

# **Case Study Review of the Effects of COVID-19 on the Supply Chain of Manufacturing Companies in California**

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## **Abstract**

Small- and medium-scale manufacturing companies may be adversely affected by disruptions in the global supply chain due to the COVID-19 pandemic. Goods imported to companies in the United States from China and other international suppliers could face delays and disruptions. To manage shortages, these U.S. companies could require implementing rapid changes to their supply chain and production. The objective of this paper is to research methods used to address the short- and long-term challenges in the supply chain of small- and medium-scale manufacturing companies. In this paper, we examine the effects of the supply chain disruption due to COVID-19 through specific case studies of Californian manufacturing companies.

## **Keywords**

Manufacturing, Operations, COVID-19, Supply Chain

## **1. Introduction**

### **1.1. Background**

The COVID-19 pandemic has disrupted manufacturing companies' ability to continue their production due to the Stay-at-Home order implementation by the Californian government on March 19, 2020. Within these orders, the government decided which companies would be deemed essential or nonessential based on what they produced. Still, industrywide changes had to be made to help protect the health of employees and reduce the spread of COVID-19. Typically, one can look at the stock value to determine how their company value reacts to these massive changes, but for small businesses, that is usually not the case. This study examines how smaller businesses that are typically more dependent on a constant revenue stream have reacted to the pandemic, and what changes they have made to stay afloat during these unprecedented times.

### **1.2. Objectives**

During the COVID-19 pandemic, there has been a lot of news coverage of the effects of the pandemic on businesses, particularly the service industry. However, according to a 2015 report, 12.5% of the total U.S. gross domestic product is generated by manufacturing industries, and it is crucial to examine how this industry has been affected (Scott, 2015). Analyzing how manufacturing companies have approached the changes brought about by the pandemic to hold answers to how to approach future significant normalcy upheavals.

## **2. Literature Review**

### **2.1. California Stay-at-Home Order**

To mitigate the spread of COVID-19 in California, state and local governments have issued Stay-at-Home orders. The first of such orders went into effect in seven counties in the San Francisco Bay Area on March 16. The California state government followed by issuing the Stay-at-Home order on March 19, by which time, twelve additional counties had issued their shelter-in-place orders. The order was amended on April 14 to include six key indicators for modifying the Stay-at-Home order (State of California, 2020a). On April 28,

a Resilience Roadmap was announced by the Governor's Office, defining stages by which the Stay-at-Home order would be rolled back. Stage one was the restrictions still in effect as established by the original Stay-at-Home order. In contrast, Stages 2-4 involved a gradual reopening of businesses and lessening of social distancing (State of California, 2020b).

The California Stay-at-Home order required that all people stay in their homes unless going out for essential activities, such as medical care or grocery shopping (N-33-20, 2020). The order also required all businesses to shut down, except for those working in sixteen industries deemed essential, including Healthcare and Public Health, Food and Agriculture, and, most relevant to this paper, Critical Manufacturing. Critical Manufacturing was defined to be primary metals, machinery, electrical equipment, appliances and components, and transportation equipment manufacturing, as well as manufacturing operations that support the operation of other essential industries. Other essential industries relevant for this paper include Chemical and the Defense Industrial Base (Cybersecurity & Infrastructure Security Agency, 2020; Order of the Health Officer No. 20-10, 2020). Essential industries can remain open provided they follow social distancing protocols, which differ from county to county (CalMatters staff, 2020; City and County of San Francisco, 2020; County of San Diego, 2020).

## **2.2. Chinese Manufacturing**

According to Boston Consulting Group, China generated \$3.7 trillion in manufacturing in 2018, more than the U.S., Germany, South Korea, and the U.K. combined. China's initial manufacturing dominance came from the low labor costs the employed to make high labor-intensive products for export (Colotla et al., 2020). Since the cost of labor in the country has been increasing, they have still maintained a competitive advantage through large scale manufacturing and increase productivity through advanced manufacturing systems. With the Chinese government financing industrial development initiatives, there has been greater growth for the manufacturing of products in the high-tech sector. Overall, China is still able to maintain control of the world's manufacturing by innovating and investing resources into increasing its productivity and quality to meet the market needs of overseas companies such as those in the United States.

