



COMMENTARY

What does the COVID-19 pandemic teach us about global value chains? The case of medical supplies

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Abstract

The COVID-19 pandemic has caused a dramatic shortage in the medical supplies needed to treat the virus due to a massive surge in demand as the disease circled the globe during the first half of 2020. Prior to the crisis, there was an interdependence of trade and production for medical supplies, with advanced industrial countries like the United States and Germany specializing in the relatively high-tech medical devices sector, while low-cost production hubs such as China and Malaysia were leading producers of less technologically sophisticated personal protective equipment (PPE) products such as face masks, surgical gloves, and medical gowns. After the COVID-19 outbreak, global shortages of PPE products emerged as many affected countries imposed export controls and sought ways to boost domestic output. A case study of the face mask value chain in the United States shows misalignments between the priorities of U.S. federal government officials and the strategies of leading U.S. multinational producers of face masks, which resulted in exceptionally costly policy delays in terms of health outcomes. On balance, the U.S. shortage of N95 respirators during the COVID-19 pandemic is more a policy failure than a market failure. The global value chain framework highlights strategic options that could lead to more resilient supply chains and diversified sourcing patterns. *Journal of International Business Policy* (2020) 3, 287–301.

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INTRODUCTION

Global supply chains have suddenly become a new buzzword in public consciousness. The novel coronavirus global pandemic of 2020 has focused attention on supply chain shortages of personal protective equipment (PPE) and the testing kits used in the treatment and diagnosis of mushrooming numbers of COVID-19 patients around the world. The rapid shutdown of the United States (U.S.) economy led to domestic demand shocks that generated startling disruptions in the availability of everyday commodities from fresh vegetables, eggs, and milk (Yaffe-Bellany & Corkery, 2020; Reiley, 2020; Evich, 2020) and meat (McLean, 2020; Estes, 2020) to toilet paper (Oremus, 2020), with the culprit allegedly

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being the lack of responsiveness of hyper-efficient but rigid modern supply chains (O'Leary, 2020; O'Neil, 2020; Shih, 2020). At the macro-level, the coronavirus pandemic also symbolizes a more systemic malaise: the rise of protectionism and economic nationalism has replaced decades of expansive trade and foreign investment regimes; the multilateral architecture of the postwar Bretton Woods system is crumbling; and some question whether we have arrived at the end of globalization (Buruma, 2016; Farrell & Newman, 2020).

While global supply chains emerge as a protagonist in many of these scenarios, the drivers and policy implications of supply chain disruptions during the pandemic are often unclear. In large part, this is because supply chain dynamics vary considerably, not just by industry but also by the characteristics of specific products, the strategies of the companies that make them, and the distribution channels involved (Cattaneo, Gereffi, & Staritz, 2010; Staritz, Gereffi, & Cattaneo, 2011). In addition, the policy drivers of supply chains are different in importing versus exporting economies, advanced industrial versus developing nations, and the home and host countries of the large multinational enterprises (MNEs) that typically lead and orchestrate global industries (Taglioni & Winkler, 2016; Stolzenburg, Taglioni, & Winkler, 2019; Horner & Alford, 2019).

The COVID-19 pandemic has rapidly become one of the most significant disruptive events in modern times. It is simultaneously a public health crisis of unparalleled magnitude, scope, and speed that has circled the globe in a span of several months since the novel coronavirus outbreak in Wuhan, China, was officially confirmed in early January, 2020 (*Medical News Today*, 2020). There were over 12.8 million cases of COVID-19 and 567,000 reported deaths as of July 11, 2020.¹ The impact on the global economy has been equally draconian. COVID-19 has shuttered most of the world's major economies for months, as national governments have sought to weather the global pandemic with its disastrous and escalating toll on global trade and production, skyrocketing spikes in unemployment,² and a soaring public debt due to massive stimulus packages designed to shore up moribund economies and stave off economic collapse.³

Obviously, no single country can be expected to efficiently produce all of the goods needed to fight

the COVID-19 pandemic. However, there are growing national security concerns related to acute shortages of medical supplies and other products in high demand to help prevent the spread of the coronavirus. A key question related to international business and public policy is whether these current shortages in COVID-19 medical products are due to structural flaws or rigidities in their supply chains, as numerous critics have alleged, and whether and how supply chains could be made more resilient or "antifragile" to confront new threats (Farrell & Newman, 2020; O'Leary, 2020; O'Neil, 2020; Shih, 2020; *Financial Times*, 2020; Avishai, 2020). More specifically, were the international trading system and global organization of production for COVID-19 goods skewed to favor the interests of a small set of countries and firms that were the primary beneficiaries of globalized supply chains for these medical products? Is economic protectionism and the reshoring of production for essential medical supplies a likely and desirable consequence for future pandemics or major disruptions in the global economy?

