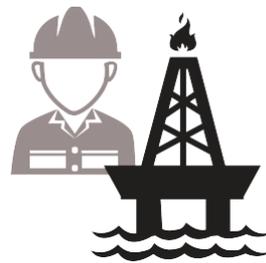
An offshore oil rig is shown in the middle of a stormy sea with dark, heavy clouds. The rig has three tall, lattice-structured towers. The overall scene is dark and moody, emphasizing the hazardous nature of the environment.

The Hazards of Global Supply Chains

EXECUTIVE SUMMARY

In Spring 2020, a global outbreak of the COVID-19 illness spurred a global pandemic that caused immense loss of life and greatly disrupted economic activity in the United States and around the world. Much of the adverse economic effects are attributable to quarantined workers and temporary suspension of travel and shipping from affected areas. Many of the quarantined regions have high concentrations of manufacturing; global supply chains for critical goods—including medical supplies and equipment—were especially strained. Supply chain failure in a pandemic is unavoidable if extensive offshoring and foreign geographical concentration of manufacturing capability has occurred, which has been witnessed globally for quite some time.



Such offshoring has resulted from progressive industry decisions to pursue cost savings in the short term without consideration of the deeper effects some decisions may have in the long term or under special conditions. In such cases, corporate strategies often diverge from national interest, where better information on the effect of such decisions on the supply chain may lead to more mutually beneficial proactive decisions. It is also prudent to develop an ability to rapidly standup manufacturing capability in sectors that have been downsized in the US or to develop new flexible manufacturing capabilities so that rapid reconfigurations can be realized. This critical supply chain preparedness can be encouraged through economic policies and a more connected network of small and medium businesses, but ultimately may require government incentives for critical industries.

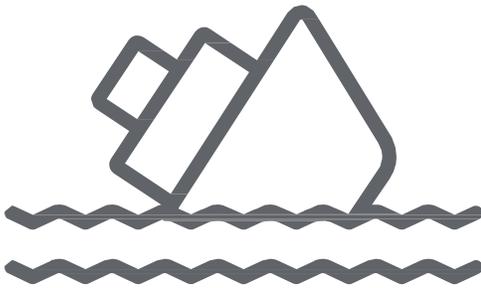
Introduction

It is generally understood by the public that manufacturing involves making things and conjures up images of beer bottles on conveyors or robots welding automobile chassis. It is further understood that product manufacturers depend on suppliers for necessary components to carry out their manufacturing capabilities. In obtaining these components, it is sometimes beneficial and of sound strategy to outsource some of the manufacturing. For example, a car manufacturer may find it too expensive to maintain glass production facilities and the materials scientists that specialize in glass research. Therefore, these manufacturers may see an economic and performance incentive from purchasing windshields from an outside supplier. The supplier can provide a superior product because they maintain expertise and production facilities for all the activities involved, including quality control, production machinery operation, process validation, and research. Since they can supply similar products to other car manufacturers, and other markets such as architectural glass, they can achieve *economies of scale* that a car manufacturer cannot achieve when working alone. That is, they can have a larger, more focused effort on producing quality glass products than a car manufacturer can afford to maintain. The result is a superior and also less expensive product, because such a vendor can afford dedicated machinery for producing glass.

This scenario outlines common questions companies must ask: what portion of products, if any, should be manufactured directly in house, and what portion of products, if any, should be obtained through a supply chain? If a product can be obtained elsewhere at higher quality and/or lower cost, then it usually makes tactical sense to purchase the product from another vendor. In this case, the manufacturing activity has been *outsourced*.

This outsourcing approach has many opportunities, but also drawbacks. The opportunities are tactical. Short-term benefits include economic and performance improvements without the need for extra investment of capital or time for new facilities and development of expertise. The long-term strategic benefits are less obvious, more difficult to predict, and may be illusory. Using the automotive windshield example, if this product is outsourced and the internal glass production facility is closed and liquidated then the automobile manufacturer has little recourse when the windshield price is doubled by their sole supplier, especially when no predictive market capability exists to forecast that this might happen. This danger or drawback is often minimized by establishing long-term partnerships with suppliers. There are many management approaches that address these issues, such as diversifying sourcing, protection through contracting, and the promise of future business. A risk for the supplier is that the manufacturer may push the cost of making technology advancements and/or changes in their products onto their suppliers, thus causing a supplier to liquidate if they cannot afford the investment needed for updating their manufacturing processes.

The result is that companies generally focus on and invest in their core competencies, making certain that their competencies align with the product they are selling. For instance, an automotive company may correctly assess that their competencies are in engine and chassis manufacture, but the seats can be outsourced. The outsourcing vendor subsequently focuses on producing the best possible component, and aligns their business strategies accordingly, and so on down the supply chain. Outsourcing has, with few exceptions, led to substantial efficiency and cost improvements that have resulted in superior products at lower prices compared with complex products produced by a single company.



