Understanding the Supply of N95 Respirators as a result of China's Trade Policy During the COVID-19 Pandemic

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Abstract

This paper seeks to compare three periods of N95 respirator supply before, during, and after China's state policy of requisitioning all N95 respirators between January and February of 2020. China manufactures a large majority of the United States supply of N95 respirators. Did this policy decision by China impact the imports of N95 respirators into the United States? By analyzing maritime import records from 2015 to 2021 using Differences in differences analysis we can compare trade activity between China (treatment group) and the World (control group) during the policy period. 2015 to 2021 was selected because it allowed for enough time before the pandemic; 2021 was the last period that data was available. The results indicated that the requisitioning of N95 respirators for use in China did not have an impact on the importation into the United States.

Keywords: China, United States, N95 respirator, trade policy, personal protective equipment

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II. Introduction

The SARS-CoV-2 virus (COVID-19) is an infectious acute respiratory disease. COVID-19 was first discovered in Wuhan, China in the fall of 2019. Since that time COVID-19 quickly spread globally during the 2019-2021 coronavirus pandemic. Quickly governments worldwide worked to impose nationwide lockdowns which included closing international borders. With the ever-increasing number of cases, shutdowns of critical manufacturing facilities became rampant. It became clear at the beginning of the pandemic that shortages would be a hallmark. One of the shortages faced was for N95 medical respirators.

Pandemics place intense pressure on both the supply and demand sides of the economy. This paper will address the supply side of the shortage of N95 respirators. Many issues exist which contribute to a low supply of N95 respirators being imported into the United States from China and the World. Global value chains have concentrated resources in countries like China. Often machines, materials, and specialized labor are centrally located to lower costs and decrease shipping times. The complex machines required to manufacture N95 respirators can cost hundreds of thousands of dollars which can be a significant barrier to entry for smaller firms. However, during a pandemic these factors can contribute to a shortage of N95 respirators. N95 respirators are a complicated product to manufacture. Complex production lines are required along with certification that the N95 respirator filters as advertised. These production lines can take as long as four months to construct. This delay increases the time required for firms to enter the market. In addition, China stopped exporting N95 respirators in January and February of 2020. China accounts for the majority of N95 respirator production globally.

Manufacturing of N95 respirators has shifted from the United States to China in recent years as a result of cheap labor, direct access to the supply chain of melt-blown fibers. Melt-blown fibers are made from polyproline plastic that is melted and liquified then with compress air spun into a fibrous material. The melt-blown fibers act as a strainer for the N95 respirator. Without a consistent supply of melt-blown fibers the production of N95 respirators cannot occur. When the global trade flow has been disrupted as a result of the pandemic it is almost impossible to ship melt-blown fibers to the United States for the domestic production of N95 respirators.

With increased shipping times, material costs, and labor costs it does not make since to produce N95 respirators in the United States. However, a small Texas based company Prestige Ameritech does produce N95 respirators domestically. A Chinese made N95 respirator costs on average 50 cents to manufacture. While a domestically made N95 respirator costs three times what a Chines N95 respirator does. Materials and labor costs in the United States to produce a single N95 respirator are greater than the total cost to produce a single N95 respirator in China. These market forces clearly dictate that China has a comparative advantage to produce N95 respirators in non-pandemic times.

N95 respirators are essential in a pandemic as the respirators are designed to filter out 95% of particles that are at least 0.3 microns in size, proving effective at filtering out the majority of COVID-19 virus particles. N95 respirators are regulated under Title 42 of the Code of Federal Regulations, Part 84 is the quality assurance standards from the National Institute for Occupational Safety and Health (N.I.O.S.H.). All N95 respirators must receive certification from N.I.O.S.H. to be sold as N95 respirators. However, there is another classification known as a surgical N95 respirator. Surgical N95 respirators are regulated by both N.I.O.S.H. and the U.S. Food and Drug Administration (F.D.A.) under 21 CFR 878.4040. (

In April of 2020, the Federal Emergency Management Agency (F.E.M.A.) issued a temporary rule into the Federal Register which prevented the exportation of N95 respirators outside the United States. The implementation of this rule was made in an effort to ensure that the United States had an adequate supply of N95 respirators. The World Health Organization (W.H.O.) issued similar guidance which also called for a rise in the production of N95 respirators by 40%. With new demand and a decrease in supply prices rose quicker than for N95 respirators any other pandemic-related item such as toilet paper or hand sanitizer.

III. Literature Review

This literature review examines the economic factors that lead to the shortage of N95 respirators during the COVID-19 pandemic of 2019 to 2021. Additionally, it illustrates how trade policies and government action intersects to add dimensions to the larger story and hopefully better understand the under lying forces in order to prevent future shortages. News articles, academic journals, and other sources were analyzed to understand the events which lead up to the current supply of N95 respirators for pandemic preparedness and prevention. Government policies have been quickly changing during the COVID-19 pandemic.

Government policies have greatly impacted the supply of N95 respirators and lead to a failure of globalization. (Gereffi, 2020) Globalization broke down as a result of government policies that restricted the exportation and seized N95 respirators in transit to other nations. These seizures caused other nations to also restrict exportation of N95 respirators and seize assets. Since no country alone can meet the increase demand for N95 respirators alone, trading becomes essential. Export bans can be extremely damaging to countries that lack the production capacity to manufacture N95 respirators. (Gereffi, 2020) The Chinese government barred all exports of N95 respirators in January and February of 2020. Total Chinese exports declined by 17% in January and February of 2020 in comparison to the same time in 2019. (Friedt, 2021) The damage to global exports has been estimated to be as high as 45% as China is a major country in the global value chain. The initial shock in global value chains can be blamed for the initial drop off in international trade.