One of the most significant supply chain disruptors every year is the period that Chinese manufacturing shuts down for Chinese New Year, commonly referred to as CNY. With one week of official holiday and up to ten days of employee travel time, this event shuts down manufacturers for roughly three weeks out of the year. Considered as the largest human migration in the world by Statista, there are often still existing workforce shortages after the holiday, which drops productivity for the weeks following the holiday. Besides, freight costs are raised during this period of peak demand, which forces companies to outbid each other to pay to have their products expedited out of the port, causing increased shipping costs and potential delays for weeks (Insight Quality Services, 2020). Because of these reasons, companies plan far in advance to get inventory up before these shutdowns, so the impact of a halted segment of their supply chain is reduced to a minimum (East West Manufacturing, 2019).

## **2.3. The Implications of Telecommuting**

For some companies, telecommuting has allowed for work to continue during the Stay-at-Home orders. To telecommute is to "work from home doing work traditionally or usually done in an office" (Oxford University Press, 2020). By using technology such as email, video meetings, and cloud file management, employees in certain industries can fulfill their jobs while working remotely.

Before the COVID-19 pandemic, Americans were working at home to some degree. According to a 2017-2018 survey done by the Bureau of Labor Statistics, 25% of American wage and salary workers "sometimes worked at home" while 15% "had days they only worked at home" (USDLE-19-1691, 2019). Similar to the national averages, the survey found that the manufacturing industry had 25.7% of workers "who did work at home" and 15.7% "with days they worked exclusively at home." During the COVID-19 pandemic, the number of Americans working from home has increased significantly. According to a Gallup poll conducted March 30-April 2, "62% of employed Americans currently say they have worked from home during the crisis" (Brenan, 2020). The same poll indicates that 59% of workers would "prefer to continue to work remotely as much as possible" after restrictions are lifted.

Telecommuting's effects on the worker and feelings of autonomy are a point of interest in the literature. Telecommuting is positively related to "perceived autonomy for employees" (Gajendran & Harrison, 2007). Paul Santagata, Head of Industry at Google, feels that recognizing "universal needs such as respect, competence, social status, and autonomy" is vital for increasing psychological safety in the workplace (Delizonna, 2017). Allowing an employee to feel that they are in control of how they spend their time may be an important factor in contributing to a better work environment.

Another area of interest is how telecommuting affects workplace relationships. Gajendran and Harrison (2007) found a "positive effect of telecommuting on the employee-supervisor relationship." They also did not find that "telecommuting would be negatively related to co-worker relationship quality" with the relationship "very close to zero." To avoid damaging co-worker relationships, the paper recommends casting "telecommuting as normative rather than exceptional or privileged." If the COVID-19 pandemic causes working from home to be a more regular part of typical work, employers and employees may find it to be a viable path for those that can do so.

### **3. Case Studies**

To gain a clear perspective on how the pandemic has affected American manufacturing, five small- to medium-sized companies were interviewed. Interviewees were owners, engineers, and/or company executives who were able to give an over-arching perspective on the effects of the pandemic on the company's profitability, supply chain, and productivity. Each interview took place over videoconferencing during the week of April 27, 2020. Pseudonyms have been given to the companies and interviewees to protect anonymity.

#### **3.1. Company A**

The first company we interviewed is a small musical instrument manufacturing company. Their business was deemed nonessential and forced to shut down during Stage 1 of California's Stay-at-Home order. Only about 10% of their manufacturing is supplied from foreign countries. Before the pandemic, the company changed their suppliers from China-based suppliers to suppliers in India and Costa Rica that better suited their needs. Company A strives to diversify its supplier portfolio to ensure they do not rely too heavily on one supplier, but due to their niche manufacturing, some of their processes require materials that are only produced by one manufacturer. Like most other companies, Company A did not have contingency plans for something of this scale to affect their day to day workflow so profoundly.