To better comprehend these complex issues, this article will cover four related topics. First, I will briefly outline the global value chain (GVC) research framework, and indicate how its focus on patterns of governance and corporate strategies in global industries provides a key context in which the options and tradeoffs for national policymakers and other stakeholders can be evaluated. Second, I will highlight the trade interdependencies for two categories of essential medical goods prior to the onset of the COVID-19 pandemic: the PPE used by medical staff in treating coronavirus patients, such as face masks, surgical gloves, and medical gowns; and medical devices, covering more sophisticated equipment like life-saving mechanical ventilators, patient monitors, and X-ray machines. Third, I will zero in on the case of face masks and N95 respirators in the U.S., in which well-publicized shortages raise critical questions about the contentious interplay between policymakers in the current U.S. administration of President Donald Trump and company strategies of leading American manufacturers that created prolonged supply shortages and distribution bottlenecks that greatly elevated the health risks for medical personnel and patients alike. Fourth and finally, I will discuss some implications of the PPE case for more resilient supply chains and post-crisis policymaking in the future.

THE GLOBAL VALUE CHAIN FRAMEWORK

During the 1990s–2010s, an extensive literature has emerged that chronicles the growth of the global economy in terms of the decisions of major U.S. and European companies to move production offshore and establish cross-border production networks. Known by various labels, global commodity chains (Gereffi & Korzeniewicz, 1994; Bair, 2009), global production networks (Henderson, Dicken, Hess, Coe, & Yeung, 2002; Coe & Yeung, 2015), and GVCs (Gereffi & Kaplinsky, 2001; Gereffi, 2018, 2019), a distinguishing feature of these studies is that they offer a network-centered perspective on the global economy that views different types of MNEs as “lead firms” that orchestrate complex, multi-tiered global supply chains. These global networks leveraged the advantages of lower costs, superior scale, and spatial flexibility by combining a variety of factors: proximity to natural resources; access to large pools of low-cost and well-trained labor; the increasing speed and sophistication of global logistics providers; and the innovation, design, and marketing prowess of MNE lead firms in a diverse array of agricultural, manufacturing, and service sectors (see Dicken, 2015; Low & Pasadilla, 2016; Ponte, Gereffi, & Raj-Reichert, 2019).

The GVC approach has spawned a proliferation of review articles that highlight the complementarity of scholarship on GVCs, global strategy, and international business, including the evolving capabilities of MNE lead firms and domestic suppliers (Hernandez & Pedersen, 2017; Kano, Tsang, & Yeung, 2020; McWilliam, Kim, Mudambi, & Nielsen, 2020; De Marchi, Di Maria, Golini, & Perri, 2020). In effect, GVCs link the macro-level of international trade, investment, and finance with the meso-level of national and regional economies, and the micro-level of local suppliers, communities, and workers. The GVC framework includes several critical features relevant to our analysis of the supply chains for COVID-19 goods:

- *Global industries have governance structures* The strategies of GVC lead firms set the performance requirements (e.g., price, quality, standards, delivery schedule) for globally dispersed tiers of suppliers. A core insight of the early GVC literature was the contrast between “producer-driven” chains, whose lead firms were multinational manufacturers in relatively technology- and capital-intensive industries, such as automobiles, computers, and pharmaceuticals, and “buyer-

driven” chains, whose lead firms were retailers (such as JC Penney, Walmart, and Carrefour), branded merchandisers (e.g., Nike, Adidas, Liz Claiborne, or Disney), and supermarkets (e.g., Tesco and Kroger) (Gereffi, 1994). Subsequently, a more elaborate fivefold governance typology was introduced that included hierarchies (vertically integrated firms whose affiliates are bound by equity ties) and competitive markets as endpoints, along with three types of recurrent production networks – captive, relational, and modular – with varied levels of explicit coordination between lead firms and their suppliers (Gereffi, Humphrey, & Sturgeon, 2005; Sturgeon, 2009).

