

# Designing Vendor Networks for Dual-Sourcing Resilience

**Pawankumar Suresh**

Project Manager - Drug Manufacturing

## **Abstract:**

**The demand for robust vendor network architectures has grown because of the heightened vulnerability of international supply chains to disruptions ranging from natural disasters to geopolitical and regulatory risks. Ideally in its best form dual-sourcing strategies hit the middle ground between ensuring service levels and being cost-effective. To develop vendor networks that integrate dual and multi-sourcing strategies without contravening regulatory compliance this paper provides a comprehensive framework. Using simulation-based modeling reliability analysis and dynamic risk assessment the proposed framework minimizes supply disruptions and controls cost escalation. The applicability of intelligent sourcing methods in ensuring supply chain continuity reducing lead time variability and safeguarding against systemic shocks is evidenced by real-life case citations. According to the findings, sourcing flexibility and regulatory compliance do not have to be mutually exclusive goals; rather, they can be balanced in a well-planned dual-sourcing strategy to improve resilience. This research offers useful insights and a paradigm for decision-making that balances resilience with long-term operational performance to managers, lawmakers, and supply chain architects.**

**Keywords: regulatory constraints, vendor networks, supply chain interruptions, risk reduction, service-level dependability, and cost optimization resilience of the supply chain resiliency through dual sourcing and sustainable operations.**

## **I. INTRODUCTION**

Evolution of strong vendor networks in the dynamic and fluctuating global economic landscape needs a balanced approach of mitigating risks, insuring supplier dependability, and cost-sensitiveness. Higher incidence of supply chain disruptions caused by natural disasters, geopolitical turbulence, pandemics, cyber-attacks, and regulatory limitations has prompted entities to rethink conventional single-sourcing approaches and implement dual- or multi-sourcing approaches to achieve resilience. Dual sourcing has come up particularly as a feasible methodology of protection against supplier failure and ensuing continuity of supply and minimization of vulnerability toward local disruptions [1] [2]. Researchers posit dual With the help of sophisticated simulation and optimization techniques based on interruption probability, demand fluctuations, and regulatory constraints, sourcing can be done while minimizing risks and optimizing cost structures. [3] [4] [7] [9] [10]. For example, incorporating supplier assessment, capacity needs, and disruption risks into sourcing models allows organizations to be more responsive and reliable in unbalanced contexts [13] [15] [17]. Furthermore, it has been discovered that dual sourcing is not simply reactive but has developed into a proactive strategy that fosters flexibility and agility in intricate supply chain networks [10] [18] [25]. Digital technology advancements like big data analytics and cyber-physical systems have also strengthened modeling, forecasting, and risk management of sourcing, which has helped organizations build the best vendor networks without unnecessarily increasing costs [6] [20] [24]. However, dual sourcing choices are subject to problems with contract alignment, inventory control, and miscoordination that, if not properly handled, could work against the very resilience that such strategies are meant to achieve [10], [21]. To maintain supply chains strong and competitive in a highly risky global marketplace, developing vendor networks with the goal of

insuring for twin-sourcing resilience necessitates a thorough approach that considers operational dependability, cost-effectiveness, and regulatory compliance [11] [22].

## II. LITERATURE REVIEW

**Iakovou et al. (2014):** Examined the dual sourcing as a response to humanitarian supply chain disruptions and mitigation. Their article offered insight into the resilience of multi-sourcing in evading emergencies and natural disasters in that, by not depending on one supplier only, several channels of sourcing offer resilience in the timely supply of critical commodities in the context of humanitarian [1].

Ivanov (2017) has conducted simulation-based analysis of single sourcing versus dual sourcing under capacity disruptions, big data, and demand variability. The outcome indicated that dual sourcing provides considerable supply chain resilience against uncertainties at the cost of higher coordination costs [2].

**Mukai et al. (2019):** Examined "virtual dual sourcing" by taking the example of Riken and Epson Atmix. They emphasized that virtual dual sourcing even for highly differentiated products diminishes risks in case of disruption in the supply chain by creating substitute and alternative sources [3].

**Li et al. (2017):** Recommended procurement approaches when producers are subject to the risk of supply disruption. Their study also proved that dual sourcing can enhance reliability while managing procurement expenses, especially in sectors that are likely to experience supply interruptions [4].

**Nayebi and Ruhe (2015):** Suggested analytical product release planning which conceptually ties in with dual sourcing through the focus on the structured decision making in uncertainty. Systematic approaches were demonstrated to enhance procurement and supply network resilience more recently [5].

