

THE PENNSYLVANIA STATE UNIVERSITY
SCHREYER HONORS COLLEGE

DEPARTMENT OF SUPPLY CHAIN AND INFORMATION SYSTEMS

Analyzing Success Case Studies in Pivoting Manufacturing Strategies to Benefit Frontline
Healthcare Responders in the COVID-19 Pandemic

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FALL 2020

A thesis
submitted in partial fulfillment
of the requirements
for a baccalaureate degree
in Supply Chain and Information Systems
with honors in Supply Chain and Information Systems

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ABSTRACT

The COVID-19 pandemic highlighted major challenges throughout global supply chains. As the virus spread throughout the world and governments implemented various restrictions, some companies were forced to close their operations if they produced “non-essential” goods, some companies had to innovate their current facilities to adhere to the new restrictions, and many companies faced supply shortages and demand shocks. The COVID-19 pandemic is unique compared to other disruption events due it being simultaneously a regional and global event with an unclear timeline or duration as to how long the pandemic will impact the world. In addition to these disruptions, many companies and supply chains were ill-prepared in terms of having positive redundancy and risk management strategies built into their supply chains. Because of this, this thesis serves a critical role as a resource for companies that are looking to implement successful strategies into their supply chains to overcome challenges posed by a major disruption event by analyzing case studies and compiling best practices from companies that successfully accomplished this during the COVID-19 pandemic.

This thesis analyzes three case studies: 3M, which successfully increased manufacturing capacity of N95 respirators; Merrow Manufacturing Company, which innovated their supply chain to produce nine types of PPE with the goal of creating a long-term sustainable supply chain for PPE in the U.S.; and Cartamundi, which temporarily pivoted their supply chains to produce plastic face shields until they can return to manufacturing their traditional product lines. From this analysis, the research found numerous commonalities of key factors that lead these companies to success. The first factor is companies were quick to successfully act when their company values were implemented and supported by the workforce and the shift a company was

looking to make is aligned with those values. The second is the use of strategic relationships and established lines of communication between critical internal and external stakeholders, including suppliers, major customers, innovation and design teams, and manufacturing facilities. Thirdly, utilizing a balance of regional or domestic supply chain model, or simply having suppliers and manufacturing facilities close to the point of demand, allowed for these companies to mitigate some challenges posed by this global pandemic. Lastly, companies were able to successfully pivot their manufacturing facilities and supply chains to support the greater good and to keep their businesses open by having flexibility, adaptability, and resiliency to innovate their current processes. Learning from these key success factors and implementing these strategies can aid in building more resilient supply chains and mitigate the impacts of future major disruption events.

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ACKNOWLEDGEMENTS

I am very thankful for the support, mentorship, and teachings of Dr. Novack not only throughout the thesis-writing process, but also throughout my entire career at Penn State. Additionally, a huge thank you goes to my adviser, Melissa Paloskey, who always went above and beyond to help guide me in reaching my goals. Lastly, I would love to thank all of my professional and personal mentors from the Schreyer Honors College, Alpha Kappa Psi, the companies I interned for, and the R. Gene and Nancy D. Richter Foundation.

Above all, I want to thank my parents for their loving support and guidance. From answering all of my phone calls stressing about my career path or classes to always supporting and encouraging me when I was frustrated or had wild ideas, graduating and finishing this thesis would not be possible without my mom in particular. Lastly, I would love to thank my siblings and my best friends for all of the memories and for being amazing people in my life.

Chapter 1

Introduction

Nature of the Problem

The COVID-19 global pandemic caused major disruptions throughout global supply chains across numerous federal and commercial organizations, bringing to light numerous inherent weaknesses within global supply chains. As the virus spread around the world, governments and businesses acted to slow the spread of the virus through implementing work from home orders, social distancing instructions, travel bans, border closures, and mandatory business closures, among many others. This pandemic falls within Quadrant III of Kaku and Kamrad's Risk Classification Matrix as an event with a low likelihood or frequency of occurring yet a high impact once it does occur (Kaku and Kamrad, 2011). Such events are extremely difficult to predict and therefore very difficult to prepare for a specific type of event occurring. Furthermore, as this event is global in nature, the impacts of it are felt on a global scale, impacting governments and companies throughout their supply chains and making this supply chain disruption very different from others, such as localized or regionalized natural disasters.

The nature of this event and the decisions made to combat its challenges had impacts that caused a bullwhip effect throughout supply chains in causing both supply and demand shocks. Examples of supply shocks in relation to the COVID-19 pandemic include manufacturing facilities shutting down due to quarantine orders or lack of Personal Protective Equipment (PPE) for their employees and difficulty in obtaining raw materials for manufacturing due to the geographic locations of suppliers and their suppliers' suppliers. Conversely, this event also

causes demand shocks in greatly increased demand for medical supplies (including ventilators, surgical masks, and other PPE), consumer paper or food products, and decreased demand in business or leisure travel, aerospace parts, and commercial food products. The gap between the supply and demand for the critical supplies needed to combat this virus created a major challenge for governments and organizations to treat the virus and its related health impacts. Likewise, because of the change of demand in many industries, companies found themselves in a position of decreased demand for their products with an idle labor force, possessing the available capacity needed to manufacture the critical supplies to combat the virus.

The nature of this event highlighted inherent weaknesses of global supply chains, including dependence on limited numbers of suppliers within a particular geographic area, lack of visibility throughout supply chains to have forewarning of a disruption, and a lack of infrastructure or supply chain network in producing and transporting critical goods to the point of demand. All in all, these numerous issues stem from the core issue of supply chains having a lack of risk management, resiliency, and flexibility. Addressing these core issues and implementing strategies to combat them will be key toward developing more resilient supply chains to mitigate the impacts of future major disruption events.

