

# The Effects of COVID-19 on the California Metal Casting Industry Supply Chain

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## Abstract

In 2020, the COVID-19 pandemic had a profound effect on all supply chains and markets worldwide. However, most of the analysis has taken place from the brick and mortar or buyer's perspective. The purpose of this paper is to capture the effects of these closures and business limitations further upstream at the supplier level. Specifically, the metal casting business that supplies all sorts of industries, from medical implants to construction. Due to the cancellation of non-essential surgeries at hospitals, demand for medical implants has stagnated while the demand for construction has continued. By surveying stakeholders in California's metal casting industry, this research explores how this complex and diverse vocation fulfills these demands and how they have adapted to these changes.

## Keywords

COVID-19, Manufacturing, Supply Chain, Metal Casting, Production

## 1. Introduction

In the aftermath of the 2020 COVID-19 pandemic, many businesses and industries experienced drastic and uncontrollable changes. In perhaps one of the most overlooked industries, net shape and metal casting manufacturing businesses were not exempted from the list of casualties. In initial research for the effects of COVID-19 on industries, the commonality is that the analysis has occurred on the brick-and-mortar level. In other words, from the buyer's perspective. This paper aims to research and analyze the affect effect that the COVID-19 pandemic has had on the casting industry from further upstream in the supply chain... the supplier level. Since this industry fulfills such a wide variety of needs in the marketplace, from large-scale construction to medical implants, and even household appliances, the effects carried from the initial shock and followed through with the unique restrictions have formulated a unique set of challenges for the industry to overcome. Hospitals canceled non-essential surgeries, and the demand for medical devices stagnated while the demand in the construction industry surged. By providing research through exclusive interviews with industry professionals, we will be able to analyze where the supply chain fell short and how net shape manufacturers were able to overcome this unique set of challenges.

## 2. Objectives

This research paper will explore how the metal casting industry has been affected by this global pandemic and key response decisions and whether they appropriately interacted to overcome the pandemic's hindrance to business. Using other key studies and business resources for reference and interviewing plant managers in the field, we considered specific elements like work reduction due to decreasing demand, worker safety changes, and indicators like lead time and inventory to understand the effect on businesses.

## 3. Literature Review

Wetzel (2020) investigated the impact of COVID-19 on foundries in the Midwest to see how their production shifted due to the COVID-19 pandemic. They found that some foundries pivoted from their typical products to manufacture components for ventilators, MRI machines, etc. This pivot allowed the foundries to remain working, and in one case,

increase production and use overtime to keep up with surge demand for these products. Other input from the foundries was the use of on-site 3D printers to make face shields for the local community. The same journal touched on some of the pivots the suppliers of the metal casting industry adopted. One company that is a supplier of paints and coatings to the metal casting industry was able to pivot to make hand and bottle hand sanitizer to meet shortages at the onset of the pandemic.

A Staff article in *Modern Casting* (2021) found that the metal casting industry saw a 17% drop in production in 2020 compared to the previous year. This journal projects that the future growth of the industry over the next five years will be 7.5% per year. Additionally, they predict that the industry will grow 20% in 2021, exceeding the drop in production from the downturn caused by the COVID-19 pandemic the year prior.

The Primary Metals Manufacturing sector, which includes metal casting, experienced a 12.8% drop in employment across the United States in this sector (BLS, 2020). The lowest point for employment was recorded at 349 thousand employees in May 2020, whereas it was 388.6 thousand employees once year prior in May 2019. Since May 2020, this sector's employment level has slowly increased, up 2.237% from May 2020 to January 2021.

#### **4. Methods**

This study needed data about how the pandemic impacted different foundries in California. Authors sought to get data directly from primary sources through interviews, as most companies in this sector do not publish their information. We collected contact information on multiple California metal casting companies and were able to secure interviews over Zoom to ask further questions on how their operation had been affected.

We selected two companies in the metal casting industry as candidates to interview that will be referred to as Company A and Company B. In Southern California, Company A is a mid-sized steel and aluminum investment casing foundry that serves the aerospace industry almost exclusively, fulfilling both commercial and military contracts. In Northern California, Company B is also a mid-sized investment casting foundry whose customers are 50% medical, 45% aerospace, and 5% general-purpose investment casting contracts.

We formulated our more general questions based on our combined knowledge of casting processes and the casting industry. Then, we formulated more industry-specific questions based on the background information of the companies.

