Due to the COVID-19 illness pandemic, supply chains are confronting their most difficult stretches which have never seen. Supply chain management should be re-examined as far as its essential methodologies on looking for superior strength against abrupt occasions. In this unique circumstance, Supply Chain 4.0 methodology turns out to be an opportune and proper technique to be thought of.

Crisis management has to be planned during the pandemic situation by all partners. Diversification can be accomplished through multi-sourcing from extra suppliers, which is able to produce by procuring material from several locations. They have to plan their suppliers and instigate looking at predicting sourcing.

The ideas of Lean and Six Sigma programs should be perceived by representatives at each level. They can be prepared to distinguish openings for development and constantly improve activities, through representative commitment since workers take care of issues in groups that inspire their information and interest. Carrying out a ceaseless improvement program changes the way of life of the association to one that qualities improvement and advancement, it's anything but an outlook where change is acceptable.

Covid 19 has exhibited the requirement for supply chain resilience; the capacity to ricochet back and adjust to problematic change. Flexibility and agility are indispensable supply chain qualities that permit firms to adjust to quickly changing purchaser interests. This is especially the situation with Omni-channel retailing. A few associations adjust by executing bimodal supply chains, successfully combining two separate inventory chains into one.

Allow free communication to interchange the ideas of employees, support formal and informal learning and support failure that helps to develop end-to-end visibility.

Supply chain directors need to prepare for nimble systems that disregard strength, for example, regularly changing providers trying to limit costs yet with inadequate respect for what happens when something turns out badly.

In a lithe supply chain, provider adaptability and their responsiveness to showcase choppiness are significant. On the other hand, in a lean production network, dependability and low varieties in lead times are significant. Basically, a mix of these two can successfully oversee weaknesses. It is basic for organizations to distinguish how much danger the organization will take and how far could it be relieved. Sturdiness and resilience should be assembled in supply chains to handle awaiting vulnerabilities.

The recent developments will constrain organizations to re-examine their worldwide worth chains. These chains were moulded to augment productivity and benefits. And keeping in mind that without a moment to spare assembling might be the ideal method of creating numerous intricate items, the COVID-19 flare-up has uncovered hindrances related to a framework that requires the entirety of its part to work predictably.

There is developing mindfulness among the firms that the supply chain should be more adaptable and alert: 68% say that the emergency has constrained them to adjust their plans of action. With the breakdown of conventional business channels, organizations all throughout the planet needed to respond rapidly and dispatch new drives to arrive at their clients

Competent employees sourced by the organization to face challenges, achieve targets and oversee work priorities. Look at the exercises gained from current difficulties in the supply chain, and reconsider, improve, and change starting from the earliest stage advanced changes to make associations more dexterous and drive change

PepsiCo dispatched two direct-to-purchaser sites namely PantryShop.com and snacks.com to satisfy client needs. The sites worked from the ground up in under a month, offering customers direct admittance to a portion of Pepsi's top-selling Stock Keeping Units that helps to track the movement of inventory.

Make straightforwardness on multitier supply chains, build up a rundown of basic parts, decide the beginning of supply, and recognize elective sources.

Gauge accessible stock along the value chain—including spare parts and after-deals stock for use as a scaffold to keep creation running and empower conveyance to clients.

Business pioneers should assemble trust and take care of significant issues by tuning in and drawing in with their labour force and stakeholders. They should be authentic and run different situations while anticipating the pandemic situation. These situations incorporate technique,

money; move estimating, cross-line exchange, consistency suggestions, and possibility arranging. So remaining associated with key partners is significant, and permeability is vital.

A disturbance occasion happening anyplace in the supply chain impacts a company's capacity to proceed with tasks, give completed merchandise to business sectors, or offer basic types of assistance to clients. A vital part of viable Supply Chain Risk Management is the ongoing sharing of the right data from each and every hub in a supply chain to improve responsiveness and adaptability and make it ready to withstand likely disturbances.

The fragile position is obviously unfortunate and the hardy position of the metal ring, the presence of the middle positions requires affirmation that organizations may dwell there for two reasons. In the first place, there might be restricted assets with which to invest resources into both capabilities. Second, there might be restricted command over the climate in which the supply chain works.

Distinguish and secure coordination's limit, assessing limit and speeding up, where conceivable, and being adaptable on transportation mode, when required.

Improve production and dispersion ability to guarantee representative security, for example, by providing personal protective equipment and drawing in with correspondence groups to share contamination hazard levels and work-from-home alternatives. These means will empower pioneers to get current and projected limit levels in both the labor force and materials.

The supply chain has been influenced by COVID-19 and faced a lot of encounters like reverse logistics, which has been confronting heaps of testing issues in 2020. Dissecting blockages in reverse logistics can be through guaranteeing consumer loyalty and authoritative maintainability. Oversee money and net working capital by running pressure tests to comprehend where supply chain issues will begin to cause a monetary effect.