How the Research will be Conducted

Because of these challenges felt broadly across industries, this thesis serves a critical role in compiling case studies and analyzing where firms were successful in mitigating these challenges and overcoming the disruptions they faced to aid in their own success as well as

support the greater need in combating the virus through the production of critical COVID-19 supplies. These companies and case studies are grouped into three major categories, as follows:

1. **Increased Capacity:** Prior to the pandemic, these companies already manufactured critical supplies and had the supply chain network and resiliency to increase capacity to meet the increased demand levels.
2. **New Product – Long-Term:** Companies in this category are those who did not have experience in producing these supplies yet pivoted their manufacturing capabilities to create a new product line for their business, with the short-term goal of supporting the COVID-19 recovery efforts and the long-term goal of retaining this product as a new market opportunity and product line in the future.
3. **New Product – Short-Term:** Companies in this category are those who pivoted their existing supply chains to support the creation of a product new to their product offerings to support the efforts in fighting the COVID-19 virus, but do not have intentions of maintaining this product as an offering for their company in the long-term horizon.

The information collected for the research is found through publicly available sources such as published materials in news articles, company blogs, and supply chain research journals. Following the collection of information, this thesis will dive into the various attributes of the supply chains that allowed for the resiliency to increase production levels as well as the flexibility in pivoting manufacturing to produce the demanded supplies. From this analysis, the

research will provide a conclusion outlining best practices and positive attributes of the supply chains so it can be used as a resource for companies to build these strengths into their supply chains to aid in their company's success during future disruption events.

Structure of this Thesis

To provide adequate background information to better understand the environment in which supply chains were operating and elaborate upon what makes the COVID-19 pandemic unique, Chapter Two of this thesis focuses on the following subject matter topics: the COVID-19 Pandemic, Unique Attributes of this Event, the Preparedness of Global Supply Chains to Respond to the Pandemic, the Highlighted Weaknesses of Global Supply Chains, and lastly, Motivating Factors for Companies to Support. Following this background information to set the stage for this thesis, Chapter Three elaborates upon the methodology through which this research will be conducted. Chapter Four dives into the various case studies and company examples, categorized into the three main divisions mentioned above: Increased Capacity, New Product – Long-Term, and New Product – Short-Term. This thesis will conclude by providing an analysis of the key attributes that led to these companies' success in transforming their supply chains and emphasize the importance of building resiliency and flexibility into supply chains.

Chapter 2

Background

COVID-19 Pandemic Background

COVID-19 is a novel type of coronavirus, which is an infectious respiratory virus, that was first discovered in Wuhan, China in December of 2019. As the virus quickly spread throughout the globe, the World Health Organization (WHO) declared the outbreak a pandemic on March 11, 2020 (World Health Organization, 2020). As of October 31, 2020, there were over 45.4 million cases recorded globally, with over 1.2 million deaths, impacting 216 countries around the world (World Health Organization, 2020). As the virus is known to spread through person-to-person contact and has long incubation periods, governments were quick to enact social distancing measures, stay-at-home orders, and closure of non-essential businesses. According to the Centers for Disease Control and Prevention (CDC), social distancing is a term that means people should stay a minimum of six feet physically distanced from other people around them. The goal of social distancing is to decrease the spread of the virus, as it was found that COVID-19 spreads when people are in close contact for prolonged periods of time (Centers for Disease Control and Prevention, 2020). This recommendation from health professionals impacts how many businesses and manufacturing facilities operate because many current structures and business practices are not designed to maintain a minimum distance of six feet between people.

Furthermore, while the specific rules vary state-by-state in the United States (U.S.), commonalities between businesses deemed as “essential” and could remain open during the

beginning stages of spread in the U.S. include grocery providers, healthcare operations, pharmacies, gas stations, transportation businesses, and banks, to name a few. Contrarily, commonalities of business types deemed “non-essential” and were initially instructed to close, followed by the slow opening as long as they complied with government guidelines, included gyms, salons, construction, and industrial manufacturing not related to essential functions, to name a few (Jiang, 2020). These orders and guidance impacted the global supply chain in nearly every industry, including manufacturing facilities shutting down, limited availability of transportation modes, and temporarily closing businesses to comply with the new rules.

Critical Supplies Needed

There are various critical supplies necessary for the medical facilities and hospitals treating patients with COVID-19, such as ventilators for patients and PPE for medical staff treating patients of the virus, as well as supplies for the everyday use to increase people’s protection against the virus, such as face masks and hand sanitizer. Because COVID-19 is a respiratory virus, ventilators are used to help patients breathe if their lung function declines or to support their breathing efforts while fighting the virus. A patient can use a ventilator for varying lengths of time, from a few hours to a few weeks, depending on the severity of their symptoms (Yale University, 2020). The supply within the hospital network as well as stored in the Strategic National Stockpile was not enough to support the forecasted demand. Furthermore, additional biomed devices necessary to treat COVID-19 include oxygen delivery devices and oxygen therapy devices. As for PPE for the frontline healthcare workers, these supplies can include N95 respirator masks, gloves, gowns, goggles, and plastic face shields (Emergencies Preparedness

and WHO Headquarters, 2020). Beyond the scope of the medical facilities treating the virus, there are many other supplies that can decrease the everyday citizen's risk of contracting the virus, including masks and hand sanitizer. The general public is recommended by the CDC to refrain from using the N95 or surgical masks to allocate them to healthcare workers. Rather, the general public can purchase or make cloth masks from home using materials such as cotton fabric and elastic (Mayo Clinic Staff, 2020).

Unique Attributes of this Event: Simultaneously Regional and Global Event

As mentioned previously, the WHO has reported that the COVID-19 pandemic has impacted 216 countries around the world – making this pandemic a truly global issue. Simultaneously, as the virus spread throughout the world, various regions and countries were impacted in various magnitudes at varying times. As of October 31, 2020, according to the WHO Coronavirus Disease (COVID-19) Dashboard, the top three regions of the world impacted, ranked by cases per one million in population, were: the Americas, Europe, and South-East Asia, respectively (World Health Organization, 2020). Furthermore, as the national and local governments made independent decisions regarding how best to protect their own area and respond to the virus, the impacts of these decisions varied country by country. For example, on January 31, 2020, the Chinese government blocked travel to and from Wuhan and on March 17, 2020, the European Union voted to close twenty-six countries from travel (Taylor, 2020). These actions and statistics emphasize the point that the COVID-19 pandemic was both a regional and global event, greatly increasing the uncertainty and challenges regarding operations across geographies.