First, we broke down our more general questions into the areas we wanted to focus on. Some of the major categories were questions on their business focus, day-to-day operations, the effects on specific customers and their industries, and changes to their own supply chain.

More specific questions included how their customers were affected, such as the effects on their specific customers and customers industries, how the workflow and workspaces were changed to keep workers safe, and even whether some of these COVID-19 protocols would continue to be in effect after the pandemic has ceased.

We were not sure how forthcoming the foundries would be about specific numbers due to concerns about privacy, but we also wanted to get as much quantitative data as possible. We asked questions about production levels to compare to that of previous years.

At the beginning of each interview, the contact at the company was asked if it would be acceptable to record the Zoom call so that we could refer to information later as needed. These interviews took place between February and March 2021.

#### **5. Data Collection**

The interview we had with the General Manager of Company A was tailored to find out if there was growth or decrease on the downstream side of the supply chain and to find out the production levels of previous years before the pandemic.

During the first quarter of 2020, the company did not face any challenges due to COVID-19 (Company A, personal interview, February 11). This is because, in the first three months of 2020, the company was still making orders that were placed in 2019. The interviewee noted that their lead time is typically between three to four months on placed orders. Since they were affected three months into 2020, they believe when the pandemic is over, and the economy is on the rise, another three months will elapse before they begin receiving customer orders at the volume of before the pandemic.

The company's current market is essentially all aerospace, including contracts with military and aerospace manufacturers (Company A, personal interview, February 11). There was a notable change in the aerospace industry due to flight restrictions and the fear of contracting COVID-19 due to commercial flights' crowded nature. One of their contracts that has been significantly affected is with the Boeing Company. Boeing themselves think it will take about five years to get back to the production level during the 2019 boom before the pandemic when commercial airlines were doing exceptionally well. Another factor for the decline in Boeing production was the production halt of the 737 Max plane due to crashes, one of them taking place in March of 2019 in Ethiopia and another five months earlier near Indonesia (Ethiopian Airlines, 2019).

Company A did not experience much impact (Company A, personal interview, February 11). Most of their suppliers are small businesses that serve many markets, meaning that a challenging year in one industry would not significantly affect material demand. Although there was no significant impact with suppliers, there was one situation where they had to outsource their wax extrusion used for gating from another vendor due to a problem with their current supplier. The company they typically purchase this wax extrusion from had an entire department get sick, stopping production within that department. Although pandemic has impacted the cycle and lead time of many companies, the decrease in customer orders and the same number of active workers has meant that Company A has shortened their lead time from 18 weeks to 10-12 weeks, making them more competitive on the market.

With this additional downtime, Company A reached out to Yale University COVID-19 project, offering to assist in producing ventilator parts and similar accessories. Unfortunately, they did not receive a response.

We also had the opportunity to interview the Executive Vice President of Company B. Company B's customers are 55% medical devices, 40% commercial aerospace, and 5% general commercial products (Company B, personal interview, March 2). Commercial aerospace was where they felt the most impact, leading to a decline in sales revenue of 22.8%. There was also a decline in the medical device section but not as impactful as commercial aerospace. Along with sales revenue loss, they also lost future contracts due to customers having to put plans on hold as they dealt with their own issues within their company.

As for the company's supplier side, Company B did experience a significant impact with their nickel-based superalloys material supplier (Company B, personal interview, March 2). The supplier's corporate owners decided to close after 50 years of operation due to COVID-19 related issues. Company B was notified by the supplier one day before the official closing day. Fortunately, they were able to find another supplier in southern California. As for lead and cycle times, Company B did not notice much of a change as their cycle time is not limited by the workers they have but rather by the process itself.

In the months leading up to the COVID-19 pandemic, Company B was in the process of expanding to a new facility. In fact, a month before the start of the lockdown, loan paperwork was signed for the construction of a new facility and upgraded tooling for manufacturing. This placed the company in a difficult situation which led them to decide whether to cancel these plans or to continue headstrong and finish this endeavor before costs began to pile up. This strategy of pushing forward rather than falling back particularly resonated with the Executive Vice President and led them even to cut their own pay to make sure that workers did not feel like their job might be threatened (Company B, personal interview, March 2). They believe that repeatedly hiring and dismissing workers erodes their trust. Company B would prefer to invest in their current employees now rather than spend resources finding replacements when business picks up again. Whereas companies of similar size to Company B might have only one certified welder on payroll, this strategy has led Company B to employ three certified welders, making them stand out to customers.