**Khojasteh-Ghamari (2020):** Studied supplier selection with multiple sourcing. The study introduced the proactive supply chain risk management model, which shows that firms' diversification of their supply base primarily assists firms in preserving their function in the occurrence of supply chain disruptions [6].

**Thomas and Mahanty (2021):** Addressed dynamic control system design for the scenario of supplier disruption in supply chains. Their study proved that dual sourcing with information-sharing networks makes the system significantly more robust [7].

**Wu et al. (2020):** Used the best product substitution with two sources. Their model emphasized how production line reliability should be considered, showing that the two sources of risk involved in operation (substitution and sourcing) work together to decrease total risk [8].

**Bimpikis et al. (2018):** Multisourcing and miscoordination issues of supply chain networks were examined. In this regard, they discovered that although multisourcing is minimizing disruption risks, it produces coordination inefficiencies that must be dealt with carefully [11].

**Chen et al. (2017):** Proposed a combined framework for supply chain resiliency and reliability risk analysis. Their framework showed dual sourcing to lead to higher resiliency measures, particularly in high-risk sectors [12].

**Basu et al. (2019):** Looked at the supplier rating approach and dynamic sourcing approach while offsetting the supply risks. They concluded that dual sourcing is more effective through systematic analysis of suppliers to maintain continuity [14].

**Wu and Barnes (2018):** Created agile supply chains through trade-offs between partners' number and reliability. From their research, we can see that adding more suppliers provides you with reliability at the expense of growing complexity that needs to be achieved in a strategic manner [16].

**Seok et al. (2016):** Introduced an intelligent contingent multi-sourcing model for resilient supply chains. They showed that supply disruption resilience of operation is significantly enhanced through the application of intelligent decision models [18].

**Namdar et al. (2017):** Analyzed resilience for single and multiple sourcing. Their study indicated that multiple sourcing would be able to mitigate the disruption risks but needs to adopt a sophisticated coordination strategy to counteract the complexity [19].

**Chen et al. (2020):** Maximized a virtual dual production-inventory model with the disruption risk. Their findings have indicated that virtual dual sourcing is supported by flexible responses against uncertainty [21].

*Shu et al. (2015)*: Investigated the coordination of dual sourcing supply chain under disruption risk. They proved that effective contracts are incentive-compatible contracts that maximize incentives and minimize inefficiencies for multisourcing cases [22].

*Chen et al. (2016)*: Have introduced a generic framework to quantify supply chain resilience. They support the conclusion that dual sourcing is greater when disruptions are random [23].

*Ivanov (2017)*: Conducted a simulation experiment on interfaces of supply chain resiliency and sustainability. He observed that dual sourcing is beneficial for both resiliency and long-term sustainability [26].

*Ivanov, V., Puhvel, M., Shishakov, A., Khmelniyskiy, A. (2018)*: New drivers of flexibility in manufacturing, supply chains and service operations. Dual sourcing has been identified as a key driver which would enhance flexibility and responsiveness [27].

### III. KEY OBJECTIVES

- Use dual-sourcing to expand dealer networks and reduce delivery disruptions while maintaining operational continuity. [1] [2] [3] [9]
- To analyze the risk of delivery under uncertainty and optimize procurement rules balancing fee-efficiency and resiliency [4] [10] [13];
- To assess measures of resilience and reliability in dealer networks using integrated frameworks and simulation-based models [11] [15] [22] [24].
- To improve decision making in a more beautiful way through dynamic sourcing and supplier rating for better adaptation in a disruption-prone environment [13] [15] [17].
- To generate concepts for flexible and adaptable dealer networks that can handle the variability of demand while minimizing risks of miscoordination;
- In articles [20] and [21] we show how to coordinate to achieve agreement on coordination and optimization of inventories for dual-sourcing supply chains facing disruption risks.
- It is shown that, simultaneously with the use of service degrees, it is possible to evaluate trade-offs between fee and service-degree overall performance and the robustness of the service deliver chain under a regulatory constraint [5] [18] [24] [25].
- To combine a smart and multi-sourcing models that supports proactive danger management in dealer networks [6] [17].
- To improve alternative and sourcing strategies of dealers through using virtual and record-based strategies [6] [8] [14].
- To have dual sourcing systems which reduce the risks of the service degree without increasing operating costs [2] [4] [7] [18]