- *Global supply chains have specialized divisions of labor* Different locations make specific components and final products, which increases the efficiency of the chain. However, disruptions or substandard products at one location can jeopardize the entire chain if sourcing options are not diversified (Sturgeon, Van Biesebroeck, & Gereffi, 2008; Buckley & Strange, 2015; Sun & Grimes, 2018).
- *The geography of supply chains can vary over time* This is based on multiple factors (e.g., country conditions, company strategies, technology shifts, or government policies), but regional and global sourcing patterns coexist and are often complimentary in many industries (Gereffi, 1999; Dicken, 2015; Whittaker, Sturgeon, Okita, & Zhu, 2020; Gereffi & Wu, 2020).
- *Value is distributed unevenly across supply chains* Relatively high-value activities⁴ are increasingly located in specialized components within the production process, and in pre-production (e.g., research and development, design) and post-production (e.g., marketing, brand, and finance) services in value chains. This is sometimes referred to as the “smile curve of value creation” (Mudambi, 2008; Rehnberg & Ponte, 2018; Fernandez-Stark & Gereffi, 2019).
- *State policies can exert conflicting pressures on lead firms as well as suppliers in value chains* While the expansion of international production networks and export-oriented industrialization for developing economies was promoted by advanced industrial states and global financial institutions like the World Bank and the International Monetary Fund from the 1980s through the early 2000s, a series of events including the global recession of 2008–2009, the U.S.–China trade war, resurgent economic nationalism, and the

novel coronavirus health crisis of 2020 have magnified the prospects for policy conflicts in the current era (Wade, 2018; Horner & Alford, 2019; Mayer & Gereffi, 2019).

Together, these propositions constitute interacting dimensions and building blocks of the holistic, multi-level, and actor-oriented GVC framework that can be used to assess opportunities for development and upgrading for both countries and firms linked to global industries (Gereffi, 2018; Ponte, Gereffi, & Raj-Reichert, 2019). The next section of this article draws on this approach to examine the extent of globalization and the nature of lead firms in several of the medical supply industries associated with the COVID-19 pandemic.

INTERNATIONAL TRADE IN MEDICAL SUPPLY GVCs, PRE-COVID-19

Based on the broad GVC framework, we can make a few preliminary assessments to characterize the status of medical supply trade prior to the outbreak of the COVID-19 pandemic in 2020. Typically, medical supplies are producer-driven value chains involved in business-to-business transactions between their lead firms or top suppliers and institutional clients, such as hospitals, healthcare distributors, and government agencies. However, company strategies within this producer-driven governance structure show meaningful variations, reflecting the characteristics of the industry segments or niches in which the lead firms operate.

In the medical devices segment, global trade is led by large vertically integrated MNEs headquartered in advanced industrial economies with worldwide production facilities. Although a number of major medical-device export industries are situated in relatively large, newly industrialized, global manufacturing hubs (such as Mexico, China, and the Republic of Korea), as well as smaller, more specialized locations (such as Ireland, Costa Rica, Singapore, and New Zealand),⁵ the main suppliers in these settings are usually subsidiaries of MNE lead firms from the innovative centers of medical device production, such as the U.S., Germany, Switzerland, the Netherlands, and the United Kingdom (OECD, 2020b).

In the less technologically sophisticated PPE segment of medical supplies, by contrast, there is more external contracting by third-party suppliers, even though regulatory oversight and certification are required for all factories that sell medical

devices to major markets⁶ (Bamber, Fernandez-Stark, & Taglioni, 2020). Thus, there is more scope in PPE than medical devices for supplier-centered (rather than lead-firm centric) company strategies,⁷ which expands the role of external contractors and large developing economy suppliers for PPE items like face masks, medical gowns, and surgical gloves (see Bamber, Fernandez-Stark, & Taglioni, 2020: fig. 3).

In general, booming international demand has driven the globalization of medical supplies and devices in recent decades. Among the many medical products that industry experts have identified as critical in the fight against COVID-19, the U.S. imported US\$22 billion of these goods from the world in 2019, before the outbreak of COVID-19.⁸ The U.S. imported about \$5 billion (26%) of these products from China, which is the leading supplier of numerous items, including PPE, protective goggles, thermometers, and medical headwear. However, depending on the product, the main foreign supplier for the American market is often not China. The European Union is the primary source of CT (computed tomography) systems, hand sanitizers, patient monitors, X-ray equipment, and breathing masks. Other leading exporters for specific products include: Mexico (medical protective clothing, catheters); Malaysia (sterile gloves); Singapore (ventilators, oxygen masks); South Korea (ultrasound systems); and Canada (oxygen concentrators) (Bown, 2020: fig. 3).