Unique Attributes of this Event: Unclear Timeline or Duration

Another factor that makes the COVID-19 pandemic unique and greatly heightens the uncertainty surrounding it is the unclear timeline of how long the pandemic and virus will be impacting the world. In other disruption events, such as natural disasters (i.e. hurricanes, tornadoes, and fires), there is a clearer timeline of how long the event will take place. While the time it takes to recover from the event can vary greatly depending on the damage caused by the event, the initial event itself typically has a forecasted duration publicized via the media or government-sponsored announcements. For example, the average hurricane lasts six days, ranging from hours to up to two weeks (Johnson, 2018). Based on this figure and more specific details on the particular hurricane as they occur, people have a more definitive timeframe for how long the event will occur, with the uncertainty based on the timeframe of the recovery efforts. However, the COVID-19 pandemic operates differently, in greater uncertainty based on the event itself as compared to the recovery efforts. From a business perspective, there is uncertainty in when and how business operations will return to normal, when the risk levels in disruption happening throughout the supply chain will decrease, and when border closures will alleviate, aiding in sourcing options. From a big picture perspective, uncertainty surrounding the global pandemic includes if and when there would be a second wave of cases and the possibility of reinfection of previous patients. All of these factors in regards to the timeline of the pandemic cause this event to be very unique and therefore demand alternate or innovative solutions.

Unique Attributes of this Event: Disruption from Supply and Demand Shocks

According to a Fortune Report, ninety-four percent of companies faced supply chain disruptions due to the pandemic (Karger and Seewald, 2020). As illustrated in Figure 1 below from the Geography of Transport Systems publication, pandemics can cause severe disruptions

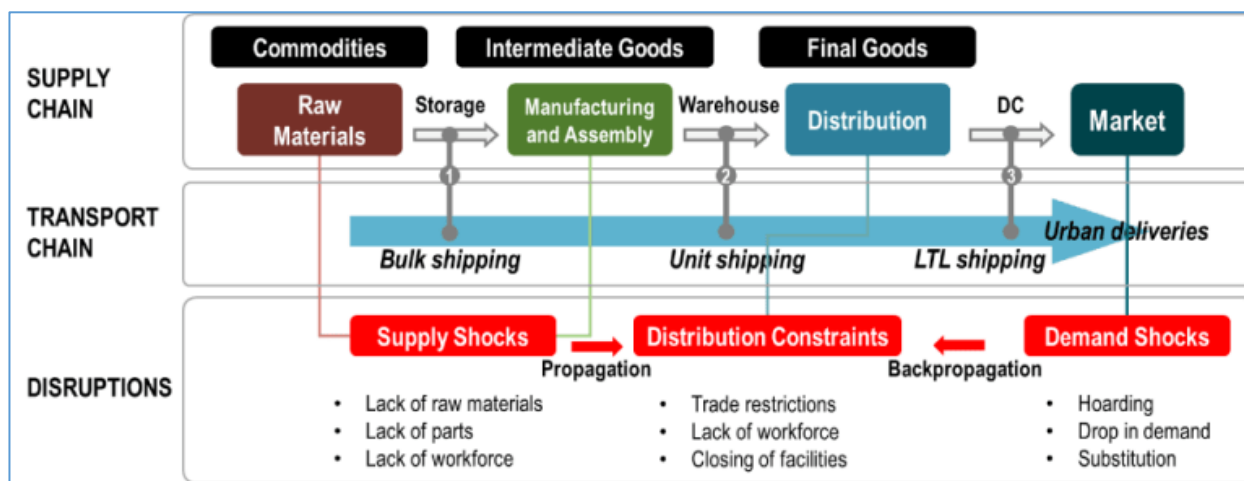


Figure 1: Impacts of a Pandemic - Geography of Transport Systems

to businesses through both supply and demand shocks, making them unique. As in many other major events, shocks are felt on only one end of the supply chain.

Supply shocks are defined as “an unexpected sudden change in availability of raw materials, parts, goods, and manufacturing capabilities” (Rodrigue, 2020). This definition and examples listed in Figure 1 are exemplified by the COVID-19 pandemic particularly through the lack of raw materials and reduced workforce. With countries shutting down manufacturing operations, the lack of workforce and manufacturing capabilities starting with the raw material supplies cause ripple effects throughout the supply chain in making sourcing raw materials much more difficult. Furthermore, even if companies were able to source the materials they needed, many ran into restrictions in maintaining their previous levels of manufacturing capabilities due

to government orders for city lock downs or due to noncompliance with social distancing recommendations.

LMI conducted a study and published a report titled “COVID-19 and Supply Chain Resilience: What’s Next?”

where they surveyed various companies on the impacts to their supply chains from the pandemic, culminating in the chart in Figure 2: COVID-19 Supply Chain Effects to the right (Jones and McCarthy, 2020). Many of the issues

