

Claremont McKenna College

Fragile Chains

The Political Economy of the Global Production of Personal Protective Equipment (PPE)

submitted to

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by

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Abstract

As a result of centuries of globalization, supply chain networks have stretched far and wide, and are pivotal to the functioning of the global political economy. Yet, the ongoing COVID-19 Pandemic has exposed supply chain fragilities in personal protective equipment (PPE). This paper focuses on how and why this is the case. Understanding that China's competitive currency, labor policies, state support, and scale production make her a key player, PPE shortages first emerged when internal Chinese demand mushroomed. That being said, domestic PPE inventories in the U.S. had already been at critical lows, and were exacerbated by a lack in supply chain diversity as a result of privatization, which favored multinational monopolies. The lethal blow to PPE shortages was the lack of policy coordination - the Trump administration had failed, on both a domestic and international level, in its response to the pandemic.

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Chapter One: Introduction

The globalized Personal Protective Equipment (PPE) supply chain, when encountering the COVID-19 pandemic, has revealed severe fragilities through product shortages, economic nationalism, and poor pandemic policies. China, a protagonist in the PPE arena since the opening up of the Chinese economy after the Deng-era reforms, exhibits her competitive edge through four avenues: her competitive currency which attracts FDI, her labor policy which cheapens costs of production, her subsidies and state support which grow the manufacturing sector, and her large, integrated production base which allow for scale production. The effects of this are amplified by the nation's membership into the World Trade Organization (WTO) in 2001.

The PPE market should not be underestimated, for it was worth an estimated 2.5 billion USD even as of 2018 (Park et al., 2020, 2). A further analysis of China's share in global PPE production reaffirms its role in the medical supply chain: the nation produces at least 50% of the world's PPE (OECD 2020), though some sources reckon that this number could be as high as 80-90% (Park et al., 2020, 3). For instance, in terms of surgical masks, which consist of a filter, shell, coverweb, nose clip, nose foam, and straps, the raw materials of polyester, polypropylene, and aluminum are crucial (Fiore 2020). China produces 42% of the world's polyester (Aizenshtein 2010), 27% of polypropylene (Plastics Insight 2021), and more than 50% of aluminum (The Aluminum Association). This would infer China's importance not only in PPE production itself, but also in the inputs needed for PPE manufacturing.

Chapter Two: The Evolution of the Global Supply Chain

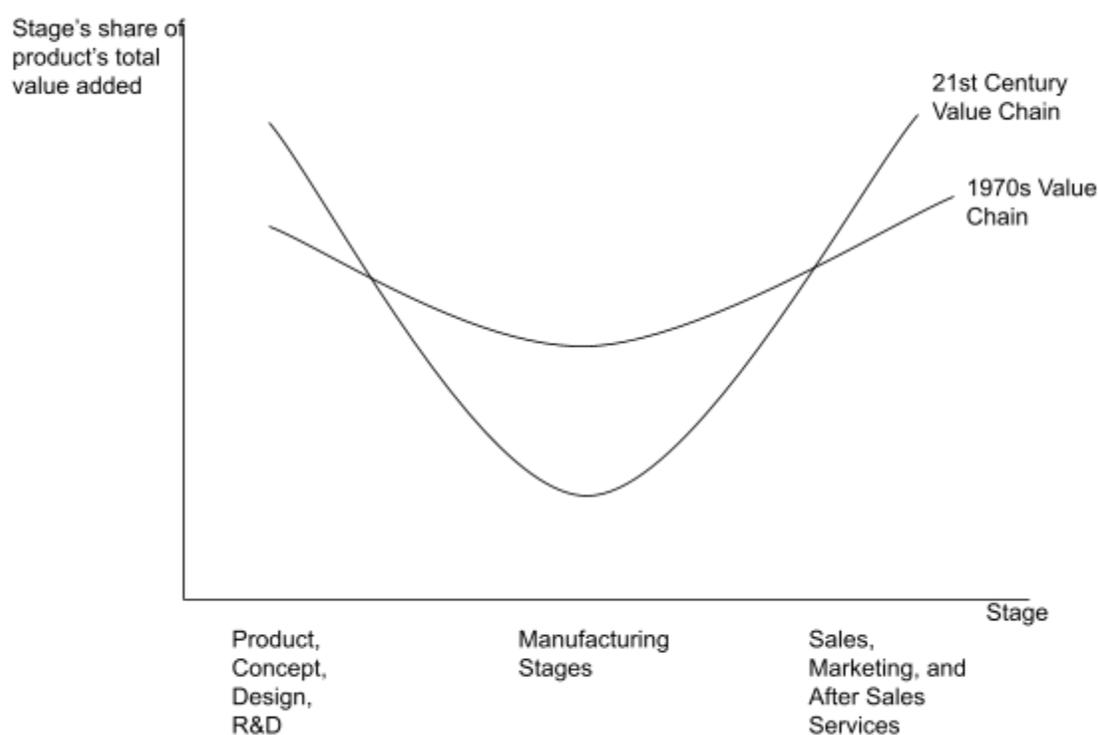
Before a full examination can be made regarding the comprehensive impacts of COVID-19 on the global supply chain of PPE, one must first understand the origins and the development of the current global supply chain and ask: how and why did the current system come to be?