The top exporters of COVID-19 goods are quite varied at the global level (see Figure 1). A look at the overall trade structure of COVID-19 products reveals that the top five global exporters, which together account for 50% of trade, are Germany (15%), the U.S. (11%), Switzerland (9%), China (8%), and Ireland (7%). The U.S. represents 18% of global imports for COVID-19 products, followed by Germany at just under 9% of the total. While the U.S. and Germany tended to specialize in the production of medical devices, China and Malaysia are the most specialized in PPE goods (OECD, 2020b). Thus, trade interdependencies rather than pronounced asymmetries characterized the exchange of COVID-19 products prior to the outbreak of the coronavirus pandemic in 2020.

Between 2008 and 2018, global trade in PPE and medical devices has more than doubled in value (Bamber, Fernandez-Stark, & Taglioni, 2020). The driver was a large increase in demand, resulting from a rapidly aging population in both rich and middle-income countries, increased expenditure on

Country shares in global exports by good

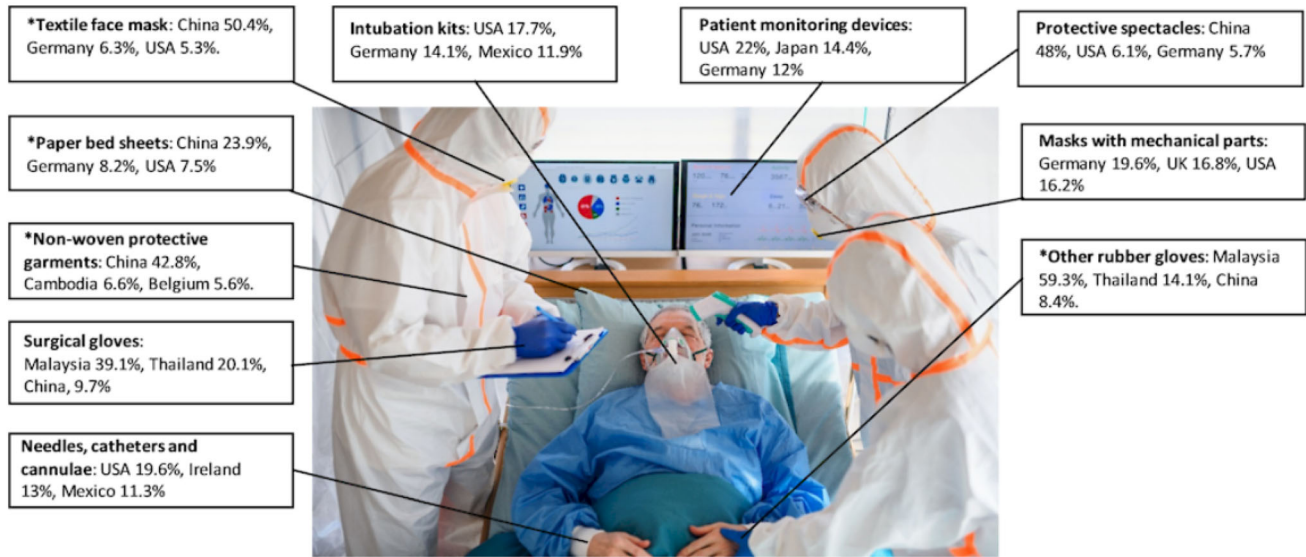


Figure 1 Top exporters of certain COVID-19 goods, 2018. Note: The products marked with an * belong to broader categories of goods than those captured in the shares,

meaning that these include other products that might not be essential in the fight against COVID-19. Source: OECD, 2020b: 5

healthcare in the developing world, and low tariffs that resulted in a plentiful supply of low-priced and high-quality goods. While exports of medical goods from the advanced industrial economies increased by 45% since 2008, the “non-traditional” exporters grew twice as fast (100%) (see Figures 2 and 3).

Notwithstanding these pre-COVID-19 growth trends in the PPE and medical device GVCs, it seems obvious that the outbreak and global spread of the coronavirus pandemic in the first half of 2020, and the dramatic surge in demand as the number of infected patients soared, were bound to create severe shortages of COVID-19-related products in the countries hardest hit by the virus. The diversity of established exporters for medical supplies meant that trade was in principle an option to help meet burgeoning demand. However, the trade war initiated by President Trump against China in early 2018 imposed an additional cost due to the tariffs (Bown, 2020), and the more serious and widespread problem of export controls emerged in the cascade of nearly 80 countries that introduced export prohibitions or temporary restrictions for COVID-19 products by the end of April, 2020 (WTO, 2020).