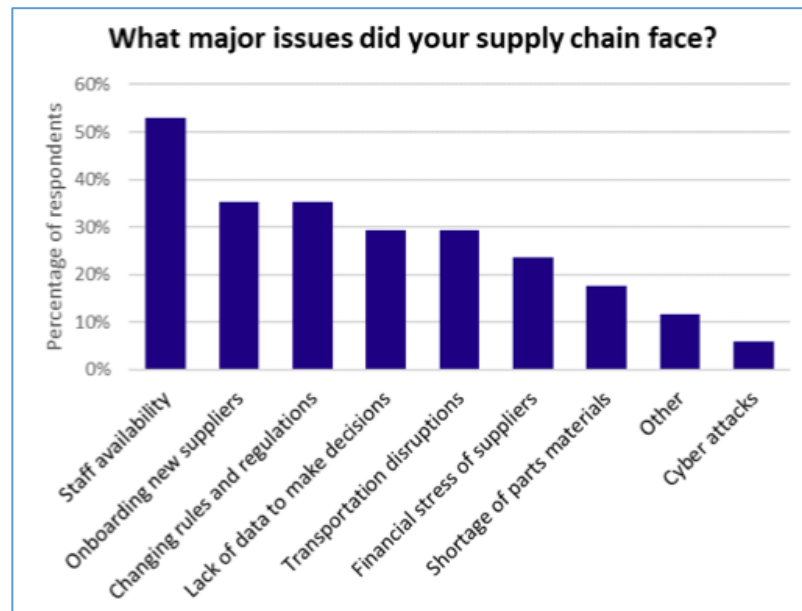


Figure 2: COVID-19 Supply Chain Effects - LMI

illustrated in Figure 2 are supply shocks. LMI concluded the greatest issue was staff availability, mostly due to many companies shutting down facilities to comply with stay-at-home and social distance orders as well as the increased risk of employees contracting the virus, as more than half of the companies surveyed felt these impacts. To highlight a few additional supply shocks mentioned in this report, additional issues supply chains faced included onboarding new suppliers when their currently contracted supplier was unable to support the demand, drawing light to a dependency on too few suppliers for one raw material or good in which many supply chains were forced to quickly find, negotiate, and onboard new suppliers in a short timeframe. Changing rules and regulations was a major factor in the disruption by governments of countries, states, and local regions. All were quick to implement and change various public health and economic policies. Lastly, the supply shocks mentioned here include the financial stress of

suppliers and shortage of parts materials, which both severely impact the supply lines of many supply chains.

Alternately, demand shocks, as defined by the Geography of Transport Systems publication, “imply a sudden change in demand due to unforeseen circumstances” (Rodrigue, 2020). As stay-at-home orders began to be implemented throughout the U.S., panic and fear instilled and was shown in the form of hoarding of paper and cleaning products, such as toilet paper, hand sanitizer, and disinfectant wipes. This change in consumer behavior sparked grocery stores and big box retailers to implement limits on the quantity of these products consumers could purchase in an attempt to decrease the amount of hoarding taking place. Likewise, other products that had major increases in demand were those related to protecting oneself from obtaining the virus. For example, N95 masks had a global increase in demand by 3,500 percent and nasal swabs, used in the testing kits, increased by 1,755 percent (Jones and McCarthy, 2020). Conversely, other products had great decreases in demand, particularly those related to travel as many companies and governments moved toward canceling all non-essential travel and implementing travel bans across country borders. Data comparison from 2019 to 2020 in April shows a ninety-five percent drop in passengers screened by the Transportation Security Administration (TSA) for air travel and it is estimated in April of 2020 nearly half of the world’s aircraft fleet were grounded (Ellwood, 2020). Furthermore, the demand for energy is down as well with less people commuting to work and less office buildings being utilized (Rodrigue, 2020). As these shocks hit supply chains from both the supply and demand sides, the simultaneous supply chain disruption makes the approach to solve the problems caused by the COVID-19 pandemic much more unique.

Preparedness of Supply Chains to Respond to the Pandemic

The pandemic drew light to how successful many companies' and governments' Supply Chain Risk Management (SCRM) plans and implemented strategies were to mitigate these disruptions felt by their organizations. From research conducted by Procurious and RiskMethods in their report titled, "Disruption, Recovery, and Resilience: Supply Chain Risk Management becomes Mission Critical," they concluded many businesses struggled to pinpoint the points of highest risk throughout their supply chains because their SCRM strategies were outdated and underinvested (Procurious and RiskMethods, 2020). Most notably, from a survey sent to various supply chain representatives, thirty-nine percent of respondents stated they were "blinded by a lack of insight into supplier and geographic risk." In a research study, Accenture found that even if some companies had implemented dual sourcing strategies in adding diversity to their sourcing portfolio across multiple countries, they had failed to consider a multi-country failure scenario, as exemplified with the global COVID-19 pandemic (Accenture, 2020). Lastly, the top regret of respondents from Procurious and RiskMethods' study, prior to the pandemic, was not investing enough into technology related to SCRM. This was exemplified in their survey when twenty-seven percent responded they "didn't have the tools and agility to respond fast enough." This report highlighted that many supply chains were not prepared to face supply chain disruptions of this magnitude or timeline that arose due to the uniqueness of the COVID-19 pandemic.

Not only were companies' supply chains unprepared, but also the United States government's preparedness levels were inadequate to meet the demand necessary, best exemplified through the stock levels in the Strategic National Stockpile (SNS). The purpose of the SNS is to supplement supplies necessary for public health emergencies and to serve as a

short-term buffer to provide supplies, medicines, and devices for care until the adequate level of materials are received to fight the public health emergency (Public Health Emergency, 2020). To be clear, the SNS was never designed nor built to provide all necessary supplies during a global pandemic impacting all fifty states in the U.S. Rather, its purpose is more tailored toward short-term support for a localized event.

Already facing challenges in not being strategically set up to handle a global pandemic, another factor of the SNS that aids in leaving the U.S. unprepared is that the SNS is comprised of idle inventory that has a shelf life (Virgin, 2020). In theory, the SNS stores the safety stock for the nation, leading to high expenses regarding the inventory carrying costs and the labor expenses dedicated to managing this inventory. Furthermore, the consideration that medical supplies have a shelf life prior to expiration is another factor playing into the trend to keep and maintain a lean amount of inventory. Throughout the pandemic, the SNS has worked to distribute supplies from the inventory they have, including the critical items such as surgical and face masks, N95 respirators, and face shields, as well as aid in the procurement and production of these supplies. However, these inventory levels are not enough to support the United States in the fight against the pandemic, leading the government to look toward commercial companies and private industries in the production and procurement of the necessary goods.

Highlighted Weaknesses of Current Global Supply Chain

The impacts of the tradeoff between resiliency and efficiency in supply chains – that can be detrimental in the face of major disruption events – was brought to light during the pandemic. In the past, redundancy in supply chains was understood as an inherent negative and the goal was

to reduce redundancy to achieve high levels of efficiency. However, in striving for extremely efficient and lean supply chains, many companies found themselves struggling to overcome the challenges the pandemic brought on due to their dependency on a limited number of key stakeholders in the efficient supply chains. Particularly through the lens of sourcing, dependency can be viewed in two ways: companies relying on only a minimal number of suppliers for critical raw materials or goods or relying on a group of suppliers within just one geographic region or within one country's borders. In either of these scenarios, the company has built an efficient supply chain reliant upon these suppliers in which they most likely have a strategic sourcing contract in place. However, in not having a more diverse supplier pool to source from, a major disruption event such as the COVID-19 pandemic can ricochet negative impacts throughout their supply chains in not being able to procure critical raw materials. These negative impacts can include manufacturing delays or work stoppages until the material can be sourced.