In addition, the Chinese government began to instruct companies to ramp up production while diverting all current supplies to the central government. The central government also began to import N95 respirators from across the world. (Hokeman, 2020) The Chinese government's response significantly increased demand for N95 respirators. China is the largest supplier and manufacture of N95 respirators in the world. In 2019 China accounted for roughly half of global production. In 2019 China was able to produce around six million N95 respirators per day. By early March of 2020 China had increased production by roughly twenty times to 120 million N95 respirators per day. A key reason for China's rapid ability to produce N95 respirators is that the central government re-tooled and re-purposed idle manufacturing lines from industries like automotive and electronics. (Dallas, 2021) Build Your Dreams (B.Y.D.) a Chinese electric car and bus manufacture quickly revamped production lines to manufacture N95 respirators at the beginning of the pandemic. B.Y.D. quickly become the world's largest producer of N95 respirators. (Gutierrez, 2020)

3M a global manufacture of N95 respirators with operations across Europe, Asia, Latin America, and North America. 3M is the largest producer of N95 respirators in the United States. 3M was producing 550 million respirators at the beginning of 2019. 3M quickly started up dormant assembly lines and began to produce 1.1 billion N95 respirators worldwide. (Gereffi, 2021) In April of 2020, former President Donald Trump invoked the Defense Production Act of 1950 (D.P.A). The D.PA. authorizes the federal government to direct companies operating in the United States to direct production in ways that benefit the national interest. The D.P.A. along with other federal directives banned the exportation of N95 respirators outside of the United States. (Hokeman, 2020) Export bans can harm the United States as other countries may retaliate and seize N95 respirators destined for the United States. (OECD)

The result of export permits and restrictions have on the economy for N95 respirators include: keeping countries with no production capacity from receiving N95 respirators, countries are often inclined to retaliate against a country when that country needs more N95 respirators then it can produce, export licenses can deter exports when N95 respirators are needed in a crisis, export restrictions can also push up prices and foster criminal behavior through counterfeiting and price gauging. The black market presents an incredibly lucrative opportunity for drug cartels and criminal enterprises to profit. (OECD)

Export bans can still be dangerous for countries that have some production capacity but not enough to account for the increase in demand due to the pandemic. Export bans can also cause retaliation which can be damaging when a country needs to import materials such as the melt blown material which is required for the production of N95 respirators. Government planning and interventions are critical in order to increase supply in the short-term. Government policies such as incentives for firms to convert existing manufacturing lines to produce N95 respirators can help to secure a stable supply. N.I.O.S.H. certification is required to produce and sell N95 respirators. The certification process can often take many months to even years when a new company would like to enter the market. By speeding up the certification process to only a couple of weeks the quantity of N95s imported can be greatly increased. Trading between nations especially during a global pandemic can be extremely costly as the trade routes and services that are normally used may be unavailable or prohibitively expensive. (OECD)

To counter these problems in the short-term 3M a major manufacture of N95 respirators requested a waiver from liability from the Trump Administration. The waiver would allow the sale of N95 respirators designed for use in construction to be used in a health care setting. (Gereffi, 2020) Healthcare N95 respirators have additional layers of protection against bodily fluids. Because of these additions these N95 respirators are also certified by the FDA.

As cases of COVID-19 decline and the supply of N95 respirators companies that quickly entered the market to sell N95 respirators have found themselves with inventories that cannot be sold. Mass vaccination drives have also decreased the need for N95 respirators as COVID-19 cases are falling and hospitalizations are declining. After China removed its ban on the exportation of N95 respirators health care organizations quickly purchased cheaper Chinese made N95 respirators. With increasing supply and lower demand prices quickly plummeted. A Chinese made N95 respirator cost 25 cents to produce while a domestically made N95 respirator often costs at least three times what a Chinese respirator costs. Domestic production of N95 respirators cannot compete in the global economy. (Evstatieva, 2021)

In January and February of 2020, the People's Republic of China imposed mandates that all N95 respirators produced in China would be requisitioned for use in China. United States companies 3M and Honeywell were banned from exportation. Restrictions were placed on all companies in *Table 5.* This regulation effectively blocked all exports of N95 respirators to the United States as China is the biggest exporter to the United States of N95 respirators. (Dallas, 2021) The question to be answered is: Did China's decision to requisition all N95 respirators produced in China in January and February of 2020 have an effect on the supply of

N95 respirators imported into the United States? By studying this question, we can better understand the effect that Chinese trade policy has on the United States regarding N95 respirators.

IV. Data

The data on imports of N95 respirators from China was constructed in the following manner. All publicly available maritime imports of N95 respirators were collected from Import Genius. Import Genius is a commercially available database of import and export records. By searching the Import Genius database using the term “N95” and by filtering for data between January 1, 2015, and May 31, 2021. May of 2021 was the last month that data was available. The Pandemic period lasted between January of 2020 and May of 2021. Records were retrieved which could be further filtered. Further filtering was required as some import records contained machines to manufacture N95 respirators and not the actual respirators. By removing all records except for those of individual N95 respirators a more accurate tally could be produced. I summed all the quantities of imported N95 respirators by month-year. The data from Import Genius counts N95 respirators in the form of boxes. The personal protective equipment industry uniformly sells N95 respirators in boxes of either 20 or 50. To obtain a standard unit of measure I assumed that all boxes contained 35 N95 respirators. To obtain 35 as the quantity of N95 respirators in a box; the median of 20 and 50 was taken which is 35. By multiplying the monthly Quantity of boxes by 35 to obtain the Adjusted Quantity. The Adjusted Quantity is a more accurate measure of total N95 respirators imported into the United States. However, the Adjusted Quantity still assumes a middle range quantity and so the total quantity of N95 respirators maybe lower or higher than calculated.

The data observes both imports from China and the World. The World is a combination of 29 countries that include Argentina, Australia, Bahamas, Belgium, Brazil, Cayman Islands, Columbia, Costa Rica, France, Germany, Hong Kong, India, Italy, Jamaica, Japan, Malaysia, Mexico, Mozambique, Netherlands, Oman, Panama, Peru, Singapore, South Korea, Spain, Taiwan, Thailand, United Kingdom, and Vietnam. Only imports from China were used as the treatment group. Imports from the World were used as the control group as those countries were not subject to China's trade policy that the research-tested. Hong Kong and Taiwan were grouped with the World and not China as it was determined that China's trade policies did not apply to these countries even though their sovereignty is disputed.