Before the shutdown due to the pandemic, Company A kept a large safety stock of finished product and raw materials, a company policy that has been in place for many years. At any one point, they could have 2-4 weeks of raw materials required to build their main product and 2-3 weeks of finished goods in a "supermarket" as they called it, ready to be shipped. After the Stay-at-Home order was put into effect, the company was forced to furlough most of their workforce, reducing their overall employees to nine, most of which telecommuted. Despite being deemed nonessential, four of these employees came into the shop and took over the shipping of finished goods. These individuals wore proper PPE and abided by the CDC's recommendations of social distancing and sanitation. Still, they felt it was essential to ship their products to help soften the blow of the pandemic.

The reduction in the workforce has dramatically reduced the company's manufacturing capabilities, though the company has been focusing on finishing WIP such that it can also be shipped. Most of Company A's suppliers have been able to ship limited quantities of materials required for their manufacturing processes, except for one integral part for a certain product model. This has caused this model to go out of stock, with no estimation of when it might come back, due to the supplier being heavily affected by stay-at-home orders. Though their production has been reduced to a skeleton crew, the policy of carrying a large safety stock has resulted in no other bottlenecks than this, and they are ready to scale up production again when the Stay-at-Home order ends.

Prior to furloughing the majority of their employees, Company A prepared for an increase in online sales of peripheral devices to their main product line and had the employees in this department of the business trained those that would be working through the Stay-at-Home order on the processes to ship these types of goods. Following the Stay-at-Home orders, Company A was excited to see a jump in sales of these online orders

valuing from \$50,000 to \$150,000, the largest week in company history. The company has been ordering the raw materials required to fulfill these orders and has not encountered many problems in its suppliers' supply chain.

Payroll is the most considerable expense, typically accounting for 30% of their monthly expenses. Furloughing employees cut payroll from \$40,000 per week to \$15,000 per week, leading to payroll not having as large of an impact on their company. In addition to this cut in payroll, their existing SBA loan has been forgiven for six months of payments. Finally, the company received a PPP loan of \$430,000 from the stimulus package, which will become a grant under the condition that 75% of the loan is spent on payroll over the following eight weeks, and they reemploy the original 42 employees by June 30. These measures leave the company in an excellent place to pick up where they left off before the Stay-at-Home order went into effect.

Overall, Company A is in a good position to hire back all of its employees by June 30 so that their PPP loan does not have to be paid back. Their supply chain has not been terribly interrupted in part to their lack of dependency on Chinese manufacturing, and large safety stock. Before the Stay-at-Home order, this company bought out a smaller manufacturing company and has used the lack of throughput in its manufacturing line to implement the process of in-house production. When asked about their projected losses, it was said that the loans and grants from the government would cover their losses, and they are looking forward to the opportunities gained from this time instead. From this experience, they plan to increase their stock of finished goods further, and they will continue to keep the same stocks of raw materials.

### **3.2. Company B**

Company B is a small aerospace company in California with a focus on engineering. They are considered an essential business and have remained operational during the COVID-19 pandemic. Their supply chain is mostly domestic with some international suppliers as well. For many of their ordered goods, American companies still had stock available.

The company, being on the smaller side, did not have contingency plans for a large-scale event like the pandemic. However, since they are small and agile, they can handle situations as they arise. They did not have to furlough any workers, but they had more employees working from home instead of in the office. More surface cleaning occurred as well. Because the company's workplace consists of multiple facilities, they were also able to significantly distance workers from one another. Their workplace was already decently isolated, and so daily operations did not change drastically. They felt that they had done well to protect their employees while continuing business.

Inventory was a manageable situation for Company B in the short term. They had enough supplies to continue operations for the next few months. Since they shifted more toward engineering and less toward manufacturing during the pandemic, their inventory would last for a longer time. They have a few primary vendors for material sourcing and fabrication. These vendors did slow down but were able to come back up to speed slowly. For Company B, this meant being able to prepare more engineering work for the eventual manufacturing in the future. Since some vendors had increased hiring, they may end up with more capability after the pandemic than before.