The second key weakness of the current global supply chain that many companies faced in light of the pandemic is a trend of having a lack of visibility throughout the various stakeholders and links in the chain. As referenced in LMI's study shown in Figure 2 in the "Unique Attributes of this Event: Disruption from both Supply and Demand Shocks" section of this thesis, a lack of data to make decisions stemmed from a lack of visibility throughout the supply chain in which many companies struggled to obtain real-time data regarding the state of their stakeholders (i.e. manufacturing facilities, transportation carriers, suppliers) as well as data regarding changes in demand for their products to make more accurate forecasts (Jones and McCarthy, 2020). Additionally, in Procurious and RiskMethods' study, twenty-five percent of respondents said they were held back in addressing the disruption caused by the pandemic due to a lack of analytics to access real-time data, and twenty-seven percent said they did not have the

tools and agility to respond fast enough when they were able to gain visibility into the impacts on their supply chains (Procurious and RiskMethods, 2020). Supply chains that lacked the technology and visibility struggled to respond quickly in identifying the particular links in their supply chains that were the most impacted.

Motivating Factors of Companies Pivoting their Supply Chains

The first key motivating factor of why companies would pivot their supply chains is that aiding the greater good in producing life-saving equipment and supplies during the pandemic aligns with their company values and purpose. Many companies have made commitments to adhering to positive Corporate Social Responsibility statements and have incorporated some of these values into their company's actions. The COVID-19 pandemic is a great example of an opportunity with which companies can act on these statements, as Kramer mentions in his Harvard Business Review article titled, "Coronavirus is Putting Corporate Social Responsibility to the Test" (Kramer, 2020). Kramer mentions how frequently the actions by companies during a time of need are used as case studies in business courses for years after the event, and by companies doing what they can to aid in the manufacturing of necessary products in response to the 2020 pandemic, they are enhancing their reputation as a socially responsible firm.

The second key factor is that companies who have seen decreased demand for their typical product lines suddenly found themselves with idle workforce and manufacturing capacities. To decrease the amount of furloughs and layoffs needed to meet the financial goals of the company, many companies sought ways to obtain "essential" status in manufacturing products with increased demand due to the pandemic (Supply Chain Dive Staff, 2020).

Furthermore, some smaller companies that closed their facilities and furloughed their employees, therefore not having as much income coming into their business, could struggle to stay afloat after the pandemic is over (Dua, et al., 2020). Because of these two reasons, many companies were looking for ways to repurpose their manufacturing facilities to keep running throughout the duration of the pandemic.

Another motivating factor is that through various grant programs, public funding became available to support companies willing to invest in the changes necessary to transform their manufacturing facilities to make necessary products. For example, the Coronavirus Aid, Relief, and Economic Security (CARES) Act signed on March 27, 2020 provided funding for the Department of Commerce's National Institute of Standards and Technology (NIST) to create a program called the NIST Manufacturing USA National Emergency Assistance program to provide funding to companies supporting "rapid, high-impact projects that support the nation's response to the COVID-19 pandemic" (Manufacturing USA, 2020). With opportunities like this to receive funding, companies could find the support they needed to make the investments to support the efforts.

Lastly, some companies viewed the challenges of the pandemic as a new opportunity for their firm to add and keep a new item to their long-term product lines. These firms conducted analyses of the market and decided that their capabilities support the long-term production of the products as well as they are able to see consumer demand in the future for the product that would make financial sense for their company. Chapter Four of this thesis discusses this further in analyzing companies that successfully made these choices in adding a new product during the pandemic, with full intentions of adding the product to their long-term product offerings.

Chapter 3

Methodology

From the information and the analysis provided in Chapter Two: Background, it is clear to see the COVID-19 pandemic caused many challenges and supply chain disruptions that companies and governments struggled to overcome. Because these challenges were felt broadly across industries, this thesis serves a critical role in compiling case studies and analyzing where firms were successful in mitigating these challenges and overcoming the disruptions they faced to aid in their own success as well as support the greater need in combating the virus.

This research was completed through analyzing publicly available sources, both through research studies conducted as well as articles published by respected media sources and the companies themselves. After the information was compiled, the case studies were grouped into three main categories: Increased Capacity, New Product – Long-Term, and New Product – Short-Term. These categories represent the three large methodologies of which companies were able to successfully adapt their manufacturing processes to produce the supplies demanded for the pandemic. While there are a variety of products with increased demand as a result of the pandemic, this research focuses on the PPE demanded by the frontline healthcare workers. Chapter Four delves into three case studies, one from each category, elaborating upon the background information and history of the company, the actions they took to pivot their manufacturing and supply chains, the results of their actions, and the various strategies they implemented that allowed for success.

The last step to this research is to compile best practices that were common strategies shared between the organizations to successfully pivot their manufacturing and supply chains. Analyzing these best practices and identifying the commonalities will allow this thesis to serve

as a future resource for supply chains to build resiliency and flexibility within their organizations.

Chapter 4

Analysis

When analyzing the various companies that acted during the beginning stages of the COVID-19 pandemic to aide in the manufacturing of highly demanded supplies, there were three major categories that arose. The first category consists of companies that were already producing the item and increased the capacity of their manufacturing to support the increased demand. The company studied in this category is 3M and their production of N95 respirators. The second category includes companies that pivoted their supply chains and manufacturing processes to support a product that was new to them, with the intentions of maintaining this item as a product offering in the long-term. To better understand this type of company, this research analyzes the actions the Merrow Manufacturing Company took to produce nine types of PPE, most notably medical isolation gowns. Lastly, the third category consists of companies that utilized their supply chains, innovative thinking of their designers, and manufacturing facilities to create a new product to support the COVID-19 pandemic in the short-term, with no intentions of maintaining this product in the future. This thesis studies Cartamundi, a games manufacturer, and their actions to temporarily pivot their supply chains to make plastic face shields until they can return to manufacturing their traditional product lines.