To measure the variation of imports into the United States from China and from the World on a month to month basis a calculation was performed in Microsoft Excel. Data used to calculate the Percentage Change can be found in the Adjusted Quantity column of *Table 3.* and *Table 4*. The Microsoft Excel formula used for this calculation was $= (new\_value - old\_value)/old\_value$. The results can be found in the Percentage Change column in both *Table 3.* and *Table 4*.

When observing *Figure 1.* and *Figur*e *3.* there are two noticeable production spikes in imports of N95 respirators from both China and from the World. In *Figure 1.* this production spike occurred in the month of September of 2020. In *Figure 2.* a similar spike in imports of N95 respirators can be seen in the month of July of 2020. Both production spikes occurred within two months of each other however the production spike of N95 respirators into the United States from the World occurred first. Both production spikes demonstrate an occurrence where new producers entered the market. It takes on average four months to set up a new production line to produce N95 respirators. It can take even longer when applying for N.I.O.S.H. certification. When taking this into account I realized that companies began the process of entering the market in March of 2020 after the policy period from January to February of 2020. For *Figure 1.* companies in China began to enter the market in May of 2020. However, Chinese companies were already producing their domestic equivalent of the N95, the KN95. Chinese companies had to re-tool their production lines which increased the time to entry into the market and increase the delay seen in *Figure 1.* and *Figure 3*. The underlying data supports this as B.Y.D. started exporting from China to the United States around September of 2020.

When comparing *Figure 2.* and *Figure 4.* it is evident that there are major production spikes in the importation of N95 respirators into the United States from both the World and from China. These production spikes are dramatic. In *Figure 4.* there is a production spike in December of 2018 that increases 76,900% to 26,950 N95 respirators. Another significant production spike occurred in July of 2019 when imports from the World increased by 42,253% to 222,355 N95 respirators. These spikes are more common in imports from the World than China because of the significantly smaller production capacity. When the World needs to increase production of N95 respirators it is often due to a shortage in China. This can be especially problematic when the COVID-19 pandemic is occurring. The lack of available production lines also creates a challenge because new supply chains have to be created from nothing which increases the time for companies to enter the market. Starting from little production is largely the reason behind these dramatic production spikes in *Figure 4*. In *Figure 2.* it is evident that the production spikes are not as dramatic. The Pandemic placed strain on the entire supply of N95 respirators. *Table 2.* shows that in November of 2019 that the supply of N95 respirators from China increased 130.09%. This spike occurred even before the policy went into effect in January and February of 2020.

Figure 1. Imports of N95 Respirators into the United States from China*

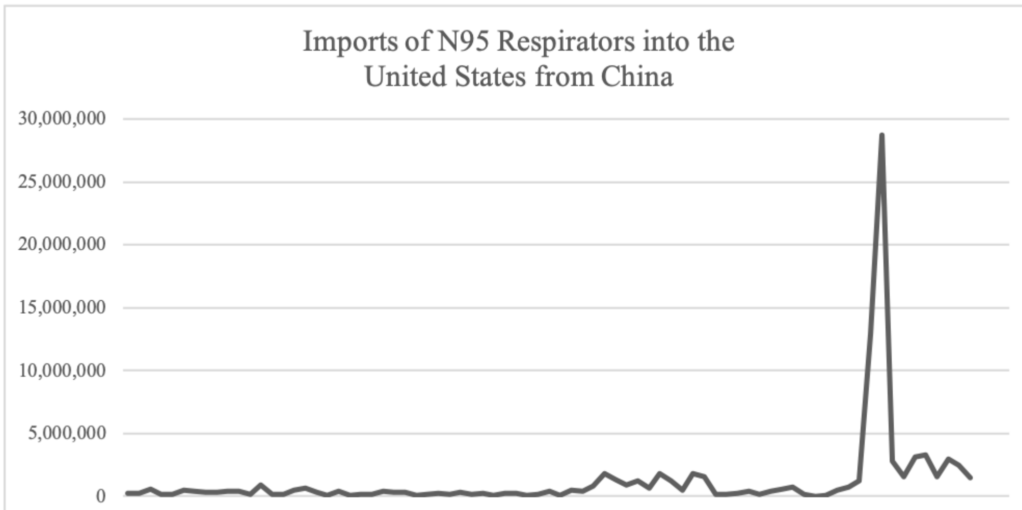


Figure 1. Percentage Change of Imports of N95 Respirators into the United States from China*

