

# How COVID-19 Pandemic Has Impacted the Supply Chain in the Electronics Industry

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**ABSTRACT:** For many decades, a relatively stable supply chain has endured for global industries. The Thailand floods, Japan's Tsunami leading to a nuclear plant leak in 2011, and Iceland's volcano eruption in the same year severely disrupted the global supply chain with the electronics manufacturing companies, but only for a short period of time. These natural disasters were confined to certain geographical sectors and the operational interruptions were short-lived. The COVID-19 pandemic has, however, presented companies with a radical set of challenges that will require a transformational shift in the supply chain strategy and operations management for all industries. By associating the VUCA (Volatility, Uncertainty, Complexity, Ambiguity) theoretical framework with the global supply chain challenges experienced in the COVID-19 pandemic, research hypotheses regarding future supply chain strategies for the electronics and semi-conductor industry players were developed and tested. Sample data was gathered with industry practitioners utilizing a convenience sampling. The results demonstrate that industry practitioners, research institutions, and the Biden administration have touted the need to re-shore manufacturing and reduce dependency on foreign countries. Outsourcing decisions justified through a cost-benefit-risk analysis must constantly be applied. Just-In-Time (JIT) and Lean, a prevalent strategy, has turned into an Achilles heel during the COVID-19 pandemic times. The trade-off analysis to maintain a safety stock of critical components has become an essential variable for decision-making. Single-sourcing is abhorred, while multiple-sourcing supported by increased data visibility with effective ERP systems has become a strategic imperative. Partnerships with vendors, suppliers, logistics providers, and all stakeholders must be strengthened and continuously enhanced in the VUCA supply chain for the years to come. The primary takeaway from the research is that top management and supply chain leaders must focus their efforts on building an agile and resilient global supply chain network as the days of relying on offshore manufacturing and an absolute JIT and Lean strategy is behind us.

**KEYWORDS:** electronics, manufacturing, supply chain, outsourcing, lean

## **Introduction**

A few decades ago, the U.S. Army War College coined the acronym "VUCA" in an attempt to characterize the environment in which military personnel would need to operate in the future. VUCA—standing for volatility, uncertainty, complexity, and ambiguity—has recently become a generalized term adopted across both geopolitical and business contexts to describe turbulence (Benjamin Baran & Woznyj 2021). The COVID-19 pandemic – VUCA operating at a hyper scale - exhibited the utmost challenge and turbulence faced at a global scale by industries never experienced before in history. Global corporations faced an unprecedented challenge to manage supply and demand in their supply chain during the pandemic as well as post-pandemic. The Just-In-Time (JIT) and lean manufacturing strategy coupled with extensive outsourcing to foreign suppliers and manufacturers, a predominant supply chain strategy adopted by global firms, exhibited the vulnerabilities that were not experienced before in a relatively stable environment. As companies now enter the post-pandemic phase, the question is what firms are doing to address these supply chain risks and issues that have plagued them during the pandemic and continue to arise in a VUCA environment. Thus, the paper aims to address some of these questions specifically for the electronics sector. What strategies are firms in the electronics sector taking to address risks of JIT and lean approaches? Has the pandemic provided impetus for these

companies to re-shore manufacturing and/or bring them closer to home? What strategies can be taken to operate in VUCA and adapt their supply chain proactively?

## Literature Review

Towards the end of the 20<sup>th</sup> century, businesses moved towards globalization, resulting in a greater need for supply chains to migrate from regional to global. The opening of China's economy attracted a wave of outsourcing and a shift to offshore manufacturing among global corporations. Within a decade, from 1995 to 2006, imports from China grew to \$300 billion per year from a \$45 billion industry. Especially in the electronics industry, the wave of outsourcing and offshore manufacturing increased considerably in the past decades. By value, the five largest exporters of electronic circuit components are Hong Kong, Taiwan, mainland China, Singapore, and South Korea that generated 71.9% of global sales for electronic components in 2022. Such high concentration on electronics manufacturing within this region proves the exposure and vulnerability in the event of a supply-chain disruption (Workman 2023).