Due to the slowdown in contract acquisition during the pandemic, both companies A and B relied on the Paycheck Protection Program (PPP), created during the COVID-19 outbreak, to keep workers employed. Company B accepted as much as 1.2 million dollars worth of funding to keep its operations stable and its workers employed. Company A attempted a similar endeavor but ultimately had to trim its workforce when its PPP fund could no longer provide.

## 6. Results and Discussion

Based on our interview with Company A, we found that the small metal casting contractor's position in the supply chain leaves them at the mercy of the companies above and below them. Their suppliers serve broad industries and thus do not undergo the same slowdowns that specific industries might experience during times of low demand. Meanwhile, Company A's customers further down the supply chain are large enough to absorb and tighten financials when there is a slowdown in the industry. This means that there will be a more pronounced impact on the middle supplier, the metal casting contractor when there is a slowdown in one sector.

### 6.1 Numerical Results

During the COVID-19 pandemic, Company A had to dismiss 30 employees, going from 80 to 50 employees. Therefore, Company A had an employee retention rate of 62.5% throughout the COVID-19 pandemic. Conversely, Company B reduced employment from 37 to 34 employees throughout the COVID-19 pandemic, resulting in a 91.9% retention rate of employees. These two retention rates are shown in Figure 1 below with the Bureau of Labor Statistics average for the Primary Metals industry for comparison.

Company A had eight positive cases of COVID-19 among the workforce to date, shown in Figure 2. It is believed that these cases were not spread while at the company but instead due to personal lives outside of work. Similarly, Company B had seven positive cases of COVID-19 among the workforce, shown in Figure 3. At Company B, it is also believed that these positive cases were contracted outside of the company.

Boeing's revenue for the last fiscal quarter of 2019 and the year 2020 are shown in Figure 4. Respectively, Boeing saw revenues of \$17.9 billion, \$16.9 billion, \$11.8 billion, \$14.1 billion, and \$15.3 billion.

### 6.2 Graphical Results

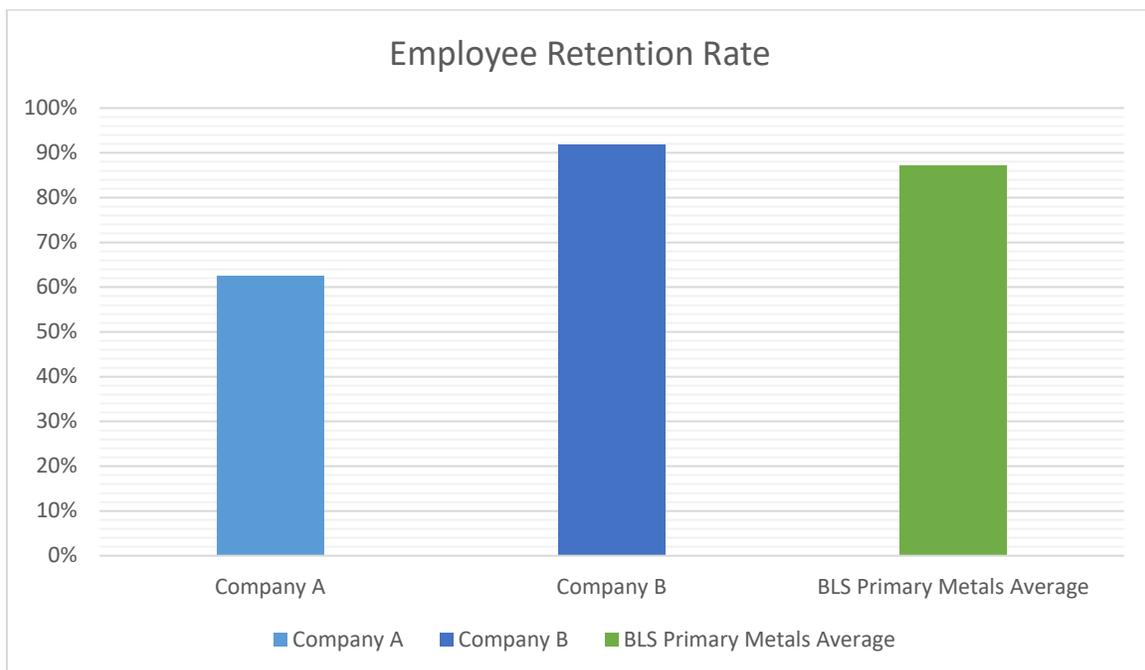


Figure 1. Employee Retention Rate of Company A and Company B through the COVID-19 Pandemic.