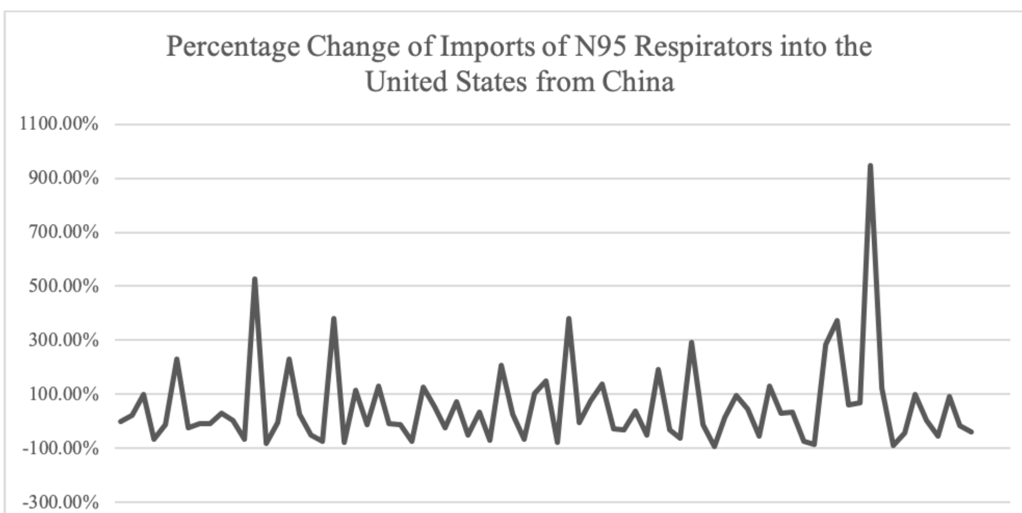


*Figure 2. Imports of N95 Respirators into the United States from the World**

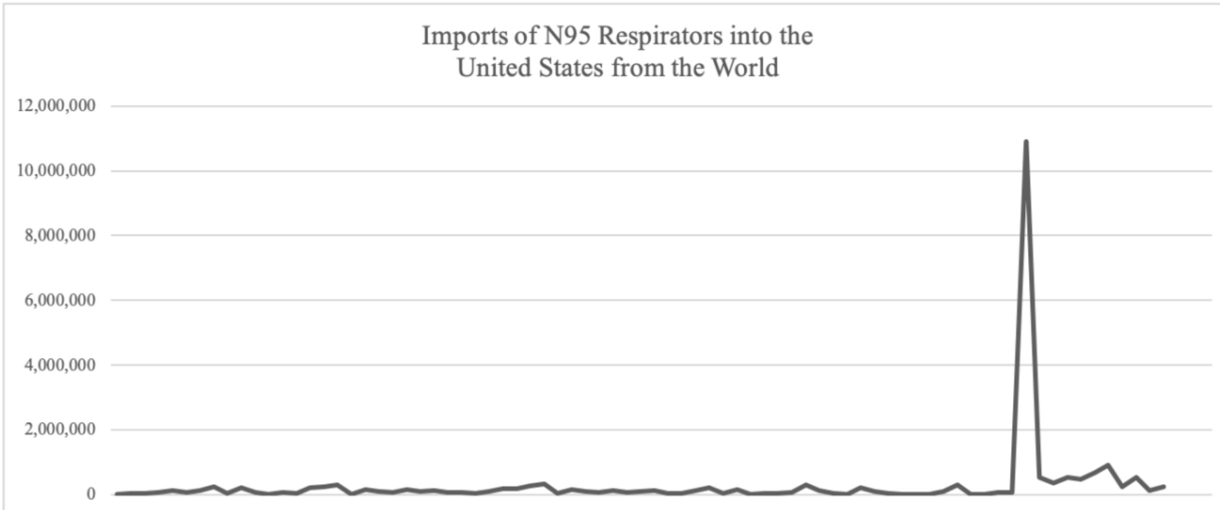


*Figure 3. Percentage Change of Imports of N95 Respirators into the United States from the World**

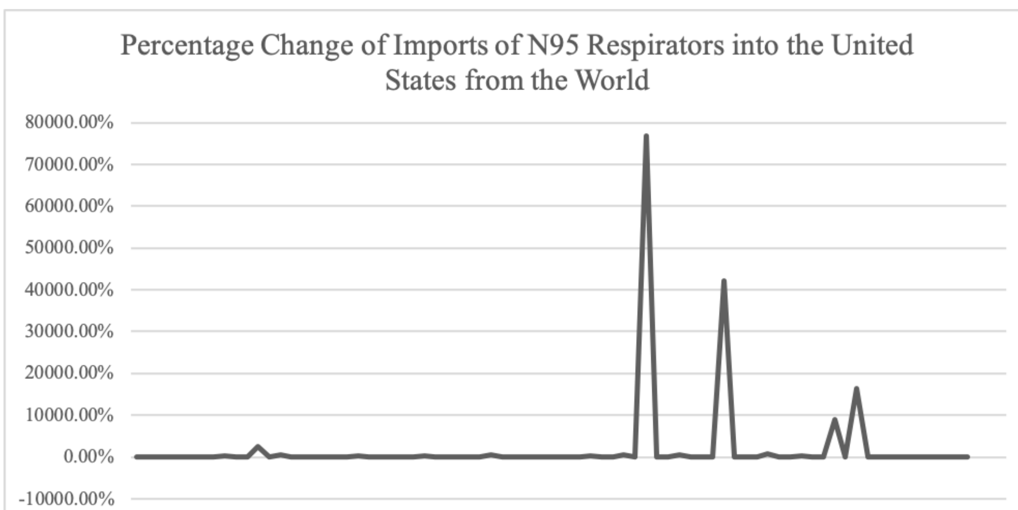
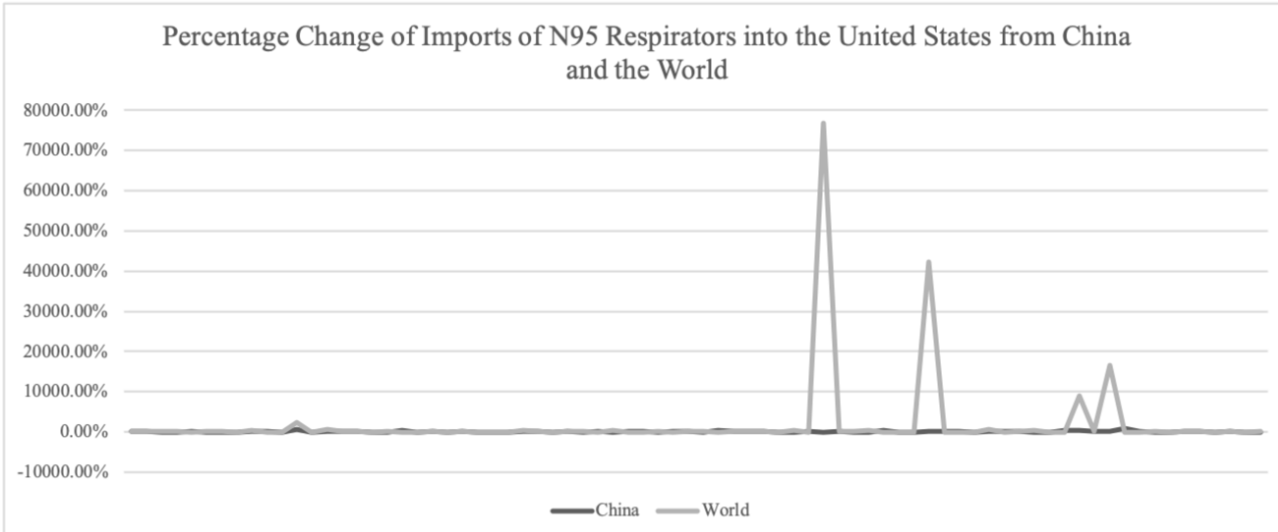
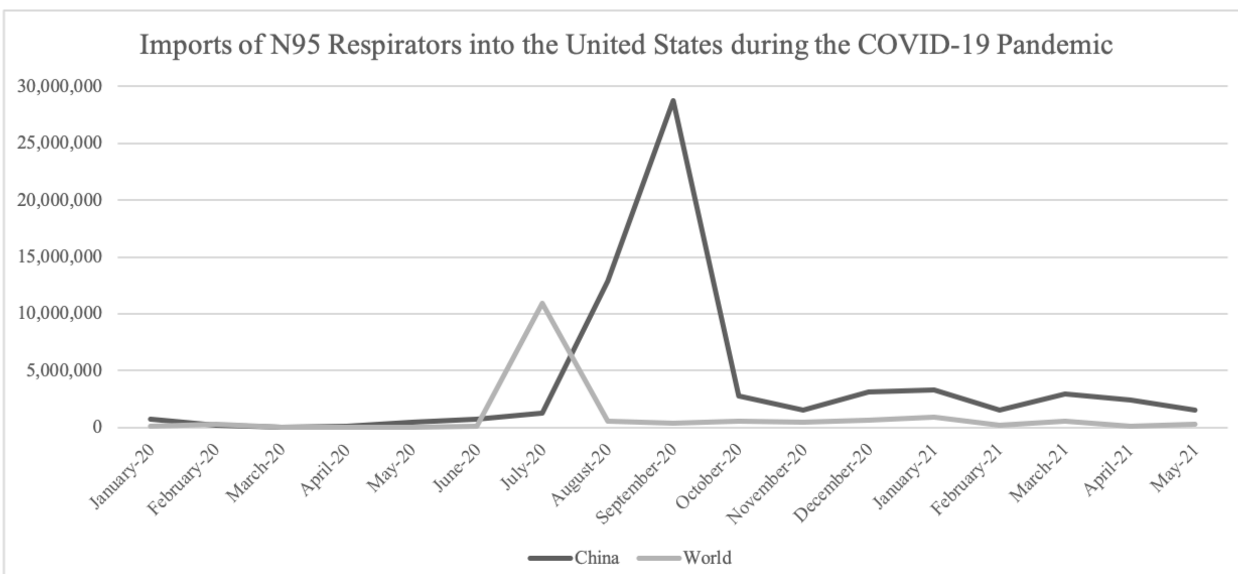