As a result of the increasing pace of outsourcing across the world, global supply and demand in a competitive VUCA global environment will inevitably require companies to develop and implement robust and effective strategies to recruit global talent and deploy advanced technological tools to manage a highly complex and diverse global supply chain. In 2005, to reflect the need to merge strategy and operational execution, the Council of Logistics Management changed their name to the Logistic Council of Supply Chain Management Professionals. The council also defined supply chain management as follow: *"Supply chain management is the systemic, strategic coordination of the traditional business functions and the tactics across these business functions within a particular company and across businesses within the supply chain for the purposes of improving the long-term performance of the individual companies and the supply chain as a whole* (Supply Chain Market 2004)."

The origin of JIT and lean manufacturing has been attributed to Toyota Motor Corporation. Toyota's production control system was established based on many years of continuous improvements, with the objective of making the vehicles ordered by customers in the quickest and most efficient way. The Toyota Production System (TPS) was established based on two concepts: "jidoka" (which can be loosely translated as "automation with a human touch"), as when a problem occurs, the equipment stops immediately, preventing defective products from being produced; and the "Just-in-Time" concept, in which each process produces only what is needed for the next process in a continuous flow. The definitions of Lean Management emphasize the aspect of eliminating waste. The Just-In-Time (JIT) system is defined in a similar way, while emphasizing mainly the aspects of smooth flow and "having the exact amount of stock goods arriving at the exact time you need it". This strategy imposed minimum inventory to keep the production line running (Clutterback 1978).

White (1993) reported in a survey conducted with 1,035 US manufacturers that a majority of the respondents (86.4%) indicated JIT provided an overall net benefit for their organization. Only 4.9% reported no overall net benefit resulted from implementing JIT. The study also found that firms with 500 or more employees typically implement JIT management practices more often than organizations with less than 500 employees, and the length of time each JIT management practice has been in operation is typically longer for the larger organizations. Overall, the findings suggest JIT manufacturing adoption was beneficial for all US manufacturers regardless of size or type of process employed.

A literature review on the history and development in global outsourcing and offshore manufacturing must invariably include the world's largest electronics corporation, Apple Inc. Apple's phenomenal commercial success is paralleled by, and based upon, the scale of production in its supply chain factories, the most important of them located in Asia (Apple 2012a, 7). Foxconn, a Taiwanese company, employs 1.4 million workers in China, is currently the principal manufacturer of products and components for Apple. Just as Apple has

achieved a globally dominant position, described as ‘the world’s most valuable brand’ (*Brand Finance Global 500*, 2013), Foxconn rose to become the largest electronics contract manufacturer in the world.

Since the mid-1960s, IBM, the leader in business computing, migrated its labor-intensive production from the United States and Europe to Asia to take advantage of cost-savings. Microelectronics components assembly was outsourced to Japan initially and then Taiwan due to considerably lower costs of labor (Ernst 1997, 40). Electronics assembly grew rapidly in Taiwan, South Korea, Singapore, and Hong Kong (‘the Asian Tigers’), and later Malaysia, Thailand, Indonesia, and India.

Moving towards the 1970s, Philippines attracted foreign investments in the likes of Intel and Texas Instruments and started production facilities for foreign semi-conductor firms. In the late 1970s, China set up special economic zones to attract foreign capital and boost exports as a means to integrate regional and global economies. Over two decades, the Chinese national economy grew immensely and expanded its manufacturing capabilities in the electronics, apparel, and other key industry sectors to become a production powerhouse of the world. Prior to the pandemic, there was already growing interest towards analyzing the meaning and scope of reshoring processes. Reshoring is understood as bringing back to a company's country of origin of a production activity that it had previously offshored. In the United States, data provided by ReshoreNow (2021) proved that reshoring increased in 2020, with a total of 1484 more companies returning home and a record number of 109,000 jobs created, bringing the total jobs added since 2010 to more than 1 million (Bilbao-Ubillos et al. 2023).

Having acknowledged that global outsourcing, offshore manufacturing, JIT and lean strategies had enabled firms to stay competitive in the pre-pandemic environment, the question begs how assured are these firms to rely on the same strategies in a post-pandemic VUCA environment?