Offshoring

As previously discussed, outsourcing a component can have many positive effects. These same benefits can also occur when a product is outsourced to a company located in a different country, termed *offshoring*. In addition to the benefits also seen with outsourcing, offshoring brings its own set of benefits and drawbacks.

These additional benefits can be substantial. If tax and labor rates are lower overseas, then a component can be produced at proportionately lower cost, all else being equal. Similarly, just as Henry Ford created a market by employing workers in his factory and producing cars that his workers could afford, international markets can be created by offshoring. Additionally, energy savings are often realized through offshoring. Copper smelting in Chile is a common practice where locally available sand is roughly 2.5% copper. Locating a smelter near this source avoids extensive shipping costs for soil back to the prime country, such as the U.S., and allows extraction of the copper locally.

Over the last two decades, one of the main drivers of offshoring has been the ability to drastically reduce the cost of labor involved in manufacturing. If labor rates in the U.S. average \$30 per hour for an industry, and that labor can be offshored for \$5 per hour, enormous cost savings can be realized in offshoring labor-intensive activities.

However, there are also inefficiencies associated with offshoring. There can be hidden costs, such as transportation, additional inspection, additional inventory, and cultural differences, along with a loss of in-house technical expertise and know-how, limiting agility. These drawbacks can be worse than simple inefficiencies and may lead to large problems down the road, especially in cases such as a global pandemic. Therefore, the common practice of driving out cost at any measure is short-sighted and can compromise the long-term competitiveness of a company and ultimately the nation, especially in high-technology sectors.

Some hazards clearly elevate offshoring beyond the level of inconvenience: tax rates can be raised, industries can be socialized without clear warning, or vendors can be acquired by venture capitalists that demand greater short-term profits. The result is the potential that cost, quality, and reliability of supply can be adversely affected, even if all of these are favorable at a time that a decision to offshore has been made. Such risk puts American competitiveness at a decided disadvantage.

The problem of reliability of supply has been long recognized. If a country goes to war, or is surrounded by neighbors at war, then the likelihood of impeded commerce increases. Geopolitical influences can shut off supplies, which has been seen with the Apartheid embargoes against South Africa in the 1970s and 1980s, or the more recent U.S. tariffs on imports from China. This results in significant disruption with implications on the availability of industrial materials. Further, a country could also use policy to forward political ambitions or motives, examples being the OPEC oil embargo of 1973, this decade's Chinese export restrictions on rare earth metals, and the most recent export restriction seen in the wake of the COVID-19 pandemic on critical medical supplies such as face masks. Unrest and revolution can also lead to supply disruptions, as can natural and man-made disasters including earthquakes, tsunami, fires, storms, floods, and pandemics. Any concentrated offshoring effort will have consequences of potential supply interruption at some point, no matter what other actions or management strategies are pursued.



Supply Chains

The discussion so far has addressed products with a single component that has been outsourced; in practice, a manufacturer (or more accurately, an original equipment manufacturer - OEM) will outsource many components. These components are purchased from Tier 1 suppliers, but these suppliers may in turn rely upon Tier 2 suppliers, who are also dependent on their own suppliers further down the chain. Such stacked dependencies create increased risk.

A supply chain is a system of companies, information, and resources that transform materials into products that are delivered to, and purchased by, a consumer. For advanced products, supply chains can become incredibly complex networks of organizations. Supply chains take time to organize, but once established, they have flow of material and embedded information starting from the basic resources to the completed product. The map can be complicated, such as when many tiers of suppliers or multiple suppliers are used for a particular component or raw material. Information transfer up and down the supply chain is generally tightly controlled, so that entities may try to maximize their profits within their sphere of activity without a true appreciation of the enterprise as a whole. This has led to supply chain management, which is related to the monitoring, analysis, and decision making associated with supply chains.

Supply chains offer a methodology to predict when resources or components will be needed, and in what quantity. For example, a vendor for computer keyboards will inform its suppliers of the need for plastic, wiring, limit switches, and injection molded structures in order to meet production goals communicated from higher tiers. A product manufacturer, with the benefit of supply chain management, will be able to transfer necessary information or orders to its suppliers in a timely fashion and make production estimates based on the current output of all of its suppliers. Supply chain risk can therefore result from unreliable suppliers, particularly if they are located near choke points.

A choke point is a location in a supply chain that causes disruption in manufacturing if it is interrupted. The disruption has the most impact if there are no redundant paths in the supply chain for delivery of components. Supply chain managers recognize this and are accustomed to accommodating unreliable sources near these points. Usually this requires contact with alternative sources, calling for bids on products, and integrating them into the supply chain—a difficult and involved endeavor as discussions over key issues such as materials, design attributes, production volumes, and quality must take place before a bid can be made. Then, the manufacturing processes must be validated and outcomes certified. Once a bid is accepted, a vendor needs to set up production lines or cells and arrange for their own suppliers. It is therefore of utmost importance to effectively manage the reliability of suppliers near these choke points, particularly for those supplying customized or critical components.