They slowed down spending initially, but because they are a small company, they are always looking for new opportunities. Onsite work outside of the office and large-scale noncritical tests had been delayed. The section of their company dedicated to a new product did have to take different actions due to the pandemic. Because the online distributor they were going to sell through began only to receive essential items, they decided to sell the new product on a crowdfunding platform. This silent launch meant having to start their marketing campaign earlier than if they had been able to sell through the online distributor. Due to the pandemic, it had been easier to connect with marketing companies.

In terms of telecommunication, not much had changed for Company B. Most of their clients are in different cities than their home office, so conference calls had remained similar to before the pandemic. The company had noticed an increase in meetings and conversations, which had led to more casual discourse and a feeling of being more involved.

Company B also discussed open mode vs. closed mode and what it means for their employees. They described open mode as a discussion period of the workday where employees are talking with each other. The closed mode is the time when employees focus on their work independently. Company B noticed that efficiency had potentially increased for employees in closed mode when working from home. This may have been due to not being distracted by other employees that were in open mode. Before the pandemic, it was rare for engineers to work from home. After the pandemic, the company will likely be more open to the idea of working from home if the productivity is unchanged or improved. However, the company does still value having employees come into the office to work as a team and engage in open mode discussion.

### **3.3. Company C**

Company C is a small manufacturing company located on the central coast of California that manufactures pressure gauges and switches. About 50% of their supply chain comes from China due to cheaper manufacturing costs and China being a hub for semiconductor components. They also import switches from Mexico and some parts from Taiwan. Because half of their supply chain is dependent on China, they prepare for Chinese New Year and the halting of Chinese manufacturing every year.

When Company C heard about the seriousness of COVID-19, it was about two weeks before CNY. This meant their suppliers were already impacted and refused to supply them with additional materials. Once their customer found out about the situation, they stepped in and helped Company C receive material needed from their supplier. They took advantage and continued producing at the same rate to build up inventory, knowing their customer is still producing parts as normal and storing them.

Company C was considered an essential business during the Stay-at-Home orders. Employees were required to wear face masks at all times within the facility. PPE was provided by Company C. All employees who were able to work remotely are doing so. Their production remained steady, however, as their customer is stockpiling finished goods based on an expected burst from the end of the COVID-19 pandemic.

Before the shelter at home order, Company C went to a split shift to make sure only half the personnel were on the floor at a time. The split shifts led to overtime, especially for team leads. After a couple of weeks of split shifts, workstations and operations were reassessed to accommodate social distancing guidelines during normal operations, and the overtime was cut. Productivity did drop with increased hours as the operators started to experience fatigue. To help combat this, all hourly production employees received a \$2/hour raise to help keep morale high during the uncertain time.

### **3.4. Company D**

Company D is a cleaning supplies manufacturing company with about 60 employees and is headquartered in the San Francisco Bay Area. Approximately 50% of its supply chain is based on manufacturing in China, with the rest spread throughout various countries. Before the pandemic, they had no contingency plan for a widespread shutdown of manufacturing. Still, they did take measures to manage supply chain risk, focusing on diversifying their customer and supplier bases.

The most significant supply chain issue for the company resulting from the pandemic was cash flow. The time it takes for them to receive payment from their customers is generally longer than the time period they have to pay their suppliers for receiving the items, and with their customers having to delay payments due to issues arising from the pandemic, they are facing a cash shortage. They also have a major customer that is planning to double the business that the customer does with them soon, which, while a long term positive, is forcing them to start producing and storing extra items, furthering the cash crunch they face. They have not been able to get bridge financing from banks due to the pandemic. They have applied for government grants for small businesses to help ease the cash flow burden, but as of the time of our interview in late April, they had received no response.