It is better to have a drawn-out agreement with nearby self-employed entities who can warmly greet your providers for your benefit. They are local people and can support an expert individual relationship. They will oversee them, channel down the information, and consequently help to acquire perceivability of the entire supply chain while additionally chipping away at a stronger methodology by hitting manages various suppliers around the world.

### **Future Research**

Research can be conducted to analyse how companies with a Supply Chain 4.0-driven strategy has performed amid the COVID-19 pandemic and the lessons learned from these organizations.

How do disruptive technologies impact the responsiveness and resilience of the supply chains amid potential disruption events such as the COVID-19 outbreak?

What are the most impacting disruptive technologies that create a more responsive and resilient supply chain for the emergency situations such as the coronavirus outbreak?

What is the impact of big data analytics on creating knowledge that improves the decision-making by supply chain practitioners in unexpected and disruptive events?

What is the impact of the IoT, cloud computing, artificial intelligence, additive manufacturing, robotics and augmented reality and their integration on the improvement of supply chain processes' performance amid the changes occurred by an impacting and sudden event such as the COVID-19 pandemic?

What are the influence of blockchain technology and its improvement on traceability and security to the supply chain's responsiveness amid events of COVID-19 magnitude?

### **Conclusion**

COVID-19 has shown us that supply chains need to change. Associations have planned supply chains so that material is sourced from minimal-expense nations, the stock is limited at each and every point, and providers are pressed, all to beat quarterly projections. But COVID - 19 has brought such dangerous results, that it shut down the entire world. Unmistakably, the current plan was not capable. The innovation is there. The issue is that most associations have it in reverse, as they put things in the wrong order. They have not astutely utilized the instruments that they when all is said and done, created. They put benefits in front of individuals. As production network experts entrusted with putting our supply chains back together, we need to follow the means organized appropriately. We need to put resources into technology, process, and organizational culture that put individuals and the benefit of our planet in front of investors. It is the solitary way for customers, representatives, communities, and investors would be able to flourish.

Resilience approaches adaptability, and adaptability is a character struggle with cost-effectiveness. Supervising is very tedious, also cash-sapping. By and by, it has been basic practice for organizations to send their administrators across the globe routinely to keep up provider connections, acquire data, and along these lines bring visibility. It is expensive; however, it is additionally inconsistent, and the COVID-19 pandemic has proved it. The Covid19 pandemic has taught a lesson about strengthening the supply chain. An SME organization looks for more available provider choices to fight the legislature's calls for re-shoring. Notwithstanding, setting up a relationship with another provider is difficult to work, and it requires significant investment. In this way, irregularities happen. So, the organization should seriously think about innovation for computerization and better control of their seaward activities.

In the pre-COVID-19 era, many firms adopted the offshoring strategy and set up production plants with necessary logistic support in developing countries to minimize production costs. However, COVID-19 shows that during a pandemic it is harder to transport products from various locations. Therefore, even if companies decide to outsource products from overseas, they will still need to strike a balance between domestic production and international trade to reduce vulnerability during a pandemic it is more earnest to ship items from different areas. Accordingly, regardless of whether organizations choose to rethink items from abroad, they will in any case have to find some kind of harmony between homegrown creation and global exchange to lessen weakness. Consumers purchased through online channels less than 25% before the pandemic, but now it increased to 160% globally.

The prevalence and prerequisites of mobile services have expanded considerably, with buyers presently liking to get services at their doorstep. Firms should now utilize home conveyance, online deals, and mobile services; and by a similar token, digitalization and the utilization of information technology are needed to screen the supply chain to diminish the effects of interruption. A few problematic innovations, for example, cloud computing, 3-D printing, Internet of Things, artificial intelligence, and big data analytics are proposed in such a manner. Social

distancing measures encourage a predetermined number of representatives can work in the industrial facility. To support the production capacity limit in spite of restricted staff, specialists have recommended computerizing the creation framework to such an extent that it can work with less human intercession. It is suggested that organizations create and carry out contactless instalment frameworks, particularly at the retail location level. For instance, while an organization re-shores its creation office, it might have to discover and fabricate associations with new providers to guarantee locational vicinity. Improved supply chain connections and coordinated efforts can likewise protect organizations from adverse consequences, taking into consideration speedy recuperation just as groundwork for future occasions.