Figure 4. Percentage Change of Imports of N95 Respirators into the United States from China and the World*



*The time frame displayed in *Figures 1.-5.* was between January of 2015 to May of 2021.

Figure 5. Imports of N95 Respirators into the United States during the COVID-19 Pandemic



V. Methodology

Differences in Differences

The Differences in differences statistical method of econometrics was employed to analyze the monthly quantities of N95 respirators imported into the United States from China and from the World. Differences in differences is a non-experimental statistical method that is employed to estimate treatment effects by comparing the change in the differences in observed outcomes between the treatment and control group. Differences in differences is used across pre-treatment and post-treatment periods. The Differences in differences method was the best option when conducting this analysis because it allowed for uncovering causal effects of interest from observational data that is outside any experimental controls. Data utilized in the analysis started in January of 2015 and ended in May of 2021. By using the Differences in differences method, we are able to study China's policy of requisitioning the supply of N95 respirators that were destined to be imported into the United States. Two groups were established to test the effects of the policy on the supply of N95 respirators into the United States. China functioned as the treatment group and the World acted as the control group. By utilizing the World as a control group, we are able to see any impact that the Chinese policy may have had. In order to ensure that the Differences in differences method was applied accurately to the data a parallel trends assessment had to be performed. There is currently no statistical method so a visual inspection of the data is performed. In order to meet the parallel trends assumption, the difference between the treatment group and the control group had to remain constant over time in the absence of treatment. *Figure 6.* shows a general agreement that this the case. The Pandemic does complicate the parallel trends assessment as supply shocks represented by spikes on the graphs are not uncommon.

Econometric Model

An econometric model was developed to analyze the policy effects. We exploit the fact that we observe both pre-treatment and post-treatment of the policy effect. The events are the pre-treatment, during treatment, and post-treatment stages of the data. The econometric model was applied to both the treatment and control group. The econometric model utilized is:

$$Y_{it} = \beta_0 + \beta_1 P_t + \beta_2 T_i + \beta_3 (P_t * T_i) + \varepsilon_{it}$$

Y indicates the total quantity of N95 respirators imported into the United States between January of 2015 and May of 2021. The i in the subscript represents each country. And t represents a month-year. Variable β_0 represents the baseline constant of N95 respirators imported into the United States before the policy period (coefficient for the intercept). The policy period lasted between January and February of 2020. Dummy variables were utilized to indicate when the policy was in effect and when the policy was not in effect. When the policy was not in effect the dummy variable was 0. When the policy was in effect the dummy variable was represented by 1. β_1 represents the average change in Y from the pre and post periods that are common to both the treatment and the control group. β_2 is the average difference in Y between the treatment and the control groups that are common in both the pre-treatment and post-treatment periods. β_3 represents the average differential change in Y from the pre to the post period of the treatment group in relation to the control group. P represents a dummy variable for the post-treatment period. T represents a dummy variable for the treatment group. $P * T$ is equivalent to a dummy variable that equals 1 for observations in the treatment group, for the second period. ε_{it} represents an error term. The error term includes data that may be relevant but was not included in the data set used in the analysis. In the form of Ordinary Least Squares (O.L.S.) the equation can be summarized as: $\widehat{\beta_3} = (\overline{Y_{T=1,P=1}} - \overline{Y_{T=1,P=0}}) - (\overline{Y_{T=0,P=1}} - \overline{Y_{T=0,P=0}})$