Thus, the arena for action for many countries shifted from the international domain to domestic terrain to find some combination of national

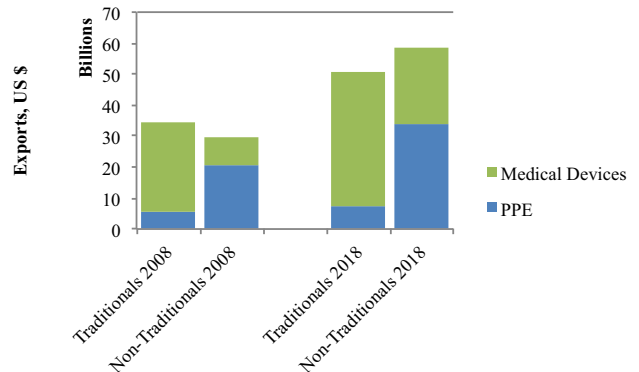


Figure 2 Exports of medical devices and personal protective equipment (PPE), 2008 and 2018. Note: Traditional exporters: U.S., Germany, Japan, the Netherlands, United Kingdom, France, Belgium, Italy, Canada. Non-traditional exporters: China, Mexico, Ireland, Malaysia, Vietnam, Costa Rica, Thailand, Singapore, Israel, Taiwan China. Source: Bamber, Fernandez-Stark, and Taglioni (2020). Using UN Comtrade Database: PPE & Medical Devices Exports to World (HS02; Codes as defined by WCO, 2020). Retrieved from <http://comtrade.un.org/>.

production plus imports required to confront the urgent shortfalls of COVID-19 products. To explore how supply chains responded to the major disruption posed by the coronavirus pandemic, I focus in the next section on U.S. efforts to deal with the shortages of a specific PPE product, face masks, and,

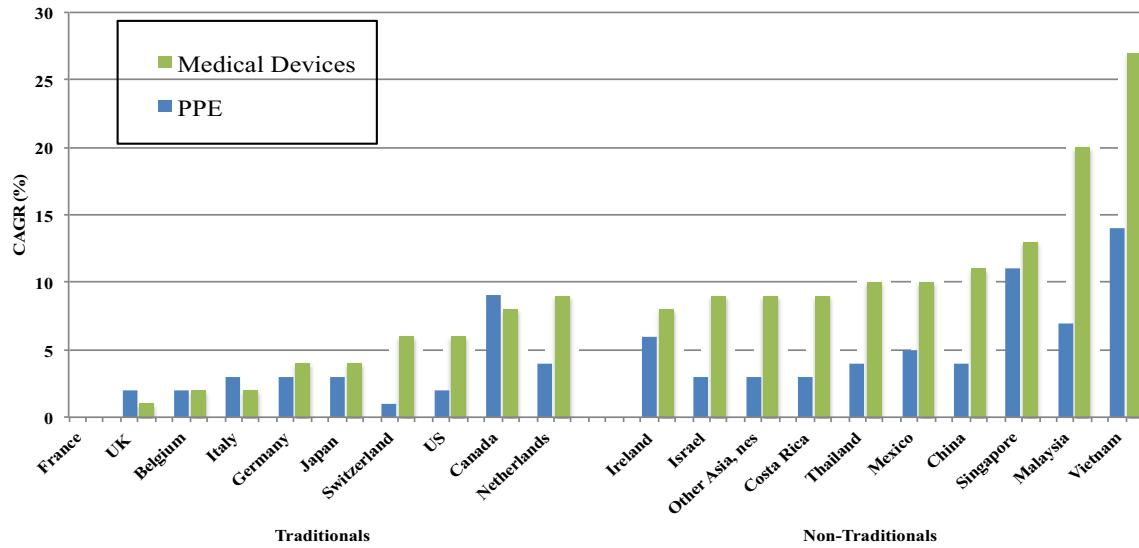
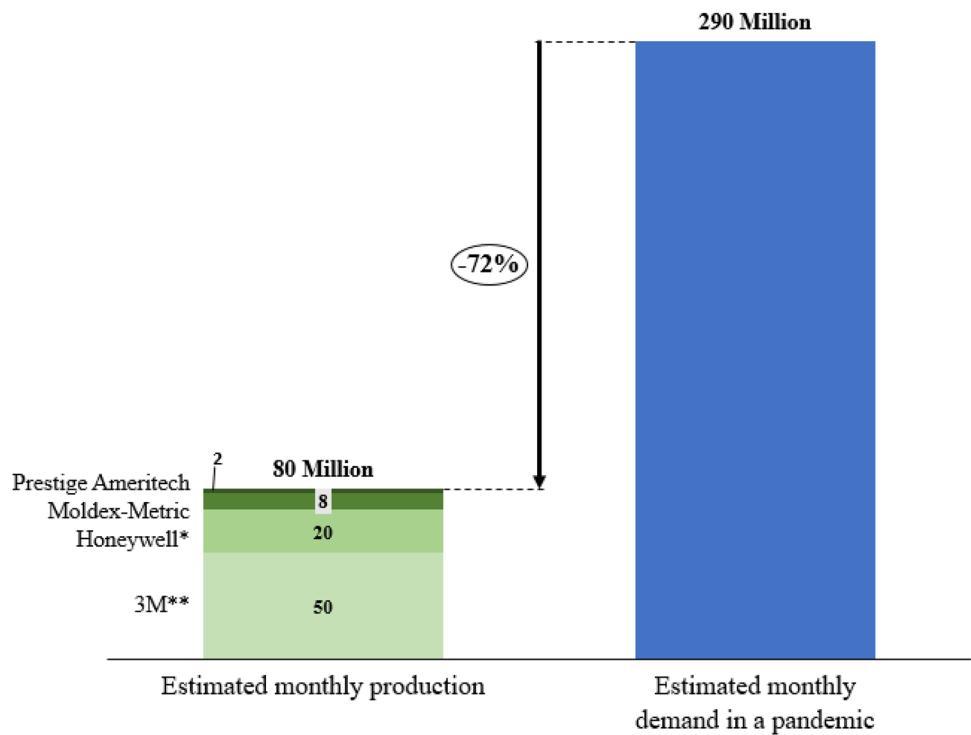