## References

1. [Amelie Meyer](#), [Wiebke Walter](#), and [Stefan Seuring](#) - The Impact of the Coronavirus Pandemic on Supply Chains and Their Sustainability: A Text Mining Approach – 2021.
2. Anna McGovern- Supply chain Resilience Vs. Cost – 2020
3. [David Rogers](#), Supply chain survival strategies for the post-pandemic era--2020
4. [Ganesh Wadawadigi](#), [Ophir Gaathon](#)- Building Supply Chain Resiliency in a Post-Pandemic World -2020
5. Gary A. Smith- Fundamental Supply Chain Changes in a Post-COVID-19 World -2021
6. Guilherme F. **Frederico**- Towards a Supply Chain 4.0 on the post-COVID-19 pandemic: a conceptual and strategic discussion for more resilient supply chains -2020
7. Hindustan Times- April 2021
8. Dr. Kapila Uma Shankar, Dr. Waqar Ahmad, Sallar Ashqi Kareem, “beta volatility and its consequences for hedging systematic risk with reference to stock market during covid-19”, *Information Technology in Industry*, Volume 09, Issue 03,2021, 482 – 492.
9. Dr. Uma Shankar, “Debt Restructuring to Elongate Asset Quality of Banks In India”, *Solid State Technology* (2020), Volume 63, Issue 6, PP No. 14540-14549
10. Dr.Kapila Uma Shankar, “Analysis on Social Banking for Sustainable Growth and Satisfaction on Social Targets”, *International Journal of Advanced Science and Technology*, Volume 29, Issue 7, PP No. 14487-14491.
11. P.Govindasamy , Kapila Uma Shankar, “Covid-19 And Global Financial Markets With Special Focus To Gdp Growth Projection, Capital Mobilization And Performance Of Stock Market” Volume XI, Issue VII, 2020, PP No. 1-9.
12. Dr. Uma Shankar. (2021). Impact of Quantitative Easing on Economic Crisis During Pandemic. *International Journal of Modern Agriculture*, 10(2), 3342 - 3350. Retrieved from <http://www.modern-journals.com/index.php/ijma/article/view/1168>
13. Dr. Uma Shankar. (2021). Influence of Financial Statement Comparability on Applicability of Earnings. *International Journal of Modern Agriculture*, 10(2), 3323 - 3332. Retrieved from <http://www.modernjournals.com/index.php/ijma/article/view/1166>.
14. Dr.P. Govindasamy; Dr.Kapila Uma Shankar; Mr.R. Ravimohan. "Indian capital market analysis 2020 year end and 2021 year beginning". *Journal of Contemporary Issues in Business and Government*, 27, 2, 2021, 6677-6693. doi: 10.47750/cibg.2021.27.02.645

15. Dr. Othman, M.M., Ishwarya, K.R., Ganesan, M. and Babu Loganathan, G. (2021). A Study on Data Analysis and Electronic Application for the Growth of Smart Farming. *Alinteri Journal of Agriculture Sciences*, 36(1): 209-218. doi: 10.47059/alinteri/V36I1/AJAS21031.
16. Kapila Uma Shankar (Dr.Uma Shankar),(2017),Prospects and Challenges in GST Implementation – An India Perspective. *Printing Area International Research Journal* 5 (35), 0130 - 0137. 18.
17. Kapila Uma Shankar (Dr.Uma Shankar), (2017),Digital Economy in India: Challenges and Prospects. *International Journal of Research in Management Studies* ((a peer review open access international journal – [www.ijrms.com](http://www.ijrms.com)), 2(11), 6 -11. 19.
18. Kapila Uma Shankar (Dr.Uma Shankar), (2017), *International Journal of Research in Management Studies* (A peer review open access international journal – [www.ijrms.com](http://www.ijrms.com)), 2(9), 20 - 28. 20.
19. Kapila Uma Shankar (Dr.Uma Shankar), (2016),Benefits of the Adoption of International Financial Reporting Standards (IFRS) in INDIA - A Study, *International Journal of Multidisciplinary Research Review -Peer Reviewed Journal*, E-ISSN 2395 – 1885, 1(21), 103 -108.
20. Kapila Uma Shankar (Uma Shankar), Prof. B. R. Megha Raj, (2015), The Relationship Between Exchange Rate and Selected Information Technology Stocks Listed in Bombay Stock Exchange of India, *Indian journal of applied research*, ISSN- 2249-555X, impact factor; 3.6241, 5(6),498 -500.
21. Dr.P. Govindasamy; Dr.Kapila Uma Shankar; Mr.R. Ravimohan. "Modeling of dividend payout, retention, yield, capital gains and irrelevance and its impact on value of the firm". *Journal of Contemporary Issues in Business and Government*, 27, 2, 2021, 5166-5178. doi: 10.47750/cibg.2021.27.02.528.
22. Shankar Singh, Uma (2021) *Reforms in Agriculture Sector and Paradigm Move in the Indian Banking towards Agriculture*. *Alinteri Journal of Agriculture Sciences*, 36 (1). pp. 433-442. ISSN 25647814.
23. B.K. Patle, G. Babu L, A. Pandey, D.R.K. Parhi, A. Jagadeesh, A review: On path planning strategies for navigation of mobile robot, *Def. Technol.* 15 (2019) 582– 606. <https://doi.org/10.1016/j.dt.2019.04.011>.
24. Dr.A.Senthil Kumar, Dr.G.Suresh, Dr.S.Lekashri, Mr.L.Ganesh Babu, Dr. R.Manikandan. (2021). Smart Agriculture System With E – Cabbage Using Iot. *International Journal of Modern Agriculture*, 10(1), 928 - 931. Retrieved from <http://www.modern-journals.com/index.php/ijma/article/view/690>
25. Ganesh Babu L 2019 Influence of benzoyl chloride treatment on the tribological characteristics of Cyperus pangorei fibers based nonasbestos brake friction composites *Mater. Res. Express* 7 015303.