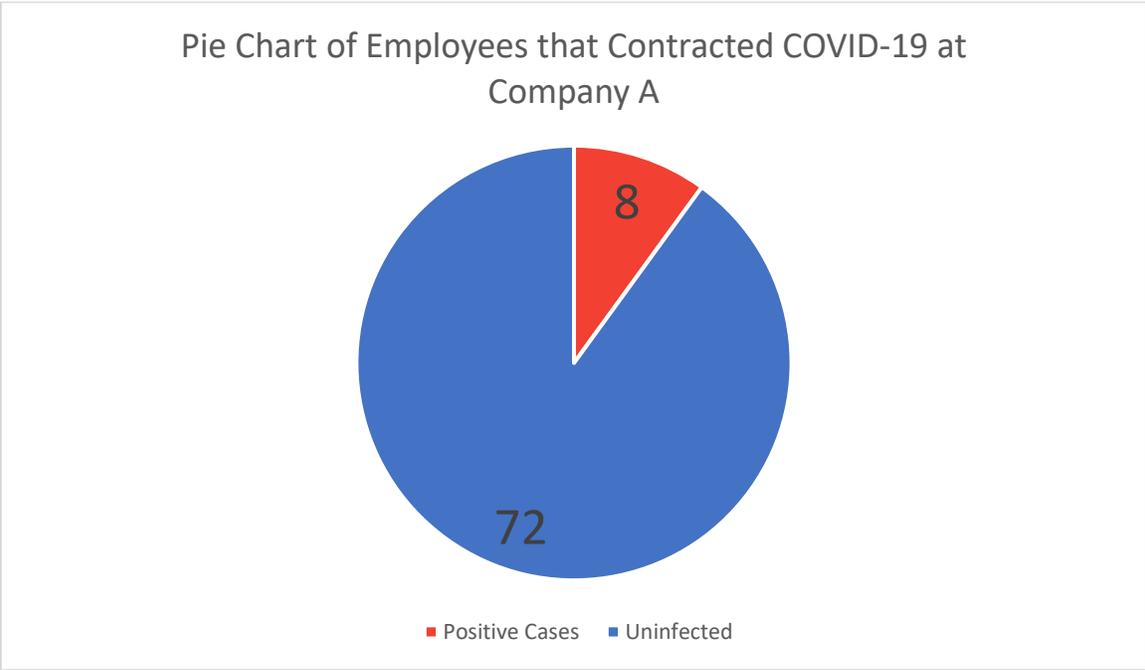


Figure 2: Pie Chart of Employees that Contracted COVID-19 at Company A

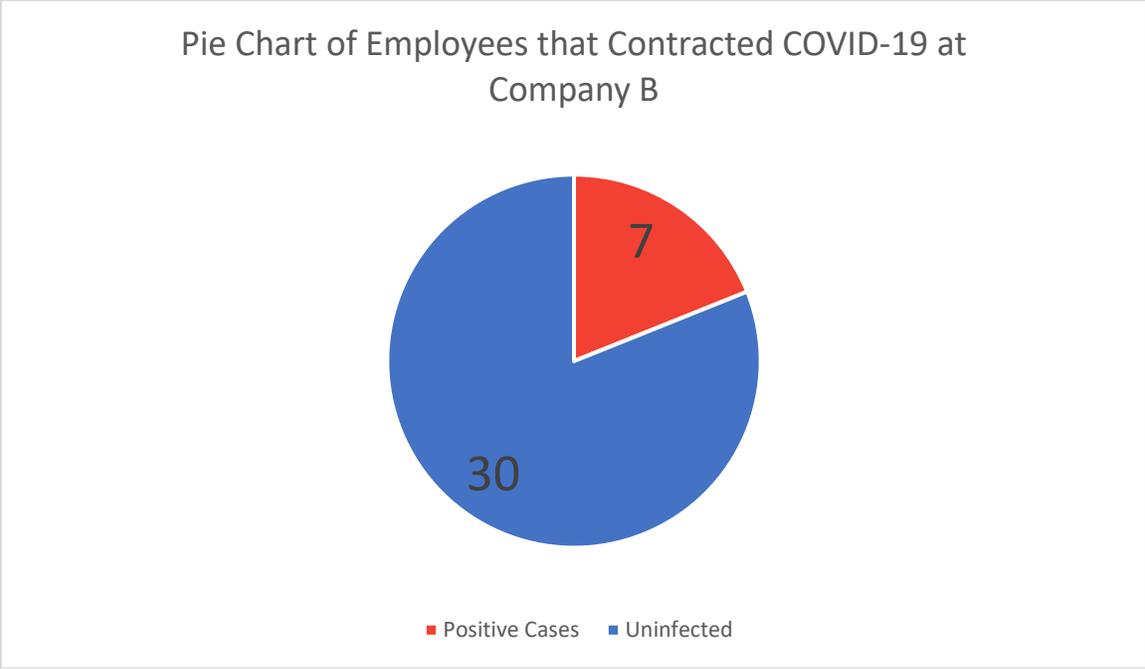


Figure 3: Pie Chart of Employees that Contracted COVID-19 at Company B

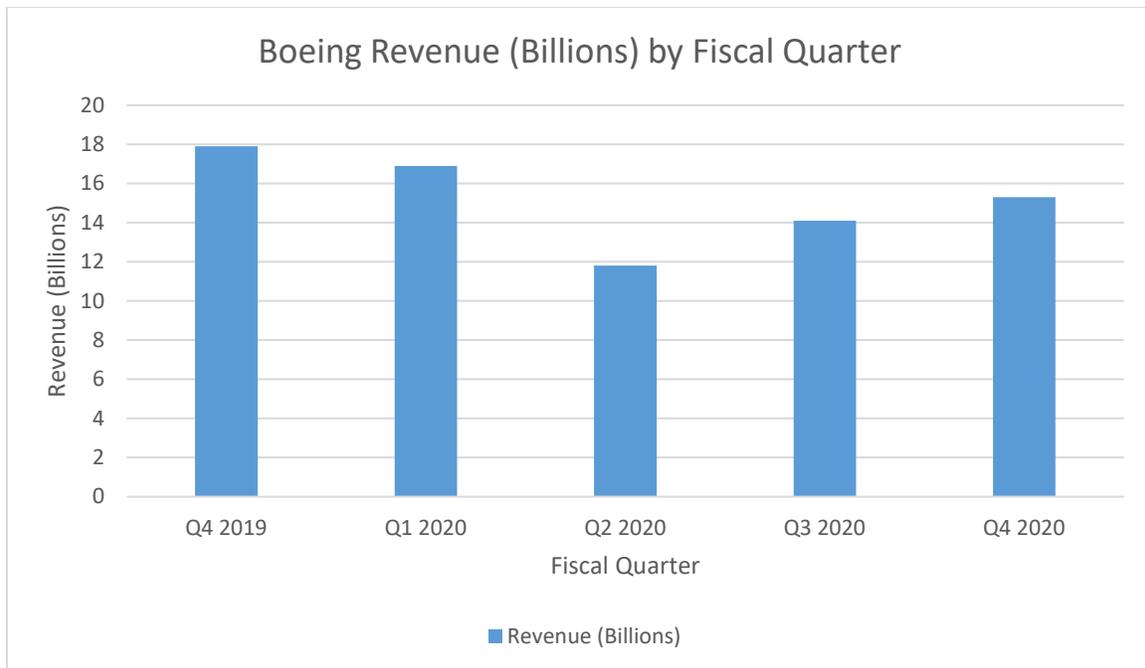


Figure 4: Boeing Revenue (Billions) by Fiscal Quarter

### 6.3 Proposed Improvements

The proposed improvements for a metal casting contractor are diversifying, holding a flexible workforce, and seeking out contracts not being picked up by larger foundry chains. Diversification would allow for less of a direct impact on production when one individual sector of downstream companies sees a demand reduction. A flexible workforce would allow for production changes to narrow down production costs to outlast the demand reductions. While other foundries shrink and are not taking on new part numbers, there is the opportunity for other foundries to take on those parts and attempt to be at the forefront when the market eventually recovers. Therefore, there is the opportunity to return to the previous level of production and grow.

Another solution could be increased automation to reduce the reliance on human workers that would be susceptible to COVID-19 and the overhead cost associated with human workers.

These improvements could be adjusted to work for other companies that are in the middle of a larger supply chain, like Company A, which has larger companies both upstream and downstream.