Increased Capacity: 3M

Beginning with manufacturing dust respirators in 1972, 3M has evolved this product line to now producing over twenty versions of the N95 mask over the years. The variances in the

versions depend on the industry using the masks, which range from industrial purposes such as construction sites or coal mines to medical purposes such as hospitals or disaster scenes. As these masks have a variety of uses, 3M had already increased production of these masks in the early months of 2020 to support people responding to the volcano eruption in Taal, Philippines and the wildfires in Australia. As this product was already seeing increased demand in early 2020, the demand skyrocketed soon thereafter because of the COVID-19 pandemic. China produces half of the world's respirators and after the virus began to spread, the Chinese government halted exports on this product, leaving many countries to have supply shortages as demand increased simultaneously (Clough and Gruley, 2020). Particularly, the United States soon found itself in a situation with decreased supply and increased demand of the N95 respirators without a strong domestic supply chain or manufacturing capabilities to address this issue.

Realizing the situation at hand, 3M expected their company's demand for protective gear to dramatically increase, leading the company to utilize manufacturing surge capacity and to encourage employees to work overtime hours to increase production. 3M utilized two manufacturing facilities in the United States, one in Wisconsin and one in South Dakota, both of which are able to manufacture the components of these respirators in-house. Additionally, many of their manufacturing lines utilize robots and automation, better allowing their facilities to accommodate for physical distancing between personnel (Clough and Gruley, 2020). Beyond the resources already within the supply chain, the U.S. government awarded two Department of Defense contracts to 3M under the authority of the Defense Production Act to help financially support the increase of production of the N95 respirators. Combined with other investments, since January 3M has invested over eighty million dollars to increase manufacturing of these respirators, culminating in tripling the company's output to over ninety-five million respirators

manufactured per month in the United States (3M, 2020). The company's goal over the next twelve months is to reach a total of two billion masks produced (Clough and Gruley, 2020).

Increased Capacity: Key Factors

There were three main factors that supported 3M in the successful increased capacity: early warning, surge capacity, and a regional sourcing and manufacturing model. Especially because the demand for their products can be immediately impacted by a disaster that occurs in the world, 3M monitors demand constantly, and this capability deemed extremely important in the response to the COVID-19 pandemic. On January 21, 2020, 3M headquarters notified their team members of the new virus. Additionally, the company took note of Singapore taking precautionary actions to ramp up production prior to the country having any COVID-19 cases. These two important pieces of information and the quick sharing of the information allowed for 3M to have early warning and act immediately, such as increasing the overtime hours of 650 employees in their South Dakota plant, to be better prepared to increase their capacity (Clough and Gruley, 2020).

The second key factor that supported 3M's success was the investment and utilization of surge capacity within their manufacturing capabilities. After the company realized their supply chains were not prepared or adaptable enough to support the increase in demand during the SARS epidemic in 2002-2003, they invested and implemented idle machinery within their factories, able to be used when necessary. Upon adding these additional assembly lines, they communicated with their suppliers about this increased surge capacity, coordinating throughout their supply chain to ensure all stakeholders were aware of this capability and prepared to

support when needed. Lastly, from the lessons learned from the SARS epidemic the company established emergency response teams who were trained and prepared to respond when catastrophic events occurred. This surge capacity and preparedness by the company enabled them to increase production and respond to the Ebola panic, H1N1 flu virus, and the COVID-19 pandemic (Clough and Gruley, 2020).

Lastly, 3M strategically implemented a regional sourcing and manufacturing model that enabled them to be successful during the pandemic. Their strategy is to source materials close to the assembly facility and deliver to customers in the regional area. While the facilities are equipped to ship anywhere in the world, the purpose behind normally operating with the regional model is to decrease the risk and impacts of export bans or tariffs. Having this model in place greatly aided in increasing manufacturing capacity in the United States of the N95 respirators because of two reasons: they could utilize regional suppliers to manufacture the N95 respirator components in-house in the United States and this supply chain was already established, not being negatively impacted by the Chinese export ban on these masks. Through this model, 3M mitigated many of the challenges associated with countries implementing more protectionism policies and limiting the exports of PPE and raw materials (Clough and Gruley, 2020).

New Product – Long-term: Merrow Manufacturing

Merrow Manufacturing LLC is a 182-year-old company based out of Falls River, Massachusetts in the technical soft goods manufacturing industry. Over the course of their existence, they have expanded their business from the invention and manufacture of an overlock stitching machine to now manufacturing numerous types of sewing machines. They also manage

and sell inventory of antiquated parts needed for legacy sewing machines as well as have a factory of 500 sewing machines used to produce non-apparel and apparel technical soft goods. Their factory is strategically designed for efficiency and quality by having application specific cells, floor engineers tracking minutes per operation, quality inspection stations to detect issues early, and trimming and inspection departments completing detailed unit reviews (Merrow Manufacturing, 2020).

As the COVID-19 pandemic began to spread throughout the world, Merrow saw an opportunity within the market in noticing the worldwide shortage of PPE, particularly in building the supply chain of PPE in the U.S. The company invested five million dollars and formed a new medical division within their organization to design and manufacture nine PPE products, including five types of medical isolation gowns. From a big-picture supply chain perspective, their goal was to create an immediate domestic supply chain for medical supplies to aid healthcare workers on the frontline of the pandemic within the U.S. This strategy led the company to not only create approximately 900 new jobs in the Northeast region, but also become the largest producer of U.S.-sourced medical gowns by May 27, 2020, according to a press release by the company (Williams, 2020). These actions resulted in Merrow signing a contract with the Massachusetts state government for an order of 2.5 million gowns in addition to contracts with over eighty-five healthcare facilities. Looking toward the future, the company has intentions of maintaining the production of PPE as an addition to their product lines. While company leadership acknowledged the cost of operating and the cost of the products might be more expensive for them to manufacture when compared to the same goods made in China, their goal is to establish a reliable source of high-quality essential medical supplies domestically in the long-term (Williams, 2020).