Prior to the First Industrial Revolution in Europe and the United States, supply chains were often parochial and localized, meaning “each village made most of what it consumed” (Baldwin 2012, 2). Yet, as early as the mid 1800s, the connective technologies of transportation of goods and transmission of data enabled the rise of globalization during the Industrial Revolution (Baldwin 2012). For the first time, production and consumption could be separated by the reallocation of goods via steamships and railroads (Irwin 2020), making possible the benefits of economic integration - economies of scale and comparative advantage. As per capita industrial activity moved from the global south to the global north from 1759-1913, the north’s cost advantage incentivized its innovation, specialization, and spurred income growth at the expense of the south (Baldwin 2012), in part due to the disequalizing effects of imperialism (Alam 2012, 2-3). Growth also accelerated from a “self-sustaining cycle of production, innovation and income gains” (Baldwin 2012, 2), and labor migration expanded. Paradoxically, socioeconomic disparities have emerged as “the tallest peaks - the cities and regions that drive the world economy - [have grown] even higher, while the valleys mostly languish” (Florida 2007).

Beginning in the 1980s, the ascendancy of information technology, telecommunications, and software eliminated the coordination costs of production. This enabled a restructuring of global supply chains: it distributed the stages of production across the globe, to regions where

each respective stage of production was most cost effective. This meant that different components of a final product could now be produced in separate countries and locations (Baldwin 2012). The results of this were fivefold: the off-shoring of labor reversed the advantages that were enjoyed by developed Western economies, it industrialized the global south and especially East Asia, it led to the the trade-investment-services-IP nexus (the trade of parts, foreign investment, coordinational infrastructures services, intellectual transmission), nations could now join existing supply chains without the prerequisite of having an existing base, and the old policies of state-owned enterprises and import substitution policies were deemed outdated by many nations (Baldwin 2012).

Figure 1: Smile Curve Comparison: 1970s VS 21st Century



Most notably, a Smile Curve comparison between global value chains in the 1970s and now (Figure 1) depicts the way in which value added varies across the different stages of

bringing a product onto the market in an IT-related manufacturing industry. As firms offshore to nations with cheaper costs of labor, the deepening of the smile shows that the manufacturing stages add the least value to the product in comparison to the product design, marketing, and after sale stages. Baldwin describes this eloquently: while “the old type was ‘my market for yours’; the new type is ‘my factories for your reform’... spawn[ing] massive demand for new disciplines from ‘headquarter economy’ firms and a massive supply of new disciplines from ‘factory economy’ governments” (Baldwin 2012, 18).

Chapter Three: Special Market Dynamics Behind the Move of PPE

Production to China

With this context in mind, a formal discussion of global supply chain evolution would not be complete without an in-depth investigation into the increasing reliance on Chinese production over the past three decades. Four special market dynamics are responsible: the competitive Chinese Yuan made Chinese exports attractive; the government's oppressive labor policies lowered the costs of production; subsidies and state support enabled the dual track approach which preserved state-owned enterprises and attracted foreign direct investment; and the construction of large factories across the nation led to economies of scale. It was these factors which enabled companies to move their PPE manufacturing operations to China - other countries like India or Mexico lagged behind as they lacked the scale that China possessed.

Competitive Currency

China has long been accused of artificially keeping its exchange rate low to increase its export competitiveness. While the legality of this is widely debated among experts till this day, it is not untrue that China's weak currency, coupled with trade liberalization, enabled the rise of the nation as the world's factory. China's central bank, the People's Bank of China (PBC), first devalued its currency in the late 1980s, and utilized a dual exchange rate system to slowly liberalize until the Asian financial crisis in the mid 1990s. Later, it pegged its currency to the U.S. dollar, briefly adopted a crawling peg, and finally, in 2005, employed a managed float relative to a basket of currencies, which is in use today. This is achieved through two main strategies: increasing RMB supply while purchasing foreign reserves to decrease foreign exchange supplies, and limiting free capital flows (Mercurio and Leung 2009). The effects of this

were consequential - “the RMB’s value in terms of foreign currencies dramatically decreased from the 1980s to 1994” (Mercurio and Leung 2009, 1292), which improved China’s balance of trade.

This was unsurprising, as due to Deng-era economic reforms, the nation’s economic system had become much more responsive to external changes in the global economy, and vice versa (Zhang 2001). Utilizing this responsiveness, China’s competitive currency was in effect an export policy because it lowered prices of domestically-produced goods in the foreign currency, ergo making domestic products more attractive in foreign markets (Etro 2006). This pulled profits from foreign firms into China (Etro 2006, 4), expanding China’s market share and its importance in the global supply chain.

In particular, PPEs are very much affected by fluctuations in exchange rates, as they are low-profit margin manufactured goods - very similar to mass-produced textiles and common commodities, which require little intellectual property (Etro 2006, 4). Bearing that in mind, whilst the exact profit margins of PPEs are not documented, manufacturing does tend to have lower margins that “rarely surpass 7%” (Marconi et al., 2020). Currency depreciation is hence impactful for it allows for producers and entrepreneurs to increase their otherwise tiny profit margins on two main grounds. First, investors and entrepreneurs respond to currency depreciations by increasing investments, as lowered production costs make these investments more profitable (Bhalla 2012), subsequently expanding China’s PPE production in terms of scale and efficiency. Second, on the basis that currency depreciation increases the domestic firm’s competitiveness in the domestic market against foreign firms (as foreign products become more expensive in the domestic market), Blecker (2012, 9) developed a model in which “firms’ target

mark-up rate is an increasing function of the real exchange rate”. This can be applied to PPE manufacturing in China as many of such manufactured products are also domestically consumed.