26. Ganesh Babu Loganathan, Dr. E.Mohan, R.Siva Kumar, “ Iot Based Water And Soil Quality Monitoring System”, International Journal of Mechanical Engineering and Technology (IJMET)(2019), Vol.10 Issue No.2, P.No. 537-541.
27. Ganesh Babu Loganathan, “Can Based Automated Vehicle Security System”, International Journal of Mechanical Engineering and Technology (IJMET)(2019), Vol.10 Issue No.07, P.No. 46-51.
28. Suganthi K, Idris Hadi Salih, Ganesh Babu Loganathan, and Sundararaman K, “A Single Switch Bipolar Triple Output Converter with Fuzzy Control”, International Journal of Advanced Science and Technology, (2020), Vol. 29, No. 5, (2020), P.No.. 2386 – 2400.
29. Ellappan Mohan, Arunachalam Rajesh, Gurram Sunitha, Reddy Madhavi Konduru, Janagaraj Avanija, Loganathan Ganesh Babu, “A deep neural network learning-based speckle noise removal technique for enhancing the quality of synthetic-aperture radar images”, Concurrency and Computation-Practice & Experience, <https://doi.org/10.1002/cpe.6239>.
30. Sivama, S., Loganathanb, G., Harshavardhanaa, N., Kumarana, D., & Prasanna, P. (2020). A comparative study of experimental and adaptive neuro fuzzy inference system based prediction model of machined AM60 magnesium alloy and its parameter effects. Materials Today: Proceedings, Volume 45, Part 2, 2021, Pages 1055-1062.
31. G. Sai Krishnan, K. Ilayaperumal, L. Ganesh Babu, S. Kumar, B. Sathish, R. Sanjana, Investigation on the physical and mechanical characteristics of demostachya bipinnata reinforced with polyester composites, Materials Today: Proceedings, Volume 45, Part 2, 2021, Pages 1134-1137, ISSN 2214-7853. <https://doi.org/10.1016/j.matpr.2020.03.481>.
32. Dr. A. Senthil Kumar; Dr. Venmathi A R; L. Ganesh Babu; Dr. G. Suresh. "Smart Agriculture Robo with Leaf Diseases Detection using IOT". European Journal of Molecular & Clinical Medicine, 7, 11, 2022, 2462-2469.
33. Shanmugasundar, G and Vanitha, M and Babu Loganathan, Ganesh and Suresh, P and Mathiyalagan, P and Sai Krishnan, G and Makos, Mebratu (2020) *Fabrication and analysis of mechanical properties of PVC/Glass fiber/graphene nano composite pipes*. Materials Research express, 7. pp. 1-7.
34. Ganesh Babu Loganathan “Design and analysis of high gain Re Boost-Luo converter for high power DC application”, Materials Today: Proceedings (2020), Volume 33, Part 1, PP 13-22.
35. Babu, G.L. (2020) Investigation on the mechanical and morphological characteristics of caryota urens spadix fibre reinforced with polyester composites. J. Balk. Tribol. Assoc, vol. 26, no. 8, pp. 128-169
36. Dr. Idris Hadi Salih, Ganesh Babu Loganathan, “Induction motor fault monitoring and fault classification using deep learning probabilistic neural network” Solid State Technology (2020), Volume 63, Issue 6, 2196-2213..