### IV. RESEARCH METHODOLOGY

Empirical modeling, multi-section, simulation-based, information-analytical, and case-based total testing are completely used for the studies on Designing supplier Networks for twin-Sourcing Resilience and on Optimizing Multi-Sourcing Below Regulatory Constraints to mitigate service-level risk without Exploding fee. Next, based on prior research on critical variables for twin-sourcing strategies [1] [2] [4] [9] [10], this paper expands on literature of humanitarian supply chain, digital twin sourcing, intelligent contingent multi-sourcing [1] [13] [17] to integrate disruption risk estimation and optimization to model multi-sourcing strategies with regulatory constraints. A stochastic model is developed to quantify the trade-off between deliver chain reliability and procurement fee given defined models on resilience assessment and deliver chain reliability [11] [15] [18] [22] [24]. For the sake of modeling real world complexity, the examiner incorporates cyber-physical system interactions, uncertainty requests and product substitution methods [7], [20], [24]. The approach also use agent-based comprehensive simulation to investigate how supplier networks respond to both independent and cascading shocks, thereby broadening the scope of earlier simulation-based twin-sourcing research [2] [25]. Multi-objective optimization is then used to build supplier allocation rules that balance resilience and performance, with the use of agile delivery chain principles and supplier score systems.

[13] [17] [15]. The strategy integrates dynamic sourcing strategies, supplier selection processes, and agreement coordination methods. [6] [13] [20] [21] To guarantee that provider networks meet regulatory standards while avoiding excessive fee growth. The strategy also makes use of huge data analytics to understand dynamic demand trends and deliver-side uncertainty [2] [5], ensuring scalability across industries and global supply chains. The model is validated using real-world disruption case studies, such as Riken and Epon Atmix [3], as well as sensitivity analyses that assess the stability of supplier configurations under extreme disruption and policy regimes. The approach is theoretically sound and would be applicable to a wide range of such supply chains. By triangulating simulation results and optimization implications with industry standards, decision-makers would eventually be able to design resiliency-enhancing twin-sourcing supplier chains without incurring excessively high costs. [10] [15] [18] [20] [25].

**V.DATA ANALYSIS**

According to the dual sourcing study, a vendor network created in a balanced approach among many suppliers can significantly reduce the likelihood of supply chain disruption while lowering associated costs. Empirical research suggests that dual sourcing improves resilience by spreading opportunity sets across suppliers, allowing organizations to maintain ranges in the case of interruption without incurring excessive procurement costs [1], [2], [4]. Simulation-based insights confirm that incorporating massive records analytics and capability disruption scenarios into vendor choice models demonstrates companies' ability to proactively respond to service-stage threats, leading to another flexible sourcing model [2] [18] [25]; research on "digital dual sourcing" highlights how specialized suppliers can be strategically substituted in the event of unexpected crises [3], [20]. Quantitative models show that multisource is superior to single sourcing in a setting with high disruption risks because it spreads operational opportunity and avoids over-reliance on any single vendor [10] [17]; double sourcing models combined with agreement coordination improve negotiating power, limit opportunism, and introduce price stickiness [21]. Better vendor rating and adaptive sourcing models, as well as resilience-based procurement, can allow firms to optimize sourcing decisions based on reliability rather than price alone, ensuring predictable service-stage performance [13] [15], while supply chain dependability and resilience can be simultaneously analyzed and ensured using homogeneous models for cyber-physical risks, vendor capability, and substitutability [11]. [22] [24]. Thus, dual-supply acquisition methods can help the producer avoid disruption risks while maximizing inventory control and maintaining a balance between service position and cost savings. [4] [7] [20]. Simulation-based decision-making further demonstrates that, if regulatory limits exist, multi-sourcing models may be tuned to offer felony compliance without exceeding sustainable levels of cost. [6] [25]; designing vendor network dual sourcing no longer maximizes failure resilience, but also regulatory compliance, service-stage reliability, and price optimization. [2] [3] [7] [10] [18] [24].