Labor Policies

Boosting China’s attractiveness is her weakness of labor which led to drastically low production costs. This is related to the last three decades being the height of China’s second demographic transition, which began in the 1970s. During this demographic window of opportunity, China experienced a shift to low fertility rates and very low mortality rates, which decreased the dependency ratio and increased the workforce. It is under these pre-existing circumstances that the absence of labor unions and the abundance of migrant labor pushed down the costs of production, ergo enabling the shift to the manufacturing stage of the Smile Curve for Chinese factories.

The political logic of China’s one-party regime is to blame for such low labor costs. Through banning independent unions and co-opting union cadres into party management (Chen 2009, 680), the Chinese Communist Party (CCP) successfully installs cells within enterprises and limits the power of union cadres in standing up for workers regarding labor and workplace disputes. This workplace subordination is reflected in three behavioral patterns. First, it inaugurates multiple “shell unions” that exist only in name, as “union dues paid by the workers were controlled by the manager, who gave not a single cent to the union for its operation” (Chen 2009, 681). As these trade unions do not really advocate for the rights of the average worker, workers are often apathetic to membership (one study showed that in two labor unions within two private enterprises, 84.2% and 89.3% of workers claimed to not be union members respectively) (Chen 2009, 681). Second, these unions are frequently manipulated by the CCP to

advance party goals instead of worker interests, with 63.2% of union heads believing that their primary duty is to carry out party instructions, in contrast to the 18.7% of such believing that their duty is to safeguard workers' interests (Chen 2009, 681-682). Third, party-dependent labor unions mean that it becomes difficult for union cadres to stand up for workers, as they may face retaliation from their superiors in the form of salary reductions or termination of employment contracts (Chen 2009, 683-684). These three effects ergo retard functional labor unions that champion worker rights, breeding unfortunate inequalities such as wage suppression, overdue wages, and unsafe workplace environments, albeit with the positive side effect of attracting firms hoping to cut costs.

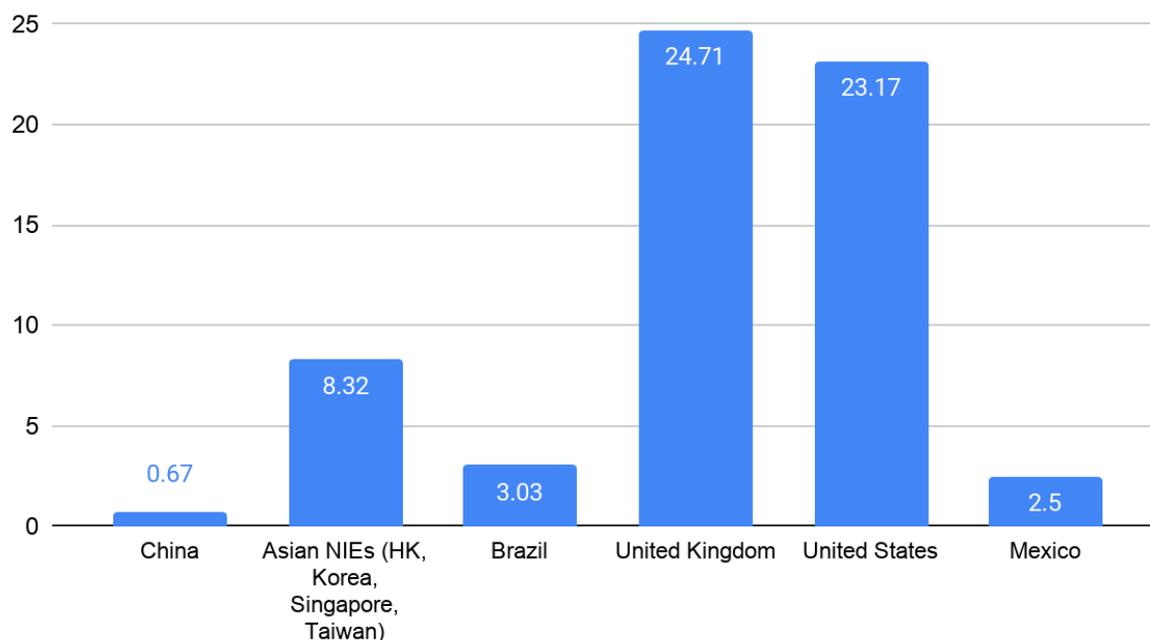
At the same time, abundance of migrant labor is erected as a result of asymmetrical endowment factors between urban and rural areas, which were aggravated by the Hukou System. After economic reforms were enacted in the 1980s and the 1990s, drastic inequalities between inland and coastal regions began to emerge (Zhou et al., 2016). This was in fact intentional, for government policies viewed coastal areas as more critical than inland areas for the development of export processing and trade openness, as evident in Deng's belief to "let some people get rich first" (Zhou et al., 2016, 193-194). For instance, the coastal city of "Shanghai's average urban disposable income of 31,383 Yuan was more than twice as high as that of landlocked Guizhou (14,142 Yuan)" (Zhou et al., 2016, 193). These inequalities are further revealed through urban bias, as industrial productivity in urban areas is considered to be higher than that in rural areas. This is observable through the higher growth rate of urban incomes in constant prices from 2002 to 2007, at 11%, than that of rural incomes, at 7% (Zhou et al., 2016, 189-190). The effects of China's Hukou system are thus twofold: it not only registers and divides all residents into urban

and rural households, but also provides urban residents with privileged status due to the better access to social security networks, healthcare, and education.