37. Qaysar Salih Mahdi, Idris Hadi Saleh, Ghani Hashim, Ganesh Babu Loganathan, “Evaluation of Robot Professor Technology in Teaching and Business”, Information Technology in Industry, Volume 09, Issue 01, PP 1182 -1194.
38. Mr.Vishwa Deepak, S.Nithish, D. V. B. M. B. L. M. (2021). Static Stress Analysis of an Addendum Modified Spur Gear Pair using FRP Material. Design Engineering, 3562-3573. Retrieved from <http://thedesigengineering.com/index.php/DE/article/view/5301>. ISSN 0011-9342,
39. Ganesh Babu Loganathan, K. I. M. G. (2021). CROWD CONTROL ROBOT FOR CONGESTION CONTROL. Design Engineering, 3377- 3391. Retrieved from <http://thedesigengineering.com/index.php/DE/article/view/5286>. ISSN 0011-9342,
40. Manikandan Ganesan, Ganesh Babu Loganathan, J.Dhanasekar, K. R. Ishwarya, Dr.V.Balambica. (2021). IMPLEMENTING INDUSTRIAL ROBOTICS ARMS FOR MATERIAL HOLDING PROCESS IN INDUSTRIES. Harbin Gongye Daxue Xuebao/Journal of Harbin Institute of Technology, 53(9), 17–27. Retrieved from <http://hebgydxxb.periodicales.com/index.php/JHIT/article/view/704>.
41. Ahmed Ameer Arsalan Hadi , Karam Dheyaa Jirjees, G. B. L. I. H. S. (2021). AN ANALYSIS OF TOPOLOGY OPTIMIZATION ON ROBOT BY FINITE COMPONENT. Design Engineering, 7336-7351. Retrieved from <http://www.thedesigengineering.com/index.php/DE/article/view/3246>. ISSN 0011-9342,
42. Dr.Qaysar Salih Mahdi, Mr.Ganesh Babu Loganathan, “Classification of Web Page by Using Neural Networks”, Efflatounia, Volume: 5 Issue 2, Pages: 650 – 663, ISSN: 1110-8703.
43. Dr.Qaysar Salih Mahdi, Mr.Ganesh Babu Loganathan, “Modelling of Radar Targets and Radar Cross Section For Air Traffic Control Radars”, Efflatounia, Volume: 5 Issue 2, Pages: 664–674, ISSN: 1110-8703.
44. Ganesh Babu Loganathan, Dr. Mohammad M. Othman, Elham Tahsin Yasin *An Analysis on Garbage Removal Process by WSN thorough Global System for Mobile Communication Media*. REVISTA GEINTEC-GESTAO INOVACAO E TECNOLOGIAS, 11 (3). pp. 493-505. ISSN 2237-0722.
45. Manikandan Ganesan, KR Ishwarya, Demos Lisanetwork, Ganesh Babu Loganathan, Design and Implementation of Single Phase to Three Phase Drive System Using Space Vector Modulation. REVISTA GEINTEC-GESTAO INOVACAO E TECNOLOGIAS, 11 (2). pp. 2221- 2239. ISSN 2237-0722
46. BABU, L. G. (2021). MICROSTRUCTURE AND WEAR BEHAVIOUR OF A356-TIB2 NOVEL METAL MATRIX COMPOSITES. In Journal of the Balkan Tribological Association (Vol. 27, Issue 3, pp. 417–425). ISSN:1310-4772
47. Muthukumar, S., Ganesan, M., Dhanasekar, J. and Loganathan, G.B. (2021). Path Planning Optimization for Agricultural Spraying Robots Using Hybrid Dragonfly –

- Cuckoo Search Algorithm. Alinteri Journal of Agriculture Sciences, 36(1): 412-419. - ISSN: 2587-2249. doi: 10.47059/alinteri/V36I1/AJAS21062.
48. S. Priyadharsini, T. S. Balaji Damodhar, C. Kannan, & L. Ganesh Babu. (2021). Improved Performance of Photovoltaic Based Embedded Dual Power Source SL-Quasi Z Source Inverter For IM Drive. EPRA International Journal of Research & Development, 6(6), 266–273. Retrieved from <https://eprajournals.org/index.php/IJRD/article/view/248>.
  49. Dr. Othman, M.M., Ishwarya, K.R., Ganesan, M. and Babu Loganathan, G. (2021). A Study on Data Analysis and Electronic Application for the Growth of Smart Farming. Alinteri Journal of Agriculture Sciences, 36(1): 209-218. doi: 10.47059/alinteri/V36I1/AJAS21031.
  50. Ganesh Babu Loganathan, Idris Hadi Salih, A.Karthikayen, N. Satheesh Kumar, Udayakumar Durairaj. (2021). EERP: Intelligent Cluster based Energy Enhanced Routing Protocol Design over Wireless Sensor Network Environment. International Journal of Modern Agriculture, 10(2), 1725 - 1736. Retrieved from <http://www.modern-journals.com/index.php/ijma/article/view/908>.
  51. Qaysar Salih Mahdi, Idris Hadi Saleh, Ghani Hashim, Ganesh Babu Loganathan, “Evaluation of Robot Professor Technology in Teaching and Business”, Information Technology in Industry, Volume 09, Issue 01, PP 1182-1194.
  52. Babu, L.G. (2020). Influence on the tribological performance of the pure synthetic hydrated calcium silicate with cellulose fiber. In Journal of the Balkan Tribological Association, 26(4), 747–754.
  53. Mohammed Abdulghani Taha and Ganesh Babu Loganathan, “Hybrid algorithms for spectral noise removal in hyper spectral images” AIP Conference Proceedings (2020), 2271(1), 030013.
  54. J. Aravind Kumar, D. Joshua Amarnath, A. Annam Renita and Ganesh Babu, “Activated Carbon Production From Biowaste Materials - Properties and Applications: A Review”. Indian Journal of Environmental Protection, 40 (5). pp. 507-511.
  55. P.Ramesh, G.Sai Krishnan, J.Pravin Kumar, M.Bakkiyaraj, Raghuram Pradhan, L.Ganesh babu, “A critical investigation on viscosity and tribological properties of molybdenum disulfide nano particles on diesel oil” , Materials Today: Proceedings, Volume 43, Part 2, 2021, Pages 1830-1833.
  56. K. Rajendra Prasad, V. Manoj Kumar, G.Swaminathan, Ganesh Babu Loganathan, “Computational investigation and design optimization of a duct augmented wind turbine (DAWT)”, Materials Today: Proceedings, Volume 22, Part 3, 2020, Pages 1186-1191.
  57. Selvam, R., & Loganathan, G. B. (2019). Product detail and analysis of hydraulic quick releasing coupling. Materials Today: Proceedings, 22, 751–755. <https://doi.org/10.1016/j.matpr.2019.10.081>.
  58. T. Muthuramalingam, S. Vasanth, L. G. Babu, D. Saravanakumar and P. Karthikeyan, "Flushing Pressure Automation for Efficient Machining in EDM Process," 2019 7th