VI. Results

Table 1. Regression of Quantity of Total N95 Respirators imported into the United States

Independent Variable	Model		
	(i)	(ii)	(iii)
Intercept	290.503 (310.048)	1045.571 (142.520)	8.75 (185.563)
Policy Period	-	-862.853 (4153.154)	-
Policy Period + 4 Months	-	-	173.967 (262.426)
China	939.033 (439.953)	3177.057 (2014.575)	317.66 (227.267)
Policy Period * China	-665.945 (2720.899)	-3165.944 (7051.015)	-306.547 (393.639)
Control for Pandemic	No	Yes	Yes
Policy Period Lagged	No	No	Yes
Num. Observation	153	33	9
Adjusted R^2	0.0303	0.0007	-0.1447
Degrees of Freedom	152	32	8

Table 2. Logarithmic Regression of Total N95 Respirators imported into the United States

Independent Variable	Model		
	(i)	(ii)	(iii)
Intercept	4.702183945 (0.108681273)	5.31914389 (0.21571091)	3.535203661 (0.49366581)
Policy Period	-	-0.1370602 (0.62889997)	-
Policy Period + 4 Months	-	-	1.646880077 (0.698148884)
China	0.943154146 (0.154216908)	0.84251358 (0.305061295)	1.68996612 (0.604614669)
Policy Period * China	-0.55353171 (0.953757982)	-0.7371763 (1.067714531)	-1.584628862 (1.047223326)
Control for Pandemic	No	Yes	Yes
Policy Period Lagged	No	No	Yes
Num. Observation	153	33	9
Adjusted R^2	0.186125896	0.15136671	0.432355981
Degrees of Freedom	152	32	8

The question being asked was whether China's policy of requisitioning all N95 respirators between January and February of 2020 had an impact on the supply to the United States? Two regressions were run to analyze the quantity. Also, a logarithmic regression of total N95 respirators imported into the United States was performed. Logarithmic regression was employed to control for the large production spikes that occurred because of the pandemic. This was necessary as the quantity regression seen in *Table 1.* is so large that it can be difficult to interpret. 'Policy Period * China' for *Model ii.* is the results from the Differences in differences econometric method. The Differences in differences method assumed that the treatment period could be identified by assigning a variable to tell if the policy period was true or false. The policy period used dummy variables. The other models either contain periods of years of month-years from before and after the policy period or a small grouping of month-years where the impact of a single production spike can have a large impact on the data. By focusing on the time period around the policy period we can gain a better understanding of the impact of the policy. The other models are useful in that they provide an understanding of the larger period of month-years before the pandemic but suffer from the large production spikes caused by the pandemic which can cause distortions in the data.

The coefficient in the 'Policy Period * China' in *Model ii.* in *Table 2*. observes only a sampling of months during the policy period. The sampling contains 33 months of imports from China and the World between January of 2020 and May of 2021. *Model ii.* is ideal for understanding the data as it is the only model which considers the sample during the pandemic period. A 95% confidence interval was used to analyze the data. The standard-error was very high which indicates that the data was very spread out from the mean. This assumption is supported by the fact that the large production spikes distorted the data. With this in mind it the results should be taken with a grain of salt. The null hypothesis assumes that there is no relationship between the policy period and the quantity of N95 respirators imported into the United States. The p-value during this period was (p = .829). A p-value at this level is not statistically significant; this could have occurred as a result of the natural variation between month-years. The alternative hypothesis assumes that China's policy did have an effect on the supply of N95 respirators imported into the United States. We retain the null hypothesis and reject the alternative hypothesis. The negative coefficient suggests that there was no effect on the importation of N95 respirators into the United States. These results provide support for the conclusion that the Chinese policy did not have an impact on the United States supply of N95 respirators during the policy period.

VII. Conclusion

Did China's policy of requisitioning all N95 respirators between January and February of 2020 had an impact on the supply to the United States? The data supports the conclusion that the policy did not have an impact on the supply of N95 respirators being imported into the United States. Further research could explore this same question when enough time has elapsed after May of 2021 to test for a larger post-treatment period. This would also help to remove some of the production shocks caused by the pandemic from the data. The policy implications of this research are broad as the United States relies on global value chains for essential goods during the pandemic. If a policy does not have an effect then what is the point of implementing that policy. Additionally, there is no harm in applying sanctions to China because any retaliation by China would have no impact on the supply of N95 respirators to the United States.

VIII. References

I. *Approved N95 Respirators 3M Suppliers List | NPPTL | NIOSH | CDC*. (2021, July 22). [Government]. Centers for Disease Control and Prevention. https://www.cdc.gov/niosh/npptl/topics/respirators/disp_part/n95list1.html

II. Dallas, M. P., Horner, R., & Li, L. (2021). The mutual constraints of states and global value chains during COVID-19: The case of personal protective equipment. *World Development*, *139*, 105324. https://doi.org/10.1016/j.worlddev.2020.105324

III. Evstatieva, M. (2021, June 25). U.S. Companies Shifted To Make N95 Respirators During COVID. Now, They're Struggling. *NPR*. https://www.npr.org/2021/06/25/1009858893/u-s-companies-shifted-to-make-n95-respirators-during-covid-now-theyre-struggling

IV. Friedt, F. (2021, January 17). The triple effect of COVID-19 on Chinese exports: GVC contagion effects dominate export supply and import demand shocks. *VoxEU.Org*. https://voxeu.org/article/triple-effect-covid-19-chinese-exports

V. Gereffi, G. (2020). What does the COVID-19 pandemic teach us about global value chains? The case of medical supplies. *Journal of International Business Policy*, 1–15. https://doi.org/10.1057/s42214-020-00062-w