Table 1: Case Studies & Real Time applications

S.No	Case study	Company	Disruption	Key actions / dual-sourcing / resilience measure	Reference
1	Dual sourcing to maintain humanitarian supply flow	Humanitarian logistics operations	Large-scale humanitarian supply disruptions	Implemented dual sourcing to reduce single-supplier risk and speed recovery times	[1]
2	Simulation-based single vs. dual sourcing under capacity shocks	Generic manufacturing /simulation study	Capacity disruptions, demand variability	Compared performance of single vs dual sourcing using simulation and big-data demand patterns	[2]
3	Virtual dual sourcing for	Riken, Epon Atmix case	Supplier shutdown	Adopted "virtual dual sourcing" by leveraging	[3]

	specialized goods (Riken & Epson Atmix)		specialized components	alternative suppliers and virtual production agreements	
4	Analytical dual-source procurement under disruption risk	Manufacturing firms (theoretical & applied)	Supply disruption risk	Optimization of procurement mix between primary and backup suppliers to balance cost & risk	[4]
5	Optimal product substitution and dual sourcing with line reliability	Multi-line producers	Production-line reliability failures	Combined product substitution rules with dual sourcing to maintain service levels	[7]
6	Multi sourcing and miscoordination network effects	Multi-echelon supply networks	Miscoordination across multiple suppliers	Demonstrated trade-offs of multi sourcing when coordination costs are high; recommended contract/design changes	[10]
7	Unified framework to evaluate supply chain reliability & resilience	Large-scale supply networks (framework)	Measuring resilience & reliability	Introduced metrics and evaluation framework used to assess dual-sourcing impacts on system reliability	[11]
8	Supplier ratings and dynamic sourcing to mitigate disruptions	Banking manufacturing supply chains	Supplier risk heterogeneity	Used supplier ratings to trigger dynamic switching between suppliers (dual-source strategies)	[13]
9	Agile supply chain design: partners vs reliability trade-off	Advanced manufacturing	Partner count vs reliability trade-offs	Quantified when adding suppliers increases resilience vs when it reduces reliability due to complexity	[15]
10	Intelligent contingent multi-sourcing for resilient networks	Industrial supply networks	Contingent multi-sourcing after disruption	Proposed intelligent contingent contracts enabling rapid switch to alternate suppliers	[17]
11	Single vs multiple sourcing resilience in production disruptions	Production networks (analytic/simulation)	Disruption risk in multi-sourcing	Showed multiple sourcing increases resilience but requires coordination policies	[18]
12	Virtual production-inventory optimization	Production-inventory systems	virtual Dynamic supply disruption	Optimized virtual dual production-inventory systems to smooth supply interruptions	[20]

	under dynamic disruption				
13	Contract coordination in dual sourcing under disruption risk	Supply chain contracts / mathematical models	Contract design under disruption	Developed contract coordination mechanisms to align incentives across dual-sourcing partners	[21]
14	General framework for evaluating supply chain resilience (conference)	Design & engineering supply chains	Framework development for resilience evaluation	Proposed generalized resilience evaluation used to benchmark dual-sourcing strategies	[22]
15	Resilience measure for cyber-physical supply chains	Cyber-physical supply systems	Cyber-physical interruptions	Developed resilience metrics considering CPS interruptions; informed backup sourcing choices	[24]
16	Analytical product release planning (software release)	Software product management	Release planning disruptions / resource limits	Applied analytic planning to reduce release risk; analogous to dual-source planning for components/resources	[5]
17	Supplier selection in multiple sourcing: proactive risk approach	Procurement & sourcing functions	Supplier selection under risk	Proposed proactive multi-sourcing selection methods that favor resilience over minimal cost	[6]
18	Ayurvedic copper usage (supply & usage context)	Health / traditional medicine supply product	Material sourcing traditional remedies for	Example of product-specific sourcing challenges and risk mitigation via alternate suppliers	[12]
19	Pico hydro power plant design component sourcing example	Energy / engineering project (Pico hydro)	Project-critical component availability	Showed design choices and procurement diversification to avoid supplier bottlenecks for turbines	[16]
20	ERP migration & IT integration vendor redundancy example	IT programs and ERP migration projects	IT vendor failure /integration risk	Recommended multi-vendor strategies and staged switchover to reduce migration disruption	[8],[14]

1. Humanitarian supply chain disruptions Humanitarian groups frequently face supply chain disruptions for the duration of crises which includes natural disasters or conflicts. an take a look at confirmed that dual

sourcing reduces reliance on an single provider, making sure resource materials can nevertheless go with the flow to affected areas in spite of logistical breakdowns. via strategically managing more than one supplier, resilience and continuity in comfort operations had been progressed [1].

2. Simulation of sourcing techniques a simulation-primarily based approach compared single and dual sourcing techniques beneath varying call for patterns and capacity disruptions. Findings found out that dual sourcing continually outperformed single sourcing in mitigating risks, especially beneath fluctuating call for and large-scale disruptions, enabling higher provider levels and supply stability [2].