- International Conference on Control, Mechatronics and Automation (ICCMA), 2019, pp. 232-236, doi: 10.1109/ICCMA46720.2019.8988592.
59. S.P.S.S.Sivam G.B. Loganathan and L. Ganesh Babu and D. Kumaran. 2019. Enhancing the Mechanical Properties and Formability of Cold Rolled Closed Annealed Sheet for Automobile Applications Int J. Vehicle Structures & Systems. 11 15-20.
60. Muralikrishna, M.V.V.; Surya Kumari, T.S.A.; Gopi, R.; Loganathan, G.B. Development of mechanical properties in banana fiber composite. Mater. Today Proc. 2020, 22, 541–545.
61. S.P. Sundar Singh Sivam et al.2019 Analysis of Product Quality through Mechanical Properties and Determining Optimal Process Parameters of Untreated and Heat Treated ALSI 1050 Alloy during Turning Operation Mater. Sci. Forum. 969 876-881.
62. S.P. Sundar Singh Sivam, Ganesh Babu Loganathan, P.R. Shobana Swarna Ratna, G. Balakumaran , “Improvement of Product Quality by Process Parameter Optimization of AISI 1050 by Different Heat Treatment Conditions: Ranking Algorithm and ANOVA”, International Journal of Innovative Technology and Exploring Engineering (IJITEE) Volume-8 Issue-5 March, 2019, PP.30-35, ISSN: 2278-3075.
63. Ganesh Babu Loganathan, “An Identical Machine-Adaptive Algorithm Based Blockchain Process and Predicting Secret Data From Hacking In Computer Numerical Control Applications”, International Journal of Mechanical and Production Engineering Research and Development (IJMPERD) Vol. 9, Special Issue 1, Jan 2019, PP.510-522, ISSN(P): 2249-6890; ISSN(E): 2249-8001.
64. S.P. Sundar Singh Sivam, Ganesh Babu Loganathan, K. Saravanan, S. RajendraKumar, “Outcome of the Coating Thickness on the Tool Act and Process Parameters When Dry Turning Ti–6Al–4V Alloy: GRA Taguchi & ANOVA”, International Journal of Innovative Technology and Exploring Engineering (IJITEE) ISSN: 2278-3075, Volume-8, Issue-4, February 2019 PP. 419-423.
65. P. Jeevitha, K. S. Elango, Ganesh Babu L, J. Ranjitha, S. Vijayalakshmi,” Glycerol as a Key Reactant in the Production of 3-Hydroxypropanoic Acid using Engineered Microbes”, AIP Conference Proceedings 2396, 030004 (2021). <https://doi.org/10.1063/5.0066423>.
66. S.Priyadharsini, C.Kannan, Ganesh Babu, C.Savithri, & K.Thamayandhi. (2022). DESIGN AND DEVELOPMENT OF 51 LEVEL NON MODULAR MULTILEVEL INVERTER TOPOLOGY WITH REDUCED NUMBER OF SWITCHES AND CONDUCTION PATH . EPRA International Journal of Research and Development (IJRD), 7(6), 267–273. Retrieved from <http://www.eprajournals.net/index.php/IJRD/article/view/609>
67. C.Kannan, S.Priyadharsini, L. Ganesh Babu, S.Mugilvannan, K.Thamocharan, & V.Velan. (2022). DESIGN OF MODULAR AND NON MODULAR MULTILEVEL INVERTER TOPOLOGY WITH REDUCED NUMBER OF SWITCHES. EPRA International Journal of Research and Development (IJRD), 7(6), 249–255. Retrieved from <http://www.eprajournals.net/index.php/IJRD/article/view/592>