One response Company D has taken to ease their cash crunch is furloughing about 50 workers through California's Work Share Program. As an essential business under California's statewide Stay-at-Home Order, they are still able to conduct manufacturing operations, so they have been having their employees work for three days a week and be furloughed for two days. An issue that arose because California was among the first states to implement shelter-in-place orders was that customers in other states still wanted orders fulfilled on

time, which was difficult for Company D as they were operating with 60% of their manufacturing workforce. That difficulty lessened as other states came under similar shelter-in-place restrictions, with other companies coming to Company D for guidance on operating under shelter-in-place restrictions.

An area that had yet to be an issue for Company D was shortages of key materials. As a large portion of their supply chain is based in China, they had stocked up on critical supplies in anticipation of the Chinese New Year shutdown. While they were not able to order extra supplies once news of the COVID-19 outbreak hit, they have been able to continue production using the Chinese New Year build-up. However, they acknowledge that shortages of key materials could occur if the Stay-at-Home order continues for an extended period, leading to build-ups of unfinished WIP and the inability to fulfill customer orders.

Company D is unsure of the cumulative effect the COVID-19 pandemic will have on their business. They had a decrease in sales of 30% from where they expected to be for April but are still up on the balance sheet for the year, including the decrease in April. They expect to lose some smaller customers and possibly some smaller suppliers, but the depth of their losses will depend on the length of the pandemic. In terms of permanent changes to their supply chain, Company D's mid-range goals have not changed due to the COVID-19 pandemic. However, they have accelerated their planned move to increase individual online sales, as their online sales through a major big-box store's website went from 200 orders a week to 700 a day overnight because of the pandemic.

### **3.5. Company E**

Company E is a mid-sized consumer electronics company comprised of 105 employees in central California and the European Union. They remained in operation during the quarantine orders as they were considered an essential business. With about 85%-90% of their manufacturing being based in China with a bit in Taiwan and Vietnam, they have recently been focusing heavily on diversifying their supply chain. They started doing so to avoid the costly Section 301 tariffs that charge the company 7.5% of the cost of the product. Their reasons for manufacturing so heavily in China are the level of quality for the cost. Before the shutdown of all nonessential companies, Company E had already begun ramp-up of inventory during November and December in preparation for Chinese New Year shutdowns. This preparation, along with forecasting for this quarter's demands, meant that Company E had higher inventory counts when impacts of the crisis-hit Chinese suppliers and Company E did not rely on as much Chinese manufacturing during this time.

In response to the Stay-at-Home order, the company instituted remote work for all who could work remotely. In addition, the company kept 27 essential workers to perform assembly, testing, receiving, and shipping of current inventory. Assembly was split between two facilities to maintain space between individuals and limit contact. Shipping operations were split into A and B shifts with the A Group coming in on Monday, Wednesday, Friday, and Sunday morning and the B group taking the remaining days. Despite workers having hours reduced from 40 to 35 per week, the amount of product being processed shows an increase in overall productivity with the social distancing practices being implemented. The company has also hired three new people in March and April.

COVID-19 has impacted the ability to maintain stock of some of their most in-demand products as well as changed methods of operations in quality control and increased cost of transportation. With a typical stockout of 10-15 products from a total of 350 highly profitable items, the company currently has 66 items out of stock as of April 30, 2020; this was additionally impacted by an increase in order volume by 50%. This means that there has been a significant loss in business due to the stockout issues.

The company typically employs two individuals based out of Taiwan to conduct quality checks for manufacturing in China. Still, due to travel restrictions and mandatory quarantine, they were unable to make it to the factories until April. So, the company employed a third-party quality group that they had worked with previously to perform an outside inspection through video calling platforms to make sure the products were correct and collect lot numbers. With many of the company's assemblies unable to be completed, they are paying additional expenses to airship their parts.

## 4. Discussion and Conclusion

### 4.1. Summary

#### 4.1.1. How Companies Operate During a Pandemic

Adapting to the COVID-19 pandemic meant changes in how companies function on a day-to-day basis. Companies A, B, C, and E implemented telecommuting so that employees could work from home. Company B noted that productivity had potentially increased for employees doing individual tasks at home. They were interested in increasing telecommuting if their employees want to work from home in the future; however, the company values in-person discussion as well.