### 6.4 Validation

Company A primarily works in the aerospace industry, with its biggest customer being Boeing. Company A pointed out that there has been a slowdown in demand from Boeing for their cast parts. Looking into Boeing's investor report for 2020, this appears to be the case. Boeing saw a decrease in its revenue from \$76.6 billion in 2019 to \$58.2 billion in 2020 (Boeing, 2021). This is a drop in revenue of 24.02% over the course of the year. However, the revenue per quarter has been slowly recovering since the beginning of the COVID-19 pandemic (Figure 2). As referenced in the Boeing investor presentation, their financial situation was hampered by both the pandemic and the grounding of the 737 MAX airplane (Boeing, 2020). Interestingly, the defense segment of Boeing's production has been more consistent throughout the pandemic.

Due to the nature of Company A and Company B's contracts, they did not begin to feel the effects of the COVID-19 pandemic until around three months later, in June. A previous study on the effects of COVID-19 on the manufacturing industry performed in April 2020 noted little slowdown, which is concurrent with the delay between the beginning of the pandemic and its effects being felt (Garlick, et al., 2020).

Company A also commented that they believe Boeing will not return to normal production levels for the next five years. Internationally, air travel is not expected to return to pre-pandemic trip length levels before 2025 (Brothers, 2021).

## 7. Conclusion

We found that the companies interviewed reacted to the COVID-19 pandemic differently, though with the common denominators of ensuring worker safety as a priority, exploring new markets, and making changes within the company. Both Company A and Company B kept the cases among their workforce to a minimum, with the cases that did occur believed to have originated from outside of the workplace. The COVID-19 pandemic also served as an opportunity for the companies to explore new markets and make changes within their company that may not have previously been reasonable. Some of these changes, such as virtual meetings, may stay after the pandemic is over, pushing both companies further into the digital age. Regarding the suppliers of the two companies interviewed, COVID-19 had a direct effect on their production capabilities either due to the incapacitation of their workforce or forcing the closing of the company. Downstream in the supply chain, customers of these two companies experience reduced demand, which forced them to cancel existing contracts and decreased the number of future contracts created. Due to pressure from above and below in the supply chain, Company A and Company B were forced to respond reactively rather than proactively due to their size compared to their suppliers and customers.

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## Biographies

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**Cole Pike** is a B.S. Manufacturing Engineering student at California Polytechnic State University, San Luis Obispo, California. He interned at AB&I Foundry in Oakland, California, as an Engineering Intern. He has competed in the SFSA Cast in Steel competition to design and cast a Bowie Knife and submit a process report. He is a member of SME and AFS.

**Elliott Hofferth** is a B.S. Manufacturing Engineering student at California Polytechnic State University, San Luis Obispo, California. He has measurable experience in industrial building construction and well as manufacturing for product development and patents. He has also gained on-campus experience as a shop technician in three manufacturing shops, including the net shape/casting lab and the turning and mini mill lab.

**Balthazar Olivier** is B.S. Manufacturing Engineering student at California Polytechnic State University, San Luis Obispo, California. Interested in engineering automation and databases, he interned with IFM Electronic to develop his experience in sensor technologies and HMI systems. An active member of SME and AFS on campus, he has also participated in SFSA Cast in Steel competition, hosted by the Steel Founders Society of America.

**Hunter Baird-Wise** is a B.S. Manufacturing Engineering student at California Polytechnic State University, San Luis Obispo, California. He is a member of SME and AFS Clubs on campus. His experience ranges from working in machine shops that deal with sinter cast parts and working in the on-campus foundry as a T.A. He also competed in a casting competition hosted by the Steel Founders Society of America.

**Mohamed Awwad** is an Assistant Professor in the Department of Industrial and Manufacturing Engineering at California Polytechnic State University (Cal Poly), San Luis Obispo, CA. He received his Ph.D. and M.S. degrees in Industrial Engineering from the University of Central Florida, Orlando, FL, USA. Additionally, he holds M.S. and B.S. degrees in Mechanical Engineering from Cairo University, Egypt. Before joining Cal Poly, San Luis Obispo, Dr. Awwad held several teaching and research positions at the State University of New York at Buffalo (SUNY Buffalo), the University of Missouri, Florida Polytechnic University, and the University of Central Florida. His research and teaching interests include applied operations research, logistics & supply chain, blockchain technology, distribution center design, unconventional logistics systems design, and OR applications in healthcare and the military.