68. G. B. Loganathan, T. H. Fatah, E. T. Yasin and N. I. Hamadamen, "To Develop Multi-Object Detection and Recognition Using Improved GP-FRCNN Method," *2022 8th International Conference on Smart Structures and Systems (ICSSS)*, 2022, pp. 1-7, doi: 10.1109/ICSSS54381.2022.9782296.
69. Ganesh Babu Loganathan, "Agility through Product design in the era of Industry 4.0", *International Journal of Early Childhood Special Education (INT-JECSE)* Vol 14, Issue 02, 2022. PP 3751-3764, DOI: 10.9756/INT-JECSE/V14I2.405 ISSN:1308-5581
70. G Shanmugasundar, Ganesh Sai Krishnan, L Ganesh Babu, S Kumar and Mebratu Makos: "Investigation of ferronickel slag powder for marine applications by using MIP method" *Materials Research Express*, ISSN: 2053-1591, Volume-9, Issue-5, May 2022, P.No 055501.
71. Mukta Jagdish, Devangkumar Umakant Shah, Varsha Agarwal, Ganesh Babu Loganathan, Abdullah Alqahtani, Saima Ahmed Rahin, "Identification of End-User Economical Relationship Graph Using Lightweight Blockchain-Based BERT Model", *Computational Intelligence and Neuroscience*, vol. 2022, Article ID 6546913, 9 pages, 2022. <https://doi.org/10.1155/2022/6546913>
72. Giri Murugan, Ganesh Babu Loganathan, G Sivaraman, C Shilaja and S Mayakannan: "Compressive Behavior of Tamarind Shell Powder and Fine Granite Particles Reinforced Epoxy Matrix Based Hybrid Bio-Composites", *ECS Transactions*, [Volume 107](#), [Number 1](#), PP 7111.
73. L. Karthick, R. Rathinam, Sd. Abdul Kalam, Ganesh Babu Loganathan, R. S. Sabeenian, S. K. Joshi, L. Ramesh, H. Mohammed Ali, Wubishet Degife Mammo, "Influence of Nano-/Microfiller Addition on Mechanical and Morphological Performance of Kenaf/Glass Fibre-Reinforced Hybrid Composites", *Journal of Nanomaterials*, vol. 2022, Article ID 9778224, 10 pages, 2022. <https://doi.org/10.1155/2022/9778224>.
74. Raj Kumar, Suganya Natarajan, Rahul Singh, Vinod Singh Rajput, Ganesh Babu Loganathan, Sanjeev Kumar, T. Sakthi, Akter Meem Mahseena, "Investigation on Mechanical Durability Properties of High-Performance Concrete with Nanosilica and Copper Slag", *Journal of Nanomaterials*, vol. 2022, Article ID 7030680, 8 pages, 2022. <https://doi.org/10.1155/2022/7030680>.
75. E. Arul Vijayalakshmi , S. S. Santra , T. Botmart, H. Alotaibi , G. B. Loganathan , M. Kannan , J. Visuvasam and V. Govindan, "Analysis of the magnetohydrodynamic flow in a porous medium", *AIMS Mathematics* 2022, [Volume 7](#), [Issue 8](#): 15182-15194. doi: [10.3934/math.2022832](https://doi.org/10.3934/math.2022832).
76. Loganathan, G.B., Mahdi, Q.S., Saleh, I.H., Othman, M.M. (2022). AGRIBOT: Energetic Agricultural Field Monitoring Robot Based on IoT Enabled Artificial Intelligence Logic. In: Liatsis, P., Hussain, A., Mostafa, S.A., Al-Jumeily, D. (eds) *Emerging Technology Trends in Internet of Things and Computing. TIOTC 2021. Communications in Computer and Information Science*, vol 1548. Springer, Cham. [https://doi.org/10.1007/978-3-030-97255-4\\_2](https://doi.org/10.1007/978-3-030-97255-4_2).