According to Stalk and Mercier (2022), today’s supply chains are in a system crisis. System crises need system solutions. Managements of companies that understand this phenomenon can take counterintuitive actions that will result in competitive advantage and better supply chain performance than competitors who do little. Marc Bitzer, Whirlpool’s chairman and CEO, said it best, “The only safe supply chain is the short one — short in distance and in time.” Physically shortening your supply chain by “reshoring” (i.e., switching to a domestic supplier from a foreign one) or “near-shoring” (i.e., switching to a supplier in a country that’s closer to your operations or customers than the one you have been using) reduces the time items spend in the supply chain but often takes the longest time to accomplish. The supply chain disruptions of recent years have made many companies doubt the wisdom of adhering to the just-in-time approach to managing inventories in the system. These firms are now contemplating maintaining “just-in-case” inventories and refining your just-in-time system by adding inventories strategically.

Toyota, the master in JIT and Lean, was rather more prepared than their competitors since they had an earthquake and tsunami 10 years previously. With this disaster occurrence, Toyota learned to adapt and make sure they were prepared in the case of another disaster by stockpiling on semiconductors. However, even with their semi-preparedness, Toyota was unable to maintain this level throughout the entirety of the pandemic which resulted in their miss of their target. Since the pandemic, there have been more “investments in plants to specifically manufacture chips for the motor industry” (Oi 2022).

Shih (2020) asserted that outsourcing is not going away post-pandemic. Modern products often incorporate critical components or sophisticated materials that require specialized technological skills to make. It is very difficult for a single firm to possess the breadth of capabilities necessary to produce everything by itself.

In June 2021, the Biden-Harris Administration released the conclusions of its 100-day review of supply chains for four critical products: semiconductor manufacturing and advanced packaging; large capacity batteries, like those for electric vehicles; critical minerals and materials; and pharmaceuticals and active pharmaceutical ingredients. (Helper and Soltas 2021).

Congress approved a bill to provide \$50 billion in investment to advance domestic semiconductor manufacturing and research. In addition, another action was proposed to address international vulnerabilities to supply chains. Echoing Shin (2020), the administration realized it does not make sense to produce everything at home, and because U.S. security also depends on the security of our allies, the United States must work with its international partners on collective approaches to supply chain resilience, rather than being dependent on geopolitical competitors for key products (Vakil 2021).

At the height of the pandemic crisis, many firms could not identify all of the suppliers they work with and thus scrambled to find alternate supply sources. Firms should keep detailed records of all their primary, secondary, and tertiary suppliers so they can easily identify problem areas in their supply chains. Organizations should also create relationships with alternate suppliers to ensure shipment of parts and materials. It may just appear their main suppliers cannot deliver parts, but alternative suppliers can.

Milewski (2022)'s study on the benefits of JIT and lean asserted that the scale of benefits was strongly dependent on the value of products and the scale of production. Simulations were carried out for four product groups: food products, footwear, electronics, and mobile phones. In the case of cheap products and small scale, the implementation of JIT resulted in a significant increase in the costs of logistics processes when delivery distances are longer. Savings of over 70% appeared in the case of expensive mobile phones, even over long distances. In the case of large-scale production sites, large cost savings occurred in almost all cases (up to over 90%). Furthermore, simulations of the impact of JIT on the profitability of enterprises were also carried out using the data contained in the financial reports of listed companies. These simulations showed a significant impact of JITs on the efficiency of companies and an increase in revenues (Milewski 2022).

## **Research Approach**

The purpose of the research is to determine if the top global electronic corporations have made any significant adjustments to their supply chain and outsourcing strategies. These companies predominantly adopted offshore manufacturing, JIT, and lean manufacturing strategies across their supply chain for many decades until the COVID-19 pandemic. The post-pandemic has now exacerbated the industry into a hyper-VUCA environment. Through meta-analysis of the most recent research publications, announcements of the major electronics firms in the global industry, and interviews with key supply chain executives, the following hypotheses will be tested:

Hypothesis 1: Electronic companies have embarked on the process of near-shoring and/or re-shoring in manufacturing of critical components and end-products in the VUCA environment.

Hypothesis 2: Electronic companies have increased suppliers in the sourcing of critical components and supply chain visibility in the VUCA environment.

Hypothesis 3: Electronic companies have moved away from absolute JIT and lean manufacturing strategies and increased safety stock in critical components in VUCA environment.