New Product – Long-term: Key Factors

The first factor that made this case study successful is that the new product line and pivoting the manufacturing facilities closely aligned with Merrow's company values. Charlie Merrow, a seventh-generation family member who now co-owns the business, is quoted as saying, "For over 180 years, our business has been intricately woven into American history, which is why this pivot to manufacturing PPE feels like a true and natural extension of our brand. This new medical-focused division is not just a response to the current situation, but an opportunity to create an entirely domestic supply chain and reinvigorate our healthcare system and local communities; creating jobs, brand longevity, and performance-oriented products for our front-line workers" (Williams, 2020). Alongside this leadership perspective, the company prides itself as an investor in American manufacturing. Having the support of leadership and overall culture to create a new product line, such as PPE during a pandemic, aides in this action being successful in the long-term.

The second factor is the use of strategic suppliers with specific attention to collaboration between the partners to innovate a new product together. Merrow utilized two strategic suppliers to innovate new designs for medical isolation gowns: one with Dupont, a textile company, and another with FORLOH, an outdoor performance brand. Dupont had the vision of providing "innovative and sustainable textiles to the new medical line," providing a unique opportunity for Merrow to partner with the organization to combine the materials made by Dupont with the manufacturing capabilities by Merrow. Similarly, Merrow worked with the technical capabilities and materials FORLOH specializes in, including ballistics-grade nylon and tactical outdoor performance brand, to innovate durable and long-lasting medical gowns (Williams, 2020). By

including these strategic suppliers in the innovation process to utilize the core competencies of both organizations, Merrow was not only able to enter into a new market opportunity in creating PPE, but also create high-quality and durable products to be used on the frontline addressing the needs from the COVID-19 pandemic.

The third key factor is that Merrow Manufacturing mitigated many of the challenges posed by the pandemic in regards to restrictions of goods crossing international borders because they utilized a supply chain based in the United States. Merrow ensured total production control by using a completely domestic supply chain. Using this capability, they were able to scale to become the largest manufacturer of medical gowns in the U.S. (Williams, 2020). As stated above, while this supply chain strategy is more expensive than a more globalized approach, it provides Merrow with a core competency of using a domestic supply chain when needed.

New Product – Short-term: Cartamundi

Cartamundi is a games manufacturer that found themselves in a difficult situation during the COVID-19 pandemic. The U.S. government deemed their business as non-essential and required the manufacturing facilities to close down. As of March 20, 2020, all factories located in the United States were closed with Cartamundi employees furloughed. Simultaneously, leaders within the organization recognized the nationwide shortage of PPE and decided to pivot their organization to temporarily use their idle workforce and capabilities to design and manufacture PPE, particularly plastic face shields, to donate where needed for frontline healthcare workers (Cartamundi, 2020).

Pivoting their manufacturing capabilities necessitated collaboration among Cartamundi's North American team, which consists of the Design Center located in Seattle, Washington, a factory in Dallas, Texas, and a factory in East Longmeadow, Massachusetts. The company utilized open source documents published by the Food and Drug Administration (FDA), detailing the designs and requirements for high quality plastic face shields. By using these designs as a base, Cartamundi then altered the recommended components for the face shields, within the constraints approved by the FDA, to align with components they had in inventory. Within forty-eight hours, the company had a design and prototype produced, innovating the FDA's recommendations to fit within their capabilities and materials available. Immediately, sourcing teams based out of their factories acted to navigate the challenges of the raw material shortage in the U.S. to procure materials in large quantities for manufacturing. Cartamundi now produces 50,000 face shields per week that they manufacture, donate, and deliver to hospitals, health care workers, and first responders in the local areas of their factories. Leadership has stated they intend to maintain this product and level of production as long as necessary with the goal of transitioning back to their normal product lines when possible (Cartamundi, 2020).

New Product – Short-term: Key Factors

The first factor that aided in Cartamundi in being successful in pivoting their manufacturing processes and facilities was the speed of innovation they operated at in order to design and produce the new face shields. The company quickly analyzed the challenges they faced: an entirely idle workforce with government restrictions constraining their abilities to manufacture and sell their products. By quickly realizing the severity of these challenges, the

company utilized their existing relationships and collaboration abilities to innovate the new product. After launching the Design Center in 2017, the company established a team responsible for managing the flow of information, streamlining of processes, and creative brainstorming for the design process between the Design Center, its factories, and its major customers. While the design and prototyping process typically takes approximately one month, the team was able to accomplish this feat in just forty-eight hours (Cartamundi, 2020). Having this organization and culture of collaboration aided in the speed of innovation for Cartamundi, allowing them to get their workforce back to work quickly and safely.

The second key factor is that the company had the flexibility and adaptability to utilize their manufacturing expertise combined with the FDA-published information in an innovative manner. While at first glance the jump from manufacturing games to plastic face shields seems large, Cartamundi leveraged their strengths and knowledge in working with paper and plastic as well as injection molded pulps and foam to manufacture the plastic face shields. They innovated their current processes and facilities to adapt their capabilities to a create a new product. Furthermore, because their workforce had this manufacturing expertise, the company was able to redesign their manufacturing facilities to install all-inclusive work stations with plexiglass dividers between stations to comply with social distancing requirements between employees (Cartamundi, 2020). Having a skilled workforce with the adaptability to repurpose their facilities allowed for Cartamundi to manufacture the face shields and benefit first responders in their areas.

Lastly, supporting the healthcare facilities treating patients with the COVID-19 virus closely aligns with the company's values and culture. Because of this alignment, Cartamundi employees supported and wanted to do what they could to support the success of this decision.

Leaders were quoted throughout the organization as seeing a sense of pride amongst the employees, leading to their workforce being motivated and productive at work. Stefan Congram, a representative from the organization, stated, “Knowing that your employees are motivated and happy to produce something like this is rewarding in itself” (Cartamundi, 2020). Acting to innovate and manufacture this new product during the pandemic, even though the company does not have intentions of maintaining this product in their long-term product offering, has helped boost the company’s culture both during the pandemic and is expected to see positive benefits in the future.