Changing household status is not easy either - despite the influx of rural migrants in search of better opportunities, there are still “nearly 200 million rural migrants in urban areas without urban hukou” (Zhou et al., 2016, 194), who often end up working low-paying jobs. In other words, institutionalized discrimination creates social barriers that cheapen the labor of rural migrants. Despite this, during the ongoing period of industrialization before having reached the Lewis Turning Point, surplus agricultural labor continues to move into urban areas, in search of labor-intensive opportunities such as manufacturing, further undermining the power that workers wielded. It is under these conditions that migrant labor was as cheap and as abundant in China over the last decade.

To demonstrate the magnitude of China’s labor cost advantage, Figure 2 depicts the nation’s 2004 hourly compensation costs for production workers in manufacturing, compared to that of other regions. Indeed, Chinese wages were the lowest among comparables - both to developed countries and fellow developing countries, despite employing more manufacturing workers than the G7 combined during this time (Lett and Banister 2006). To put this in perspective, China’s 0.67 USD hourly compensation costs for production workers in manufacturing, is less than 3% of that in the United States, which had an hourly compensation cost of 23.17 USD.

Figure 2: Hourly Compensation Costs for Production Workers in Manufacturing in U.S. Dollars, 2004



Subsidies and State Support

Given the government's negligence to and exploitation of the weaknesses of labor, subsidies and other state support only served to amplify the appeal of moving factories to China. Since the Deng-era reforms, China has transformed into a successful market economy with "chinese characteristics". Under this "reform-without-losers" approach, the government kept State-owned enterprises (SOEs) at the same time as building up the private sector, hence multiplying manufacturing opportunities within the country.

This begs the question: how were SOEs kept competitive in the market economy under this dual-track approach? By subsidizing inefficient local firms and state-owned companies, barriers of entry and costs of production were inorganically lowered by the CCP. Indeed, "China's largest oil companies - CNOOC, PetroChina, and Sinopec - all benefit from state financial support from state-owned banks" (Meltzer and Shenai 2019, 14). These production

subsidies increase the ability to export, especially for firms that are profit-making, in capital intensive industries, and in non-coastal regions (Girma et al., 2009). China is also able to target specific industries through this approach (Girma et al, 2009). The effects of this are demonstrated in a 2020 study: subsidized firms are more likely to export than non-subsidized firms (Girma et al, 2009).

That being said, under the dual-track approach, the government also prioritized direct (e.g. cheap land and tax incentives) and indirect (e.g. infrastructure) subsidies and state support which enticed private and foreign investors. Deng's dedication to reform and liberalization in the 1990s, as well as China's entrance into the World Trade Organization (WTO) in the 2000s, played significant roles in boosting confidence in the nation's economic performance, and was significant in attracting FDI inflows (IMF 2002). Most of this FDI, approximately 60% in 1998, was concentrated in the manufacturing sector (IMF 2002, 4). The International Monetary Fund (IMF) explains in a 2002 report that "the factors that have been most important in influencing FDI in China can be grouped into three categories: economic structure, liberalization and preferential policies, and cultural and legal environment" (IMF 2002, 8). The first category dictates the pre-existing conditions that made China favorable. Not only was China's enormous growth potential (due to the sheer size of the Chinese market) considered favorable, the establishment of Open Economic Zones (OEZs), especially in eastern coastal areas, enabled the further upgrading of infrastructure and transport links (IMF 2002, 8-9). In fact, "from the late 1980s to the late 1990s about 3 percentage points were accounted for by local governments and were mainly in infrastructure, particularly electricity, gas, and water, transport, post, and telecommunications" (IMF 2002, 10).

Given this, reduced barriers and preferential policies only served to further appeal to foreign investors, paving the way for the move to China. Despite the obstacles left behind by decades of trauma under Eurocentric economic liberalization (such as in the Opium Wars in the 1800s), from the start the CCP had prioritized FDI's importance in developing the export sector (IMF 2002, 11). To establish confidence among foreign investors, the government relaxed state controls and assisted with legal procedures - corporate tax incentives were made available to foreign funded enterprises (FfEs), and flexible land-use and autonomy in management was afforded to firms in the aforementioned OEZs (IMF 2002). This administration decentralization was consequential because without it, "FDI would likely to have been substantially less" (IMF 2002, 17).

Overall, economic structure, preferential policies, as well as the Chinese diaspora at large which may explain FDI inflows from Hong Kong SAR, Singapore, and Taiwan, together enabled the government in pursuing its reform agenda. The output of FfEs is evidence of this: from 1994 to 1997, China's industrial sector expanded fourfold (IMF 2002, 19). Accordingly, FfEs themselves have reaffirmed China's importance in the global supply chain by "introduce[ing] new technologies and management skills" (IMF 2002, 19), as well as by expanding the export of manufactured goods, with "the share of exports accounted for by FfEs [growing] from 1 percent to 45 percent" (IMF 2002, 20) from 1985 to 1999.