## **Results**

In an interview with a recently retired senior manager of Apple's China supply chain and logistics team by the researcher, the research questions were posed to gather a first-hand account of the

impact of the pandemic on Apple's supply chain. In the area of near-shoring and/or re-shoring in manufacturing of critical components and end-products, the respondent articulated that as a result of the recent lockdown of Foxconn's manufacturing sites in China during the pandemic, which exposed the vulnerability and supply risks of relying primarily on a single country source, Foxconn has been pressured by Apple to diversify their production to other countries namely; India, Vietnam, and Thailand. In fact, the latest iPhone 15 launched in September 2023 was produced in two manufacturing sites located in China, Zhengzhou, and India, Tamil Nadu.

When the respondent was asked about the possibility of moving away from JIT and lean strategy, it was explained that JIT and lean had contributed to extensive inventory and capital costs savings in their operations in the past and will continue to stay. From Apple's standpoint, in order to be appointed as key suppliers, the suppliers must commit to set up production and distribution facilities close to Apple's final product-manufacturing sites. Unlike their smaller competitors that may not have the volumes and bargaining power to pressure suppliers to go along with a vendor-managed inventory strategy, Apple mitigates any risks of supply shortage without incurring excess inventory stocking costs. According to the respondent, the primary challenges encountered during the pandemic were attributed to the geopolitical and trade tensions between the United States and China, coupled with China's zero-COVID-19 policy, provided further impetus to diversify the manufacturing capacity to multiple country sources. He added that most companies that relied on China as the primary production source will inevitably migrate to dual and multiple sources based on lessons learned during the pandemic.

With regard to critical component strategy, Apple has relied on outsourcing to one key supplier, Intel, for many years and has recently developed and designed its own microprocessors, M1 and M2 chips. In Dec 2022, Tim Cook, Apple's CEO confirmed that Apple will buy U.S.-made microchips at an event in Arizona on Tuesday, where President Joe Biden also spoke. Cook said Apple would buy processors made in a new Arizona factory, owned, and operated by Taiwan Semiconductor Manufacturing Company, the biggest foundry company with over half of the global market share. TSMC produces the most advanced processors, including the chips in the latest iPhones, iPads and Macs. Cook said. "Today we're combining TSMC's expertise with the unrivaled ingenuity of American workers. We are investing in a stronger brighter future; we are planting our seed in the Arizona desert. And at Apple, we are proud to help nurture its growth." "Apple had to buy all the advanced chips from overseas, now they're going to bring more of their supply chain home," Biden said. "It could be a game-changer." This radical shift demonstrates the strong alliance between corporations and government to encourage reshoring and insourcing of critical products and components back to the United States from offshore countries.

Drawing from a face-to-face interview on Feb 22, 2022, between Bloomberg's Caroline Hyde and Micron Technology Inc.'s CEO, Sanjay Mehrotra, on the current state of supply chain issues post-pandemic, it was found that Micron successfully navigated the turbulence of the supply chain problems with a strong and resilient supply chain developed even prior to the pandemic. Micron applied deep data analytics to identify vulnerabilities in their supply chain and addressed the risks and as such built redundancy in their network. Through multiple sourcing and supplier strategies, Micron mitigated the impact of the oil and gas supply disruption in the Eastern Europe region as a result of the recent Ukraine-Russia war for their production plants. In addition to multiple offshore manufacturing facilities in Taiwan, Singapore, Japan, Malaysia, Micron hosts two production plants in the United States in Manassas, Virginia, and Boise, Idaho, the headquarters that ensured consistent product supply throughout the pandemic (Bloomberg 2022).

In a follow-up announcement from Micron on October 6, 2023, by Zacks Equity Research, it reported that Micron has officially started the construction of a new memory chip factory in Boise, Idaho. This will mark the United States' first memory chip manufacturing

facility in the last 20 years. Micron revealed that it would indirectly infuse approximately \$15.3 billion into the Idaho economy and directly spend about \$13 billion on Idaho businesses throughout the lifespan of the project. This will make it the largest-ever private investment in Idaho history. Micron currently has only design and research & development centers in Boise. With the new fab factory, the company will be able to assemble memory chips domestically. The project is anticipated to bring more than 17,000 jobs to the state, of which at least 2,000 of the staff will be directly employed at Micron (Zacks 2023).