VI. Hoekman, B., Fiorini, M., & Yildirim, A. (2020). Export Restrictions: A Negative-Sum Policy Response to the COVID-19 Crisis. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.3634552

VII. Import Genius Database (2015-2021, January-May). N95. Trade Data Services, Inc. Retrieved June 12, 2021 from https://www.importgenius.com

VIII. Melody Gutierrez. (2020, June 5). *California grants another extension to BYD in delivering $1-billion order of N95 masks*. Los Angeles Times. https://www.latimes.com/california/story/2020-06-05/california-gives-extension-order-byd-n95-masks-coronavirus

IX. *N95 Masks*. (n.d.). Retrieved July 19, 2021, from https://masc.psu.edu/n95-masks/#What_is_a_surgical_N95_respirator

X. The face mask global value chain in the COVID-19 outbreak: Evidence and policy lessons. (2020). *OECD*. https://www.oecd.org/coronavirus/policy-responses/the-face-mask-global-value-chain-in-the-COVID-19-outbreak-evidence-and-policy-lessons-a4df866d/

XI. Appendix

Table 3. Quantity and Percentage Change of N95 respirators imported into the United States from China between January of 2015 and May of 2021

Year	Month	Box Quantity	Adjusted Quantity	Percentage Change
2015	January	6,464	226,240	-
2015	February	7,809	273,315	20.81%
2015	March	15,452	540,820	97.87%
2015	April	5,049	176,715	-67.32%
2015	May	4,462	156,170	-11.63%
2015	June	14,653	512,855	228.40%
2015	July	10,940	382,900	-25.34%
2015	August	10,130	354,550	-7.40%
2015	September	9,232	323,120	-8.86%
2015	October	12,087	423,045	30.93%
2015	November	12,580	440,300	4.08%
2015	December	4,224	147,840	-66.42%
2016	January	26,445	925,575	526.07%
2016	February	4,667	163,345	-82.35%
2016	March	4,398	153,930	-5.76%
2016	April	14,568	509,880	231.24%
2016	May	18,166	635,810	24.70%

2016	June	9,219	322,665	-49.25%
2016	July	2,408	84,280	-73.88%
2016	August	11,608	406,280	382.06%
2016	September	2,540	88,900	-78.12%
2016	October	5,431	190,085	113.82%
2016	November	4,792	167,720	-11.77%
2016	December	10,933	382,655	128.15%
2017	January	9,956	348,460	-8.94%
2017	February	8,736	305,760	-12.25%
2017	March	2,160	75,600	-75.27%
2017	April	4,891	171,185	126.44%
2017	May	7,479	261,765	52.91%
2017	June	5,687	199,045	-23.96%
2017	July	9,696	339,360	70.49%
2017	August	4,724	165,340	-51.28%
2017	September	6,257	218,995	32.45%
2017	October	1,900	66,500	-69.63%
2017	November	5,810	203,350	205.79%
2017	December	7,225	252,875	24.35%
2018	January	2,422	84,770	-66.48%
2018	February	4,921	172,235	103.18%
2018	March	12,177	426,195	147.45%
2018	April	2,804	98,140	-76.97%
2018	May	13,445	470,575	379.49%
2018	June	12,638	442,330	-6.00%
2018	July	22,219	777,665	75.81%
2018	August	52,816	1,848,560	137.71%
2018	September	38,134	1,334,690	-27.80%
2018	October	26,104	913,640	-31.55%
2018	November	35,720	1,250,200	36.84%
2018	December	17,743	621,005	-50.33%
2019	January	51,627	1,806,945	190.97%
2019	February	34,477	1,206,695	-33.22%
2019	March	13,109	458,815	-61.98%
2019	April	51,281	1,794,835	291.19%
2019	May	43,916	1,537,060	-14.36%
2019	June	3,414	119,490	-92.23%
2019	July	3,854	134,890	12.89%
2019	August	7,577	265,195	96.60%
2019	September	11,073	387,555	46.14%
2019	October	5,102	178,570	-53.92%
2019	November	11,739	410,865	130.09%
2019	December	15,268	534,380	30.06%
2020	January	20,508	717,780	34.32%
2020	February	5,538	193,830	-73.00%
2020	March	715	25,025	-87.09%

2020	April	2,737	95,795	282.80%
2020	May	12,979	454,265	374.21%
2020	June	20,873	730,555	60.82%
2020	July	35,151	1,230,285	68.40%
2020	August	368,480	12,896,800	948.28%
2020	September	821,306	28,745,710	122.89%
2020	October	80,284	2,809,940	-90.22%
2020	November	44,583	1,560,405	-44.47%
2020	December	89,203	3,122,105	100.08%
2021	January	93,159	3,260,565	4.43%
2021	February	43,455	1,520,925	-53.35%
2021	March	83,959	2,938,565	93.21%
2021	April	69,902	2,446,570	-16.74%
2021	May	42,912	1,501,920	-38.61%

Table 2. Quantity and Percentage Change of N95 respirators imported into the United States from the World between January of 2015 and May of 2021

Year	Month	Box Quantity	Adjusted Quantity	Percentage Change
2015	January	0	0	-
2015	February	630	22,050	-
2015	March	905	31,675	43.65%
2015	April	2,017	70,595	122.87%
2015	May	3,179	111,265	57.61%
2015	June	2,039	71,365	-35.86%
2015	July	3,087	108,045	51.40%
2015	August	6,747	236,145	118.56%
2015	September	1,340	46,900	-80.14%
2015	October	6,086	213,010	354.18%
2015	November	2,163	75,705	-64.46%
2015	December	71	2,485	-96.72%
2016	January	1,788	62,580	2418.31%
2016	February	920	32,200	-48.55%
2016	March	5,961	208,635	547.93%
2016	April	6,720	235,200	12.73%
2016	May	8,757	306,495	30.31%
2016	June	0	0	-100.00%
2016	July	4,230	148,050	-
2016	August	2,567	89,845	-39.31%
2016	September	1,535	53,725	-40.20%
2016	October	4,444	155,540	189.51%
2016	November	2,550	89,250	-42.62%