Having understood the role of subsidies and state support in centering China in global value chains, how then, has it affected the PPE manufacturing industry? There are two main types of PPE producers in China: Chinese factories which Group Purchasing Organizations (GPOs) and other foreign organizations source from, as well as foreign companies which have production facilities within the country.

Regarding the former, two examples of leading Chinese PPE distributors are Shenzhen Mindray, a ventilator manufacturer which employs over 10,000 employees and serves over 190 regions, including 9 of the top 10 U.S. cardiac hospitals (Mindray 2021); and Winner Medical, a mask manufacturer, which employs over 8,000 employees and supplies over 70 countries (Winner Medical Co., Ltd 2021). They respectively received up to 16.6 million USD, and between 3 to 4 million USD per year in direct subsidies from the government (Bradsher 2020). Moreover, during the pandemic, Sinopec and PetroChina (Lo 2020) - both SOEs heavily subsidized by the state - have been redirected to produce PPE, with Sinopec having converted a 39,000 square foot warehouse into a mask production facility (Business Facilities Magazine 2020).

These Chinese PPE producers are pivotal to the medical value chain. For instance, Premier, Inc, a GPO which “unite[s] an alliance of approximately 3,750 U.S. hospitals and more than 130,000 other providers” (Premier, Inc 2016), sources mainly from China. Another GPO, Vizient Inc., is likewise reliant on Chinese producers, as it sources PPE from healthcare companies Medline Industries, Inc and Cardinal Health, both of which manufacture 100% in China (Vizient 2020).

Medline and Cardinal provide the perfect segue into the second type of PPE production facility that hinges upon Chinese production - foreign companies which have all or a majority of their production capabilities established within the nation. Currently, two of the three largest PPE manufacturers in the U.S. - Minnesota Mining and Manufacturing Company (3M) and Honeywell International (Dai et al., 2020) - have factories based in China. Here, it is important to note that since PPE supply chain data is confidential, exact data regarding production quantities is not disclosed by any government or private entity alike (Dai et al., 2020).

Specifically, 3M was the first wholly foreign-owned company (an FFE) to have been established in China in 1984 (Stein 1987, 3), who today divides its main production plants between the U.S. and China (Gereffi 2020, 294). It is unique in that it experiences all the benefits of Special Economic Zones (SEZs) without actually being within the geographical limits of an SEZ, which includes cheaper land rental rates, cheaper labor costs, and financial incentives (Stein 1987). This is, in effect, a direct government subsidy to 3M. To maximize profitability, 3M also closely followed Joint Venture Implementation Regulations when creating its articles of association, by highlighting its focus on manufacturing, its creation of jobs, and its production capacity for the Chinese market. This was strategic as joint ventures enjoyed more preferential tax laws in comparison to representative offices (Stein 1987).

3M's move to China was also motivated by indirect state support. From an operational standpoint, 3M took advantage of an article within the Joint Venture Law which stipulated that to expand into China, a foreign company had to invest at least 25% - for this law did not set a floor ceiling for foreign direct investment (Stein 1987, 10). This allowance for 100% foreign ownership was hence an incentive itself, as it allowed 3M the flexibility of independent decision making and control over production lines (Stein 1987, 15). It is important to note here that the opportunity to enter the enormous Chinese market was also a factor.

Additionally, weak environmental regulations were also an indirect incentive. Despite policies which mandate that foreign firms follow environmental standards and pollution quotas, there exists a substantial implementation gap in China today (Stalley 2010). Profit-hungry pollution-intensive sectors like manufacturing often manipulate China's eagerness to maintain FDI attractiveness, by playing along with Beijing's environmental laws, which they know are always only loosely enforced. 3M is one such foreign company - in a 2006 report, the company

was accused by the Chinese non-governmental organization (NGO) Institute of Public and Environmental Affairs, of violating environmental standards and polluting air or water (Stalley 2010). 3M was one of 33 companies included in this list (Stalley 2010).

From a Chinese policymaker's point-of-view, there was also a strategic interest in 3M. There were two main benefits of constructing a 3M Shanghai factory: it would produce high quality products for the domestic market, meanwhile acting as a confidence boosting mechanism (a public relations effect) for other foreign companies who were considering investing or moving their factories to China (Stein 1987).

Scale Production

Adding to the appeal of moving value chains to China is the country's propensity for scale production - its gigantic factories and integrated production base, which in turn empower economies of scale. As aforementioned, China's Deng-era economic reforms attracted both private and foreign capital alike. This, along with the retail revolution in the West which made merchants (instead of manufacturers) the decision maker in the global value chain, enabled the springing up of giant, foreign-owned manufacturing facilities all over China, which first began in Shengzhen's Special Enterprise Zone (Freeman 2013). This was possible as employment in these factories did not require high technical abilities - in many cases "masses of workers may be under the same roof, but for the most part their labor is individual or in small groups, doing work identical to other individuals or groups nearby, without interacting with them" (Freeman 2013, 199). Some notable examples of this include Foxconn's Chengdu factory which employs 120,000 workers to produce iPads for Apple, as well as leading textile producer Huafeng Group which owns a complex with "over 100 buildings and 30,000 employees" (Freeman 2013, 177). These

factories are essential to the global value chain as they often produce products made for consumption outside of China (Freeman 2013, 201).