77. L. Karthick, V. Senthil Murugan, Stephen Leon Joseph Leon, Mahesh Mallampati, M. Ijas Ahamed, Ganesh Babu Loganathan, "Energy performance of a compression refrigeration cycle using environment-friendly refrigerants", *Materials Today: Proceedings*, Volume 66, Part 3, 2022, Pages 1519-1525, ISSN 2214-7853, <https://doi.org/10.1016/j.matpr.2022.07.178>.
78. Kanagaraju, T., Babu, L.G., Madhavan, V.M. et al. Experimental analysis on drilling of super duplex stainless steel 2507 (SDSS 2507) using cryogenic LCO<sub>2</sub> and MQL process. *Biomass Conv. Bioref.* (2022). <https://doi.org/10.1007/s13399-022-02536-8>.
79. Babu Loganathan, Ganesh (2022) *Agility through Product design in the era of Industry 4.0*. *International Journal of Early Childhood Special Education*, 14 (2).
80. Ganesh Babu Loganathan, Amani Tahsin Yasin, "Identification of chromatographical characteristics of complicated biological feeds," *Materials Today: Proceedings*, Volume 66, Part 3, 2022, Pages 1247-1254, ISSN 2214-7853, <https://doi.org/10.1016/j.matpr.2022.05.118>.
81. Selvam, R., Babu, L. G., Thomas, J., Prakash, R., Karthikeyan, T. et al. (2023). Analysis of a Cashew Shell and Fly Ash Rich Brake Liner Composite Material. *FDMP-Fluid Dynamics & Materials Processing*, 19(3), 569–577.
82. Babu Loganathan, Ganesh (2021) *Recent Scope for AI in the Food Production Industry Leading to the Fourth Industrial Revolution*. *Webology*, 18 (2). pp. 1066-1080.
83. Ganesh Babu Loganathan, Nawroz Ibrahim Hamadamen, Elham Tahsin Yasin, Amani Tahsin Yasin, Alaa Amer Mohammad, Israa Nabeel Adil, Sidra Bahjat Ismail, Dlanpar DzhwarFathullah, Saya Ameer Arsalan Hadi, Shaymaa Faruq Hamadameen, "Melanoma classification using enhanced fuzzy clustering and DCNN on dermoscopy images". *NeuroQuantology*, [12](#), 2022, Pages 196-213.
84. Loganathan, G., Kumaran, D., Sivam Sundarlingam Paramasivam, S., Saravanan, K. et al., "Improvement of Mechanical Properties, and Optimization of Process Parameters of AISI 1050 Spheroidized Annealed Steel by Ranking Algorithm," *SAE Technical Paper 2019-28-0143*, 2019, <https://doi.org/10.4271/2019-28-0143>.
85. Muthuramalingam T., Ganesh Babu L., Sridharan K., Geethapriyan T., Srinivasan K.P. (2020) Multi-response Optimization of WEDM Process Parameters of Inconel 718 Alloy Using TGRA Method. In: Sattler KU., Nguyen D., Vu N., Tien Long B., Puta H. (eds) *Advances in Engineering Research and Application. ICERA 2019. Lecture Notes in Networks and Systems*, vol 104. Springer, Cham. [https://doi.org/10.1007/978-3-030-37497-6\\_56](https://doi.org/10.1007/978-3-030-37497-6_56).
86. Krishnan G S and Loganathan G B 2019 Micro structural and corrosion studies by immersion in 3.5 wt% Nacl environment On Mg-6al1zn-Xca alloy with Ca addition and aged at different temperatures *International Journal of Mechanical and Production Engineering Research and Development (IJMPERD)* 1553–1562.

87. Sai Krishnan G and Babu G 2019 Experimental investigation of wear behaviour of A356-Tib2 metal matrix composites International Journal Of Mechanical And Production Engineering Research And Development (IJMPERD) 1353–1362.
88. S Dhanraj et al 2019, “An Efficiency Study On Water Extraction From Air Using Thermophoresis Method” IOP Conf. Ser.: Mater. Sci. Eng. 574 012003.
89. S.P. Sundar Singh Sivam, Ganesh Babu Loganathan, K. Saravanan (2019), Impact of Point Angle on Drill Product Quality and Other Responses When Drilling EN- 8: A Case Study of Ranking Algorithm, International Journal of Innovative Technology and Exploring Engineering, ISSN 2278-3075 PP. No. 280-282.
90. M. Vairavel, R. Girimurugan, C. Shilaja, Ganesh Babu Loganathan, J. Kumaresan, “Modeling, Validation and Simulation of Electric Vehicles using MATLAB”, AIP Conference Proceedings 2452, 030006 (2022); <https://doi.org/10.1063/5.0114084>.
91. M. Vairavel , R. Girimurugan , C. Shilaja , Ganesh Babu Loganathan , Zeynel Polat, “Analysis of Hybrid Electrical Vehicles: Types, Formulation and Needs”, AIP Conference Proceedings 2452, 030005 (2022); <https://doi.org/10.1063/5.0114081>.
92. Jason Bergstrom, Patrick Gallagher, Ian Stewart- Preparing today’s supply chains to thrive in uncertainty-2020
93. Knut Aliche, Xavier Azcue, and [Edward Barriball](#) – Supply chain recovery in Coronavirus times- Plan for now and the future-2020
94. [Oren Simon](#) - What is The Real Cost of Supply Chain Resilience – Case Study -2021
95. [Paul Michelman](#)- Building a Resilient Supply Chain in Harvard Business Review
96. [Priyabrata Chowdhury](#), [Sanjoy Kumar Paul](#), [Shahriar Kaiser](#), and [Md. Abdul Moktadir](#) COVID-19 pandemic related supply chain studies: A systematic review -2021
97. Rajesh Rajagopal- Study of select issues of resilient supply chains- 2017
98. Rethinking supply chain resilience for a post-COVID-19 world- Cap Gemini research institute
99. Riccardo Aldrighetti, Daria Battini, Ilenia Zennaro- Costs of resilience and disruptions in supply chain network design models: A review and future research directions- International Journal of Production Economics -2021
100. [Happold](#), 6 strategies for a more Resilient Supply Chain- 2020
101. [Steven A. Melnyk](#) , [David J. Closs](#), [Christopher W. Zobel](#) , [John R. Macdonald](#) - Understanding Supply Chain Resilience
102. [Willy C. Shih](#) - Global Supply Chains in a Post-Pandemic World- Harvard Business review- 2020.