2016	December	3,783	132,405	48.35%
2017	January	1,652	57,820	-56.33%
2017	February	1,519	53,165	-8.05%
2017	March	720	25,200	-52.60%
2017	April	2,992	104,720	315.56%
2017	May	5,496	192,360	83.69%
2017	June	5,013	175,455	-8.79%
2017	July	8,046	281,610	60.50%
2017	August	9,603	336,105	19.35%
2017	September	720	25,200	-92.50%
2017	October	4,115	144,025	471.53%
2017	November	2,830	99,050	-31.23%
2017	December	1,903	66,605	-32.76%
2018	January	3,805	133,175	99.95%
2018	February	1,882	65,870	-50.54%
2018	March	2,878	100,730	52.92%
2018	April	3,189	111,615	10.81%
2018	May	1,191	41,685	-62.65%
2018	June	1,367	47,845	14.78%
2018	July	3,419	119,665	150.11%
2018	August	6,311	220,885	84.59%
2018	September	926	32,410	-85.33%
2018	October	4,732	165,620	411.02%
2018	November	1	35	-99.98%
2018	December	770	26,950	76,900.00%
2019	January	1,310	45,850	70.13%
2019	February	1,500	52,500	14.50%
2019	March	8,741	305,935	482.73%
2019	April	3,778	132,230	-56.78%
2019	May	1,352	47,320	-64.21%
2019	June	15	525	-98.89%
2019	July	6,353	222,355	42,253.33%
2019	August	2,931	102,585	-53.86%
2019	September	1,405	49,175	-52.06%
2019	October	50	1,750	-96.44%
2019	November	371	12,985	642.00%
2019	December	0	0	-100.00%
2020	January	2,327	81,445	-
2020	February	8,114	283,990	248.69%
2020	March	480	16,800	-94.08%
2020	April	20	700	-95.83%
2020	May	1,816	63,560	8,980.00%
2020	June	1,888	66,080	3.96%
2020	July	311,846	10,914,610	16,417.27%
2020	August	15,105	528,675	-95.16%
2020	September	10,367	362,845	-31.37%

2020	October	151,191	531,685	46.53%
2020	November	13,364	467,740	-12.03%
2020	December	19,217	672,595	43.80%
2021	January	26,083	912,905	35.73%
2021	February	6,841	239,435	-73.77%
2021	March	15,373	538,055	124.72%
2021	April	3,512	122,920	-77.15%
2021	May	6,999	244,965	99.29%

Table 3. N.I.O.S.H. Approved N95 Respirator Manufactures

3M Company
Advanced Concept Innovations, LLC
Advoque
Aegele PPE 1 LLC
Aero Pro Co., Ltd.
Aidway Personal Care Product, Inc.
Air Filtration Solutions, Ltd.
ALG Health
Alpha Pro Tech
Amsafe Inc.
AOK Tooling Limited
Aswan International Corporation
A & Z Pharmaceutical, Inc.
BNX Converting, LLC
BYD Precision Manufacturing Co., Ltd.
Central Purchasing, LLC
Champak Enterprise Company, Ltd.

DemeTech Corporation

Dentec Safety

Dobu Life Tech

Draeger Medical Systems, Inc.

Dräger Safety Ag & Company, KGAA

Ever Green Company, Ltd.

Fido Industrial Safety Masks Manufacturer Company, Ltd.

Ford Motor Company

Foss Manufacturing Company

FSSC, LLC; DBA Indiana Face Mask (IFM)

General Motors Company

Global Safety First

Guangzhou Harley Commodity Company, Ltd.

GVS Filter Technology UK, Ltd.

Honeywell International

Honeywell Safety Products

Industrias Saver S.A.

Innonix Technologies Limited

Inovel, LLC

Jahan Company T/A Irema Ireland

Japan Vilene Company, Ltd.

Jiangyin Chang-Hung Industrial Manufacturing Factory LLLC Of China (JCH)

Jinfuyu Industrial Company, Ltd.

JSP, Ltd.
Kimberly-Clark Corporation
Koken, Ltd.
Kos Proteccion S.A.S.
Lighthouse Worldwide Solutions
LiveFree Personal Protection LLP
Louis M. Gerson Company, Inc.
Luoyang Kelijian Technology Co., Ltd.
Magnum Medicare
Makrite Industries, Inc.
Makrite Japan
Merilogy, Inc.
Mine Safety Appliances Company
Moldex-Metric, Inc.
M/S. Magnum Health & Safety Pvt., Ltd.
MSA Do Brasil Equipamentos E Instrumentos De Seguranca Ltd.A.
Nitta Corporation, SA
& M Halyard, Inc.
Optrel Tec AG
Outdoor Research, LLC
Pacific PPE Corporation
PandMedic, Inc.
Prestige Ameritech

Protective Health Gear, Inc.
Rizhao Sanqi Medical & Health Articles Company, Ltd.
San Huei United Company, Ltd.
San-M Packaging Company, Ltd.
Shanghai Dasheng Health Products Manufacture Company, Ltd.
Shanghai Gangkai Purifying Products Company, Ltd.
Shanghai Yunqing Industrial Co., Ltd.
Shawmut Corporation, LLC
Shigematsu Works Company, Ltd.
Shining Star Electronic Technology Co., Ltd.
Shuenn Bao Shing Corporation
Sperian Respiratory Protection USA, LLC
Suzhou Fangtian Industries Company, Ltd.
Suzhou Sanical Protective Product Manufacturing Company, Ltd.
Thermopore Materials Corporation
United States Mask, LLC
Valmy SAS of France (DIV)
Venus Safety & Health Pvt., Ltd.
ViruDefense, Inc.
WellSpan Health
Willson ® Dalloz Safety Products
Xiantao Zhongyi Safety Protection Products Company, Ltd.