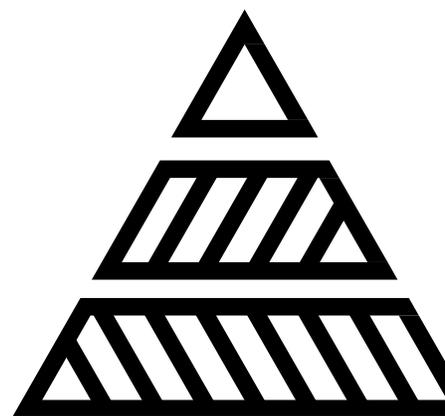
Supply Chains in Times of Pandemic

During stresses such as the COVID-19 pandemic of 2020, production of critical supplies that takes place in a given region or country represents a choke point. This has long been recognized as a concern for supply chain viability and a likely source for disruption.

From a strategy standpoint, manufacturers need to assess the likelihood and severity of supply chain disruption in such a dynamic environment. A manufacturer may assess the implications of such a disruption in terms of economic impact, particularly when all manufacturers depend on the same supplier (or region), in which case a disruption affects an entire sector or economy. When this sector relates to human health and well-being, the risks are enormous.

Concentration of production by an industry sector in one region is therefore especially high-risk and transcends the interests of a single company or entity. It is unreasonable to expect individual companies to make decisions based on the trends of an entire sector, especially if they don't have the sector-wide information necessary for the decisions; *therefore, guidance through policy is warranted*. Due to the nature of the budgeting and funding structures, private sector companies typically undertake initiatives with a shorter expected profit turnaround time. Conversely, the federal government embarks on initiatives with longer-term impacts through policy, allowing it to act as insurance to these corporations. To succeed, a country needs both the vibrant dynamics and quick pace of private sector companies, in partnership with the stability of government policy.

The result is that in an environment of offshoring to a particular region, pandemics can have catastrophic impact. Social management practices such as "quarantine in place" can slow but not eliminate the disastrous effects of a pandemic. *Managing the supply chain without policy guidance is not a viable method of eliminating the disruption within the short and ever-changing time constraints of a pandemic*. When the supply chain fails, it is already too late.



Offshoring as a Strategic Failure

Offshoring has traditionally been pursued because of pure economic advantage, to the detriment of U.S. employment, technical competitiveness, and resilience. From the perspective of an individual company, the decision to offshore an aspect of its supply chain is often rational, as there are clear economic benefits—especially when risks such as supply chain disruption can be estimated, quantified, and mitigated. However, the risk to citizens of a nation or a region—whether they be security, health, or economic risks—are not among the consideration from an individual company perspective; the well-being of citizens is the purview of government. Offshoring manufacturing capability can lead to critical market failure, and in the case of the U.S., the loss of critical domestic manufacturing capabilities. As the COVID-19 pandemic made clear, flexible manufacturing capabilities are essential for the economic and national security of the United States.

It is recognized that elimination of a hazard is a far superior strategy than accommodating a hazard with behavior changes. The only ways to have a robust supply chain in a time of pandemics are to maintain a manufacturing footprint in multiple locations, and to invest in development of advanced, flexible manufacturing technologies that can enable the required manufacturing capabilities to be rapidly stood up, thereby ensuring resilience in times of a national emergency. Given the size of the American economy and population, it is therefore both an ethical and strategic imperative to maintain critical manufacturing capability within the United States.



Recommendations

When global emergencies such as pandemics occur, conventional supply chains emerging from existing economically driven considerations cannot cope. In such cases, catastrophic outcomes, such as those experienced in 2020, are inevitable.

Robust global supply chains need to be rethought with integrated industry-society-government consensus in mind. Recognizing that this problem transcends industry interests alone, it is recommended that:

1. The Federal Government should create globally competitive incentives for U.S. manufacturers to maintain or establish domestic capabilities and rapidly scalable manufacturing capacities in industry sectors critical to the health and well-being of the U.S. economy.
2. The Federal Government should invest in research and development aimed at creation of transformative advanced manufacturing technologies that will enable rapid scale-up of manufacturing capacities of critical goods to meet domestic needs in times of a national emergency.
3. The United States should implement the recommendations in ASME's *Strategic Plan for Strengthening the U.S. Manufacturing Sector* and prioritize areas that are critical for economic welfare and national security in the future.
4. Public-private partnerships between government and industry that promote domestic manufacturing activity—such as the Manufacturing USA program, advanced manufacturing activities at the National Science Foundation, and the NIST Hollings Manufacturing Extension Partnerships program—should be made competitive with the investments of other nations. *The lack of manufacturing infrastructure in the United States should never be the rationale for offshoring.*



Supply chain management education infrastructure should ensure that industry interests are not the only interests considered in the establishment of manufacturing networks, but those of the government, and overall national and societal interest, should be presented as well.

This statement represents the views of the Manufacturing Public Policy Task Force of the ASME Committee on Government Relations and not necessarily the views of ASME as a whole.