Companies A, B, and D experienced significant effects on their online sales. Company A had a large increase in online orders. They trained additional employees to run the online shop platform. Company B was already planning on starting a new business venture selling an online product before the pandemic occurred. However, they switched from their original planned distributor to a crowdfunding website due to the first distributor receiving only essential items at the time. Company D noted that their online orders via a third-party website had a significant increase.

PPE and new cleaning practices were necessary during this global event. Using masks and frequent surface disinfection meant having to order pandemic-related items that were in high demand. Company B mentioned that acquiring those high demand products may be difficult during the pandemic. Although companies may have had some of the goods on-hand, providing enough for every employee for the duration of the pandemic could be an issue if there were delays in receiving them.

Table 1: Measures taken explicitly mentioned by the interviewed companies during the COVID-19 pandemic

	Company A	Company B	Company C	Company D	Company E
Furlough Workers	✗				
New Cleaning Practices	✗	✗	✗	✗	✗
Telecommuting for Employees Who are Able to	✗	✗	✗		✗
Reduced Hours					✗
Split Shifts			✗		✗
California's Work Share Program				✗	
Moved to Greater Online Focus	✗	✗		✗	
Hazard Pay			✗		

#### 4.1.2. Temporary Measures

Companies like Company A, D, and E have a greater dependence on manual labor resulting in one of their most considerable expenses being payroll. We found that during our interviews, each company was forced to take temporary measures such as furloughing employees or reducing hours to ease their outgoing expenses during this pandemic. The extent of these furloughs was highly dependent on whether the company was considered essential or not. Companies deemed nonessential, like Company A, were forced to furlough over 80% of their workforce to decrease their overall monthly expenditures by approximately 20%. On the other hand, essential companies were able to only reduce the number

of hours their employees worked, like Company E, or take advantage of work share programs, like Company D. For companies that found themselves deemed essential, we saw an implementation of split shifts into their manufacturing lines; leaving time in between shifts for sanitation and reducing the number of people near one another to reduce the risk of infection. These measures are temporary that, when allowed by the state guidelines, will be reverted to their original shift sizes and times.

Understandably, none of these companies had contingency plans for a shutdown of this scale and speed. Most of the companies' actions seemed to be reactionary to the government shutdowns and therefore had to implement changes to company policies and previous methodologies rapidly. Making use of the unique lack of production and ability to perform maintenance and improvement tasks without impeding production, some of the companies decided to shift priorities during the shutdown of their manufacturing. Company A used the downtime to implement a new process into its manufacturing line, while Company B started focusing on marketing a new product they released before the pandemic.

Each company had to cope with the resources they had going into the shutdown to find new sources of revenue or increase other sources due to the reduced ability of their suppliers. Where possible, companies also focused on improving current processes or altering engineering designs to make use of the unique circumstances. Each of these companies also had to postpone or cancel employee appreciation events and out of the office activities but hope to continue such activities soon.

#### **4.1.3. Existing Measures**

For several of the companies interviewed, there were existing measures they have had in place that helped them respond to the pandemic. The primary one of these measures was the diversification of their suppliers with Company A and Company D taking active measures to source their components from a wide range of factories and countries to minimize dependency on a single source before the COVID-19 pandemic. Company E expressed that they had been focusing on also expanding their supply chain to avoid the tariffs on Chinese imports and stated that they were still planning on working towards the goal of diversification after the disruptions from COVID-19 had ended. Company C is working towards a similar goal with half of its supply chain in China to source the semiconductor components that the company requires and their only other source of components coming from Mexico. As suppliers were unable to meet orders or had to shut down manufacturing, the companies that had diverse supply chains were better able to shift their supply to avoid having shortages of key materials.