What's more, China's vertical industrial base includes a robust network of regional manufacturing ecosystems, with an enormous supply of managers and entrepreneurs that can take over production at any time. This is evident from the "massive concentrations of assembly plants, skilled workers, and material and component suppliers" (BCG Global 2020) in areas like Shenzhen and Chongqing, which respectively produces "90% of the world's smartphones" (BCG Global 2020) and "includes assembly plants for Hyundai, Changan Ford, Changan Suzuki, and Lifan" (BCG Global 2020). As a result, vertical integration makes China difficult to replace in the global value chain.

Relating this back to the aforementioned effects of FDI, it can be observed that the effects of scale production create a positive feedback loop, because "once a province has attracted a critical mass of FDI, it will find it easier to attract more FDI as foreign investors perceive the presence of other foreign investors as a positive signal" (IMF 2002). This capital then makes the building of larger, more productive, and more integrated factories much easier, in turn deepening economies of scale.

The issue of scale production is pertinent to PPE production, as despite N95 and surgical masks themselves being fairly cost effective to manufacture, it requires the key ingredient polypropylene, a meltblown plastic which has "fibers of a small diameter in a random pattern that can trap small particles" (Gereffi 2020, 293). More specifically, it is the machine which produces polypropylene that requires production to be capital intensive, and within a large scale economy (Dallas et al., 2021). This machine, which assembles "multiple layers of non-woven and textile fabrics... through ultrasonic welding into a minimum of three layers" (Gereffi 2020,

293), is so technologically complex that it creates cost, time, and information rigidities when scaling up (Dallas et al., 2021). Indeed, it is estimated that each machine costs around 4.23 million USD (Dallas et al., 2021), and around nine to 12 months (Graham 2020), to make. As such, there are only around five or six companies that are capable of building polypropylene machines.

China's internal supply of polypropylene was extremely resilient, for even prior to the pandemic, it had produced 40% of the world's meltblown textile (中国出口信用保险公司资信评估 2020). Owing to this, when internal demand for surgical masks skyrocketed in January and February of 2020, China quickly utilized its petroleum SOEs PetroChina and Sinopec to serve as state producers for both meltblown cloth and other non-woven man-made fabrics as aforementioned, for polypropylene is actually derived from petroleum oil (Gereffi 2020, 293). This made up for lowered imports of meltblown from the U.S. and Europe.

China's integrated industrial base is thus vital: for instance, Winner Medical self-identifies as "one of the earliest domestic companies [to have established] a full industrial chain of medical gauze from cotton procurement to spinning and weaving" (Winner Medical Co., Ltd 2021). The logic behind this framework is that market transactions which are run vertically reduce transaction costs (D'Aveni and Ravenscraft 1994, 1194) and time lags, have greater information transparencies (Fan et al., 2009), and are less reliant on outside fluctuations in prices. That being said, internal integration of supply chain processes is not always the most cost effective overall, especially if horizontal sourcing is cheaper than vertical sourcing. As a consequence of this, producers are oftentimes tasked with the tough choice between vertical integration which potentially lowers transaction costs, and economies of scale which lower production costs (D'Aveni and Ravenscraft 1994, 1194). It is because of these reasons that

China's case is so compelling, for it achieved both outcomes - vertical integration *led* to economies of scale as vertical sourcing was more economical than horizontal sourcing.

Investigating further, a comparison between 3M's Shanghai, China facility and Prestige Ameritech's Fort Worth, Texas facility - the U.S.'s largest mask manufacturer - can put China's vast scale advantage into perspective. In terms of number of employees, 3M's Chinese facility has 20x the headcount of its American counterpart, at around 6000 employees (Shafer 2017). Prestige Ameritech has a total of 300 total employees (Dun & Bradstreet). 3M's Chinese facility also produces 3.2 billion USD in sales (Shafer 2017), which is more than 56x that of Prestige Ameritech, which generates 56.34 million USD in sales (Dun & Bradstreet). This is a telling metric, since Reese's masks cost around 79 cents (Davis 2020) to manufacture, meanwhile in Chinese factories the average mask only cost 30 cents a piece (FRONTLINE 2020).

China's WTO Entry

The strength of China's competitive currency, abundance of labor, subsidies and state support to manufacturing, and scale production, was reinforced by the country's 2001 joining of the WTO. Membership played a major role in amalgamating the nation into the global trading system, opening the door for massive capital inflows (Agarwal and Wu 2004). Joining the WTO legitimized the Chinese market, because it now had to conform to international standards on each and every sub-national level, make transparent its trade policies and regulations, and be subject to judicial review (Agarwal and Wu 2004). To be sure, to gain WTO membership, China had pledged to gradually liberalize trading rights and allow foreign-owned factories. This was pivotal: China's low-cost, large-scale, labor-abundant manufacturing sector was already attractive for efficiency-seeking global supply chains, but it was the WTO's stamp of approval

and China's ensuing obedience to WTO regulations which legalized and endorsed the cascading of FDI into Chinese factories.