During an Intel Developer forum held in September 2022, Intel the leading semiconductor company announced that it was spending billions to establish new factories in Ohio, Magdeburg, Germany, and other countries. Intel also scored a win by lobbying the U.S. government to pass the U.S. CHIPS Act, which will open up subsidies to the tune of billions for the chipmaker to build its Ohio factory (Shah 2022). Intel's CEO, Pat Gelsinger also addressed the need to multi-source considering the recent challenges encountered in the US-China tensions, such as export controls have limited the types of semiconductors that chipmakers can ship to China and other countries considered rivals to the U.S. He said Intel has distributed its foundry operations so as to adjust to the geopolitical shifts around localizing chip manufacturing and securing domestic semiconductor supply chains.

In an interview between Michael Dell and Financial Times in April 2023, chief executive of one of the world's biggest computing groups commented that Dell is "intently focused" on buying components from outside China due to growing concern over supply-chain disruptions (Gross 2023). Dell said customers were asking it to diversify where it sources components. That push comes at a time of rising tension between Washington and Beijing and after the Covid-19 pandemic exposed vulnerabilities to disruption in the production of semiconductors. "We want to ensure the ongoing availability of products and so having a more resilient supply chain is incredibly important given the nature of the world that we live in today," said Dell. The company is also one of the three largest computer vendors in China, along with Lenovo and HP (Gross 2023). The PC and server group has manufacturing outposts in the US and China, as well as Malaysia, Brazil, India, Poland, and Ireland. In the latest report published by Reshoring Initiative (2022), it was also reported that the Chips Act ratified by the Biden-Administration has boosted reshoring by 53%. Reshoring data as found in this context can be defined as U.S. headquartered companies and FDI by foreign companies that are shifting production or sourcing from offshore to the U.S. The EV Battery and Semiconductor sector investments account for the largest increases in job announcements (Reshore 2022), generating more than 360,000 jobs, a 53% increase compared to the previous year.

## **Discussion and Conclusion**

With regard to the first hypothesis, in the VUCA state, the largest electronic companies have clearly embarked on the process of near-shoring and re-shoring in manufacturing of critical components and end-products to reduce the reliance and dependency on China. The U.S.-China trade war has driven some firms to shift to a "China plus one" strategy of spreading production between China and an Asian country such as Vietnam, Indonesia, Thailand, and India (Shih 2020).

On the second hypothesis, electronic companies have also increased and diversified their supply base in the sourcing of critical components. Per the findings gathered from the interviews with Apple, Micron, and others, supply chain executives and managers have committed to invest in better information systems to identify risk and enhance supply chain visibility in the VUCA state.

Finally, on the third hypothesis, the findings revealed that these top electronic companies have not diverted from absolute JIT and lean manufacturing approaches in the areas where there is strong bargaining power with their suppliers to support a lean and short

lead time in materials supply for their global manufacturing locations. For critical components such as semi-conductors, it is evident that these top electronic companies have adopted a strategic shift to multi-source these critical components closer to home such as the United States and Europe in addition to China and Taiwan. According to Shih (2020), safety stock, like any inventory, contradicts the popular practice of just-in-time replenishment and lean inventories, a cost-benefit analysis to determine if the savings versus potential lost revenues due to a supply chain disruption should help guide decision-making towards holding safety stock or continue with JIT.

The study demonstrates that industry practitioners, research institutions, and the Biden administration have all touted the need to re-shore manufacturing and reduce dependency on foreign countries. Outsourcing decisions should be carefully reviewed and justified through a cost-benefit-risk analysis. Just-In-Time (JIT) and Lean, a prevalent strategy, has turned into an Achilles heel during the COVID-19 pandemic times. The trade-off study between zero-inventory and holding critical inventory is a strategic step in the decision-making process. Single-sourcing is abhorred while multiple-sourcing supported by increased data visibility with effective ERP systems has become a strategic imperative. Partnerships with vendors, suppliers, logistics providers, and all stakeholders must be strengthened and continuously enhanced in the VUCA supply chain for the years to come. The primary takeaway from the research is that top management and supply chain leaders must focus their efforts on building an agile and resilient global supply chain network as the days of relying on outsourcing to offshore manufacturing and an absolute JIT and Lean strategy is behind us.

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