#### **4.2. Conclusions**

A key takeaway was that the manufacturing industry was not suffering as much as other industries, such as retail (Alvarex & Marsal, 2020). Among the five companies in the case studies, none were in imminent danger of going out of business, and the essential businesses have been able to maintain a level of production similar to that before the beginning of the pandemic, with Company E actually seeing an increase in orders by 50%. Reasons for this relative strength include the essential nature of the products produced by the four essential companies and the overall increase in online sales.

Each of the four manufacturing companies interviewed that have consumer products saw significant increases in online sales. The online presence of these companies allowed them to continue being able to sell their products and generate revenue despite not being able to sell their products through retail outlets, which for Company A and Company D was their primary mode of sales. This added revenue helped offset losses in other areas and continue operations.

As a result of many employees having to work from home, telecommuting expanded greatly during the pandemic. None of the companies the authors spoke to reported a decrease in productivity from any employees working from home, and some were able to come up with creative solutions to complete tasks

that would have normally required coming into the office. As such, several indicated they would be more open to allowing employees to work from home after the pandemic, a trend likely to be reflected in the rest of the industry.

Another key takeaway was the impact of the timing of the pandemic and Chinese New Year. Due to the annual shutdown of manufacturing in China for Chinese New Year, companies with a significant part of their supply chain built an inventory of needed supplies for that period. As such, many companies had extra inventory on hand during the early stages of the pandemic, which occurred around the same time. This allowed the companies to continue to run operations and use the extra inventory on hand to cover potential shortages that occurred as a result of suppliers shutting down due to the pandemic. The inventory was used up as the pandemic continued, but companies were better able to meet orders than they would have been had they not built inventory for Chinese New Year.

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## **Biographies**

**Camille Garlick** is a third-year student pursuing a Bachelor of Science degree in Industrial Engineering with a minor in Statistics. She is expected to graduate in June 2020 at California Polytechnic State University, San Luis Obispo. She is the Business Team Lead for Prototype Vehicle Laboratory, an alternative energy vehicle student project, for which she has helped earn over \$20,000 of funding for the project. She will be working as a Jr. Commodity Business Manager Intern at Applied Materials for the summer of 2020.

**Mitchell McMillan** is a transfer student from a community college in San Diego to California Polytechnic University, San Luis Obispo. He will be graduating in June 2020 with a Bachelor of Science in Industrial Engineering and starting in a Quality Control position with Northrop Grumman in September 2020. Mitchell has been a part of the Systems Optimization Club on campus since he transferred. Through his involvement with the Cal Poly Systems Optimization Club, Mitchell worked on a project with the L.A. Sheriff's Department to optimize their data entry and analysis of their diver's certifications. He has held the position of Project Director in the club for the past year, ensuring the success of 5 ensuing projects the club has undertaken. He looks forward to his upcoming career and desires to attain his master's degree in Engineering Management in the coming years after experience in the industry to aid in his career goals.

**Roxanne Peterson** is a third-year student at California Polytechnic State University pursuing a Bachelor of Science in Industrial Engineering and a minor in Political Science. She is expected to graduate in June 2021. She serves on the Student Fee Committee for the Industrial and Manufacturing Engineering Department and works as the lab technician for the Electronics Manufacturing Laboratory. Additionally, she is involved in the Systems Optimization Club, where she has been the Project Lead for the largest project team in the club's history. In this project, Roxanne is working with the Integrated Waste Management Authority of San Luis Obispo County, and she currently serves as Project Director.

**Timothy Scheuermann** is a third-year student at California Polytechnic University, San Luis Obispo pursuing a Bachelor of Science in Industrial Engineering with an expected graduation date of June 2021. He worked as an Operations Industrial Engineer Intern for the United States Postal Service (USPS) during the summer of 2019. He will work as a Supply Chain/Manufacturing Operations Intern for W.L. Gore & Associates during the summer of 2020.

**Kyle Smith** is a fourth-year student at California Polytechnic State University, San Luis Obispo pursuing a Bachelor of Science in Industrial Engineering. His expected graduation is in December 2020. He will be working as a researcher in the Cal Poly College of Engineering's Summer Undergraduate Research Program 2020.

**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.