Chapter Four: COVID-19 and PPE Shortages

Having explored China's importance in PPE value chains, it is important next to investigate how and why shortages were possible during the COVID-19 global pandemic. It is conventional wisdom that a sudden spark in demand coupled with depleting supplies were responsible. Even China, which increased its production of masks 10x from January to March of 2020, was incapable of meeting its own demand at the height of the pandemic, and necessitated two billion additional imports of masks (Gereffi 2020, 293). In response, the Chinese government banned mask exports (Bhaskar et al., 2020, 821), which incurred international repercussions given the country's importance in the PPE supply chain. As the virus spread globally and countries plunged into pandemic status, policymakers increasingly adopted protectionist measures to secure national stockpiles, which only further undermined global supply chains, further endangering access to PPE. It is interesting to note that this spike in demand can be attributed not only to actual healthcare needs, but also to the vicious cycle of "panicked marketplace behavior" (Cohen and van der Meulen Rodgers 2020, 1-2).

Nonetheless, a further investigation would reveal that PPE resources and supplies were already initially low prior to the pandemic. For instance, the U.S. and Australia had not replenished their national stockpiles after a respective 100 million and 28 million masks were distributed in the 2009 H1N1 pandemic (Bhaskar et al., 2020, 821). Unfortunately, this meant that the healthcare industry was forced to adapt in many ways: at the beginning of the pandemic "popular news outlets [had] report[ed] unconventional solutions for PPE at local hospitals, such as plastic garbage bags for gowns and plastic water bottle cutouts for eye protection" (Livingston et al., 2020, 1912-1914), and reduction of PPE usage for low-risk individuals was even recommended as a potential solution. On a global scale, this shortage was compounded by the

depletion of the World Health Organization's emergency funds, which were at a significant low owing to the 2018 Ebola Epidemic (McCarthy and Shi 2020).

Another reason for low initial supplies is the popularity of the “Just-in-time” (JIT) business model within the PPE supply chain. This model, which “prioritizes lean production and low inventories” (Gereffi 2020, 295) to reduce cost and maximize time and space, has been extensively used. 3M, for example, reduced inventory levels by 370 million USD to increase cash flow by 10% (Gereffi 2020, 295), in alignment with JIT. Inherently, this has proved problematic in pandemic times, as low inventories have led to fewer supplies in a time of increased demand for PPEs (Gereffi 2020).

The privatization of the PPE global value chain aggravates supply chain fragilities. In past decades, anti-competitive framework and tax cuts have led to massive, monopolistic, multinational corporations, such as 3M and Honeywell. The results of this: market concentration yields bargaining power for corporations (Baines and Haiger 2020) and enables them to discontinue goods that are unprofitable yet potentially life-saving, as well as price essential products at unfair levels. Worse, it narrows supply chains, essentially putting all eggs in one basket, meaning that when a crisis does occur and a supply chain breakdown becomes inevitable, there remains a limited number of sourcing alternatives.

In addition, in the case of the U.S., while 3M was ordered by President Trump's executive order to retool its industrial N95 masks into medical N95 masks, the process was complex and lengthy. This is because the two types of N95 masks are subject to different regulations, and the medical N95 “contain an extra material that makes them splash-proof, raising long-standing industry concerns about liability lawsuits” (Gereffi 2020, 295). Since 3M

required said liability waiver from Congress in order to protect itself from potential legal difficulties, it caused delays in the actual execution of the Defense Production Act.

Are fragile supply chains *really* the culprit for U.S. shortages?

Despite the talk about overdependence on Chinese production of PPEs, the U.S. shortage problem was not actually the lack of N95 and surgical masks itself, but the poor government response to the pandemic. In conceptualizing this, it is important to note that by the late 2000s, most masks consumed in the U.S. had been produced abroad, and that the Texas company Prestige Ameritech, owned by Texan Dan Reese and located in Fort Worth, was the largest and one of the only remaining domestic manufacturers of masks (FRONTLINE 2020).

Poor governmental policies date back to the H1N1 Swine Flu Pandemic, which had sounded the alarm for the potential danger of lackluster national stockpiles. The Global Pandemic Research Center was founded in the immediate aftermath of the crisis, and the government began funding Reese's Prestige Ameritech under a short 9-month contract. Yet, once the pandemic subsided, the government chose not to renew funding, causing Prestige Ameritech to almost go bankrupt. The lingering consequences of this were salient: as Reese did not receive support in the post H1N1 years, he did not immediately amp up production when the COVID-19 crisis struck, especially because the Trump administration had turned down a January offer from the company (Davis 2020). Reese explains that from a business standpoint, his company wanted a guarantee that their initiatives would continue once the pandemic was over, unlike last time (FRONTLINE 2020). Prestige Ameritech finally received a contract in April 2020 (Davis 2020), and Premier also bought a minority share in the company after one of its main Taiwanese suppliers redirected their masks to mainland China instead (FRONTLINE 2020).

Exacerbating this, governmental health-security priorities were clearly misguided. The national stockpile was not only unreplenished, the few remaining masks were also past their expiration dates. Nicole Lurie, American physician and former Assistant Secretary for Preparedness and Response under the Obama administration, had warned the Trump administration of the dangers of this, but to no avail (FRONTLINE, 2020).

Then, when the crisis occurred, the response from the Trump administration was lagging. Due to the COVID-19 virus' exponential characteristic, where any one infection accelerates the number of infections, and its novelty, meaning the general population does not have immunity, "even small differences in timing could impact many lives" (Gereffi 2020, 293). However, because of the Trump administration's downplaying of the outbreak, the death toll multiplied along with the demand for PPE. To give an example, if stay-at-home orders were mandated just two weeks earlier than they had been, 83% of U.S. deaths could have been circumvented (Gland and Robertson 2020). By the time COVID-19 measures were put in place, the demand for PPE was already more than three times its supply. Gereffi (2020, 294) highlights that as compared to demand for 290 million N95 masks in March, U.S. producers only had the ability to manufacture a total of 80 million N95s.