Chapter 5

Recommendations and Conclusions

While the three case studies analyzed in this thesis all vary in terms of industry, capabilities, PPE produced, and intentions on removing or maintaining the new product in the future, there were many common capabilities that aided in the companies being successful in quickly pivoting their supply chains. The first commonality leading toward a successful shift is a company's values being implemented and practiced throughout the workforce demonstrated through the organization's culture as well as the company's values supporting and closely aligning with the shift. Operationalizing the company values as compared to simply listing them on a company website was crucial for companies such as Merrow and Cartamundi to successfully motivate their employees to innovate and implement supply chain changes quickly. For both companies, leaders stated that pivoting their supply chains to support first responders to the COVID-19 pandemic felt similar to a natural extension of their company due to the organizations putting a high emphasis on benefitting their local communities and the United States economy. Because of this, the first recommendation for supply chains looking to or needing to make a change in their supply chain is to ensure the workforce is aware of and motivated by the company values. Aligning the workforce around these common values allows organizations to be more prepared to take on challenges when the solutions to these challenges align with company values as well.

The second commonality is the use of strategic relationships, as demonstrated with Merrow Manufacturing's relationships with their strategic suppliers and Cartamundi's three-way

relationship with their Design Center, manufacturing facilities, and major customers. By strategically including these various stakeholders and establishing lines of communication and aligning goals between the stakeholders, each organization was able to successfully collaborate and create new products over a short timeframe. Especially when a disruption occurs that ricocheted impacts throughout supply chains such as the COVID-19 pandemic, including suppliers, leaders, engineers, and factory mechanics on the design and planning processes allowed for greater success for these companies. Additionally, having strategic relationships allows for increased visibility throughout a company's supply chain because of the more frequent communications and inclusions on decision making. Companies are able to more easily share information between parties and notify other stakeholders when an issue arises. Because of this, the second recommendation from this thesis is for companies to develop strong relationships and lines of communication with their key stakeholders, including major suppliers, employee groups, and customers, to support their supply chain shifts.

Thirdly, 3M and Merrow Manufacturing relied heavily upon their regional and domestic geographic locations of stakeholders throughout their supply chains. Due to the geographic impact of the COVID-19 pandemic as discussed in Chapter Two: Background, Unique Attributes of this Event: Simultaneously Regional and Global section, supply chains that relied heavily upon supplies or manufacturing facilities in a geographic location far away from the point of demand faced many challenges. By 3M utilizing their regional strategy and Merrow utilizing a completely domestic supply chain, they were able to source the materials needed and navigate the challenges of the global shortages on those raw materials. The third recommendation for companies looking to build the resiliency and risk mitigation strategies of their supply chains is to make their supply chains more geographically diverse. Strategies to accomplish this can

include building a supply base in various countries or having regional suppliers and manufacturing facilities located domestically and close to demand. Companies should balance the costs and risks of these geographic decisions. While it may be more expensive to maintain a regional model in some geographies, it can prove pivotal toward mitigating major disruptions.

Throughout all of these case studies, a common theme that allowed each firm to successfully manufacture products to support the frontline healthcare employees during this pandemic was having the flexibility, adaptability, and resiliency to innovate current processes to meet the new demand. Whether companies had previously produced the product or it was a new item for them, innovation and a resilient supply chain were necessary toward leading the company to success. Having this capability allowed them to not only benefit the greater good in supplying these products to the frontline healthcare workers, but also to keep their facilities running and employees working during a time period in which many companies struggled to do so. By analyzing the successful characteristics of the supply chains of 3M, Merrow Manufacturing, and Cartamundi, companies are able to learn from their actions to implement strategies to build more resilient supply chains and mitigation the impacts of future major disruption events.

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The Pennsylvania State University | Schreyer Honors College
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PROFESSIONAL EXPERIENCE

NASA Langley Research Center

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Office of Strategic Analysis, Communications and Business Development (OSACB) Intern

Aug 2020 – Dec 2020

- Investigated future areas of opportunity in human space exploration, aeronautics, and earth science for further NASA research by analyzing market reports and presenting summarized information to leadership to guide future strategic goals
- Interviewed small businesses leading the development of revolutionary technology such as supersonic commercial transport and urban air mobility to identify long-term challenges in commercializing the technology

The Boeing Company

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737 MAX Return to Service Program | Supplier Management Intern

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- Advanced 737 MAX aircraft return to commercial service through leading the delivery of 9 presentations to senior leaders of key supplier partners to define Boeing's expectations and priorities and enhance supplier relationships
- Mapped 5 Supplier Management processes to provide role clarity across stakeholder integration and process collaboration
- Streamlined the existing Internal Purchase Order flow to support the speed and agility needed for Return to Service efforts

NASA's Space Launch System (SLS) Program | Materials Management Intern

May 2019 – Aug 2019

- Investigated root causes of work orders with discrepancies between systems to ensure traceability, culminating in over 625 closed work orders and the development of a training document outlining instruction for addressing common issues
- Increased effectiveness of metric data points by correcting and redesigning graphs to monitor in weekly metrics meetings

Ingersoll Rand

Davidson, NC

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- Minimized non-contracted spend and enhanced the carrier negotiation process by improving visibility of contracts through the consolidation of truck load pricing and route information
- Developed a data analytics tool in Excel to consolidate committed shipping lanes and carrier information to increase fleet capacity by 1,100 truckload commitments for the Commercial HVAC Business Unit in a trucking market facing capacity shortages

Sheetz, Inc. | Human Resources Department

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School-to-Work Intern | Summer Intern | Office Associate

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- Consulted for the Employee Relations Department to complete a 154-page comprehensive research report on employee benefits at all of the Fortune Top 100 companies to identify trends in Human Resources and new opportunities for Sheetz
- Ensured a seamless employee onboarding experience by facilitating over 30 orientations for employees of various ages and professional backgrounds in 6 states and guiding tours around the distribution center and corporate offices

LEADERSHIP AND INVOLVEMENT

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- Mentored an inductee class of 20 students through personal and professional development curriculum tailored toward enhancing interviewing, goal setting, and collaboration skills
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- Managed communications with an alumni base of over 405 graduates by serving as a resource for current and former brothers to connect, creating unique Canva newsletters to keep them informed, and leading public relations and webmaster chairs

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- Fostered camaraderie within the Honors College by assisting 320 first-year and second-year scholars in the transition to Penn State University Park by organizing college-wide community builders and special events in the living-learning community

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