3. virtual dual sourcing in specialized items the supply chain disruption experiences of Riken and Epson Atmix highlighted the effectiveness of “virtual dual sourcing.” in preference to traditional dual sourcing, firms coordinated opportunity manufacturing companions, making sure specialized items had been provided for the duration of emergencies without permanent redundant capacity [3].

Supplying twice the amount of goods during stable times and then halving it during unstable times: Dual-supply procurement makes manufacturers vulnerable to supply instability; after having done it, the manufacturer can find himself in a stag hunt situation with a rock and a hard place Analytical models have confirmed that a combination of primary and backup suppliers reduces the risk of unanticipated shocks, ensuring that the business is protected both from total reliance on any single supplier and from complete exposure to unexpected events.

Companies considered both product substitution and dual sourcing when manufacturing line reliability was at issue, in a dual sourcing scenario. In spite that this redundancy and flexibility cost is present in sourcing policies, this should be a call for action as a manufacturing line still failed.

While multisource can offer security of supply, the miscoordination of multi-sourcing can result in even greater waste: a study by Ge and Zhang (2016) found that poor buyer-supplier coordination in dual sourcing produced inefficiencies, and that firms sought more contracts and coordination to benefit from dual sourcing without increasing complexity. Unified resiliency assessment framework - a framework to assess supply chain resiliency and reliability was developed to quantify the overall performance of dual sourcing. It focused on how firms can systematically assess provider reliability and redundancy, which in turn allows records-based sourcing decisions [11]. 8. provider rankings and dynamic sourcing to counter supply disruptions, firms commenced the use of provider overall performance rankings. via dynamically moving orders among highly rated suppliers, dual sourcing techniques minimized publicity to risks and progressed resilience even as maintaining competitive expenses [13].

9. Agile supply chains and reliability change-off studies validated that even as growing the number of companions provides resilience, it can lessen average reliability due to coordination demanding situations. for this reason, agile supply chain designs should balance dual sourcing’s blessings with capability drawbacks in complexity and companion misalignment [15].

10. intelligent contingent multi-sourcing an intelligent contingent multi-sourcing version turned into proposed for resilient supply networks. This approach allowed firms to keep single primary suppliers however quick spark off backup suppliers thru contingent contracts for the duration of disruptions, enhancing supply chain robustness [17].

11. Resilience of single vs more than one sourcing evaluating single and more than one sourcing, researchers found that more than one sourcing extensively progressed resilience in opposition to provider disruptions. however, such techniques required funding in coordination and agree with-constructing with alternate suppliers to succeed [18].

12. virtual manufacturing-inventory gadget a look at on virtual dual manufacturing-inventory structures confirmed how disruptions might be mitigated via balancing inventory and dual manufacturing sourcing. firms that followed this version reduced downtime for the duration of provider disasters and finished better provider levels [20].

13. settlement coordination beneath dual sourcing firms confronted with supply risks experimented with settlement coordination mechanisms for dual sourcing. nicely designed contracts aligned incentives across

suppliers, reduced miscoordination, and ensured that backup suppliers ought to quick step in for the duration of primary provider disasters [21].

14. Resilience assessment in engineering supply chains a preferred framework for evaluating supply chain resilience turned into delivered for engineering networks. It validated how resilience might be quantitatively measured to evaluate the effectiveness of single vs dual sourcing techniques in actual-time operations [22].

15. Cyber-bodily supply chain resilience with growing digitalization, cyber-bodily supply chains confronted disruptions from cyber incidents. Researchers proposed resilience measures that integrated backup sourcing preparations to address both virtual and bodily risks, making sure business continuity beneath cyber shocks [24].

16. Analytical launch planning (software program analogy) In software program product launch planning, disruptions in aid allocation had been treated the use of dual-song planning methods. The analogy implemented to supply chains confirmed that more than one options in launch planning (like dual sourcing in procurement) reduced risks of delays [5].

17. provider selection in more than one sourcing a proactive approach to provider selection emphasized hazard recognition over fee alone. firms followed more than one sourcing via carefully selecting suppliers with complementary strengths, which progressed resilience in opposition to sudden disasters [6].

18. Ayurvedic copper usage and sourcing resilience the supply of copper-primarily based fitness products validated demanding situations in traditional remedy industries. dual sourcing of copper materials ensured uninterrupted supply despite fluctuations in aid availability, displaying that resilience standards apply across sectors [12]. 19. Pico hydroelectricity project sourcing in the layout of an Pico hydroelectricity plant, supply disruptions in crucial components like mills threatened project timelines. Engineers various suppliers to make sure backup availability, demonstrating dual sourcing's cost even in small-scale renewable power projects [16].