To further underline poor governmental responses, Ernest Grant, President of the American Nurses Association, had advocated for the Defense Production Act long before its actual adoption - as a matter of fact, President Trump himself publicly had declared that "the DPA is a wonderful thing, but we just haven't had to use it" (FRONTLINE 2020). It was not until the pandemic raged on, severely and devastatingly, that the President finally relented and evoked the act.

Even Project Airbridge, which aimed “to shorten the amount of time it takes for U.S. medical supply distributors to bring personal protective equipment and other critical medical supplies into the U.S. during the COVID-19 pandemic response” (Federal Emergency Management Agency 2020), was ineffective. Of course, the Trump-initiated tariffs had complicated sourcing PPE from China, by bringing additional costs (Bown, 2020) to an already difficult acquisition process when countries introduced trade restrictions to meet internal demand (Gereffi 2020, 292). State governors were instead forced to fend for their own states - for instance, Maryland Governor Larry Hogan had made a deal with South Korea to bring in N95 masks for the State of Maryland (FRONTLINE 2020), in order to prevent the state’s healthcare system from further breakdown.

Clearly then, despite external factors such as the reliance on China, the U.S.’s internal pandemic policy was an absolute failure. From the neglect of the PPE stockpile, to the ignorance towards leading health authorities, to the delayed, downplayed, and deficient responses which failed to stop the spread of the virus, the Trump administration is equally, if not more responsible than fragile global chains for the U.S.’s PPE shortages.

Chapter Five: A Further Case Study of Surgical Gowns and Testing Kits

Other than N95s and surgical masks, the COVID-19 crisis also led to shortages in other low-profit-margin PPEs, such as surgical gowns and testing kits. This section will briefly breakdown the specific intricacies behind these two key products.

Surgical Gowns

Surgical gowns are similar to masks in two ways: China is its largest exporter, and the manufacturing of the product utilizes some of the same raw and processed materials. This spells trouble in a pandemic, as a redirection of assembly lines to face mask production creates a trade-off which lowers the capacity to manufacture surgical gowns. Premier Medical Supply, which sources mainly from China, “estimated that as of June 10, it had met only about 70% of the pandemic-level demand for gowns” (Eldred 2020).

COVID-19 Testing Kits

Shortage of COVID-19 testing kits were also severe, as a result of a specific component of the test - the swabs, which make use of short “flock” fibers that help pick up microscopic organisms to detect the presence of the virus (Shanker 2020). There are only two companies that provide swabs: Puritan, which is located in Guilford, Maine, and Copan Diagnostics Inc., which is located in Italy. In the case of shortages within the U.S., the latter had not been advantageous as Italy was an epicenter of the pandemic. The former had also undergone difficulties in suddenly enhancing production, due to the shortage of workers, which was caused by the dual impacts of Guilford’s aging population and Trump’s immigration policies which lowered job applicants (Shanker 2020).

Even more devastating, U.S. shortages intensified because of the Center for Disease Control and Prevention's (the CDC) decision to "develop an entirely new diagnostic test - one that the Trump administration claimed would be more accurate" (FRONTLINE 2020), instead of moving forward with the German equivalent of the test, which had already been validated. Unfortunately, many of these CDC tests ended up being unusable. Although the CDC later reversed its decision to allow non-CDC tests to be run, the damage had already been done - the rollout of commercial tests in the U.S. were delayed by approximately two whole months (FRONTLINE 2020).

Chapter Six: Conclusion

The scramble to increase domestic production, ensure export restriction, and even pursue acts of modern piracy is an obvious indicator that PPE supply chains need increased resilience moving forward. Looking ahead and into a post-Covid-19 world, China's special market dynamics will not disappear - competitive currency will continue to expand balance of trade, labor will remain cost-effective at least until the Lewis Turning Point is reached, subsidies and state support will not subside, and scale production infrastructure remains. This substantiates her role as a powerhouse in PPE supply chains, due to dominance in low profit margin manufacturing and the sheer size of its domestic healthcare market, the second largest in the world (Huang 2019).

Nevertheless, the pandemic has demonstrated that the PPE supply chain cannot survive with its current monopolies and JIT manufacturing systems. To "bolster the robustness and resiliency of supply chains", then, Gereffi (2020, 296) recommends "redundancy rather than reshoring". By diversifying supply chains through increasing domestic production capabilities, expanding the number of international production sites, seeking large international production networks, and nurturing research and development opportunities across borders, the risk of breakdown can be minimized (Gereffi 2020).

Two additional policy objectives will be helpful in providing a safety net for future crises. First, due to the multitude of stakeholders involved in PPE production, regulatory policies can enhance transparency, ensure quality, and encourage trust and confidence (Gereffi 2020, 296-297). Second, contingency plans which center global cooperation to domestic networks will mitigate the risks of future crisis events. South Korea is an example of this - its public-private

partnerships which were established in the aftermath of the 2015 MERS outbreak made its supply chains more resilient in the COVID-19 pandemic (Gereffi 2020, 296-287).

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