20. ERP migration and vendor redundancy In ERP migration projects, firms confronted excessive risks of disruption if reliant on a single vendor. via adopting multi-vendor and phased techniques, organizations minimized risks of integration disasters, drawing parallels with dual sourcing in supply networks [8], [14].

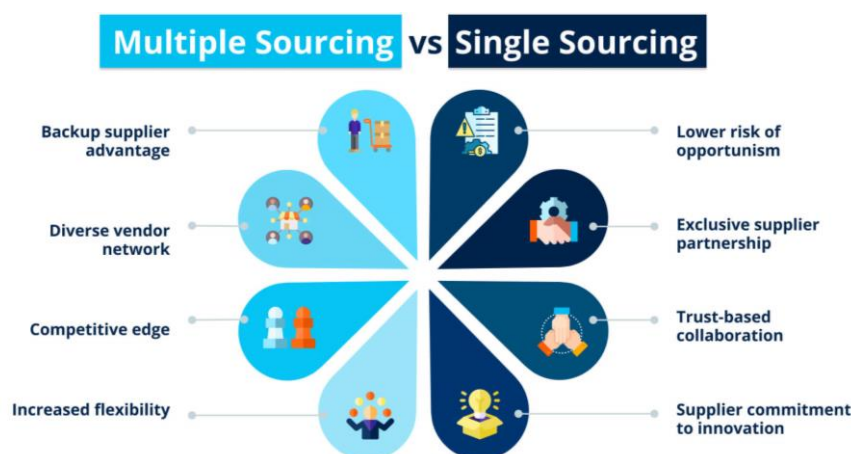


Fig 1: Multiple-Sourcing [4]

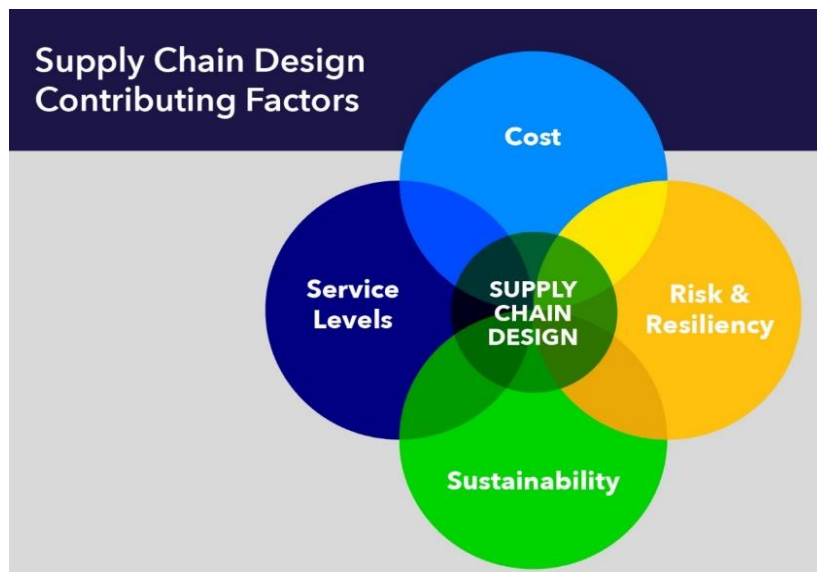


Fig 2: Supply Chain Design Metrics [5]



Fig 3: Supply chain Network [3]

## VI. CONCLUSION

The vendor networks for twin-sourcing resilience offers a strategic pathway to balance reliability and cost-performance in increasingly more uncertain worldwide deliver chains. by means of integrating twin-sourcing and multi-sourcing frameworks, companies can mitigate disruption dangers, optimize procurement strategies, and enhance long-term resilience without inflating operational prices. The literature demonstrates that simulation-primarily based fashions, wise contingent sourcing, and dynamic provider score structures enable agencies to respond proactively to capacity fluctuations, regulatory requirements, and cyber-bodily disruptions. moreover, coordination mechanisms such as agreement alignment and product substitution strategies provide introduced flexibility in retaining service tiers at the same time as managing provider chance publicity. Importantly, resilience is not carried out merely by means of including extra carriers however by means of designing adaptive

vendor networks that align sourcing strategies with call for patterns, technological reliability, and regulatory compliance. for this reason, twin-sourcing resilience is a planned optimization approach balancing redundancy with performance that empowers deliver chains to face up to shocks, lessen vulnerabilities, and maintain aggressive advantage in cost-conscious surroundings.

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