Figure 3 Traditional and non-traditional PPE and medical device exporters, 2008–2018. Note: Compound annual growth rate (CAGR). Source: Bamber, Fernandez-Stark, and Taglioni (2020). Using UN Comtrade Database (see Figure 2).

Figure 4 Shortfall in U.S. production of N95 masks. Note: *Honeywell production estimate is for May 2020; **3M estimate is for June 2020. Estimated monthly U.S. demand is from the U.S. Department of Health and Human Services. Source: Hufford (2020).



in particular, the N95 respirator. My central research question concerns the interplay of policy by the federal government under the current U.S. administration and the private sector response, and whether there is evidence that vulnerabilities in the face mask GVC were a primary cause for the supply difficulties unleashed by the COVID-19 pandemic.

THE U.S. QUEST FOR FACE MASKS DURING THE COVID-19 CRISIS: DEMAND SPIKES, SUPPLY SHORTAGES, AND POLICY CONFUSION

No product is more essential in the fight against the COVID-19 virus than face masks. These are part of the PPE repertoire used by health workers,



surgeons, and patients alike to protect the wearer from infection. A GVC analysis of the face masks utilized in the COVID-19 pandemic would typically involve a detailed methodology of value chain mapping (Frederick, 2019). This entails a variety of steps, including: (1) the definition and characteristics of the product/industry to be analyzed; (2) a description of the main stages of the value chain, such as its key inputs and components, the assembly process, testing and packing, and distribution; (3) an identification of the main companies and countries participating in the GVC; and (4) an analysis of significant bottlenecks as well as innovation opportunities along the chain. These steps will be sketched quite briefly in this article in order to focus on the political interventions associated with the unique challenges of scaling up the massive supply of face masks needed in the U.S. context to keep pace with the huge surge in demand across the country.

Key Characteristics of the Face Mask GVC

Surgical masks and N95 respirators are both used to prevent the spread of respiratory infections. They provide different levels of protection based on the effectiveness of their filtering. Surgical masks are loose-fitting and designed to trap sprays and droplets from coughing and sneezing, while N95 respirators fit more tightly and can also protect from far smaller airborne particles such as those associated with a virus. Both surgical masks and N95 respirators are disposable, which explains their high and recurrent demand.⁹

Under normal circumstances, masks are basic products and relatively cheap.¹⁰ However, the manufacturing process involves several types of inputs and is relatively sophisticated, which accounts for their different filtering properties as well as the limited number of companies that specialize in the higher-quality masks globally (see OECD, 2020a for fuller descriptions). The basic input for surgical masks is polypropylene, a polymer derived from petroleum oil and one of the most commonly produced plastics in the world. Polypropylene is “melt-blown” in order to obtain fibers of a small diameter in a random pattern that can trap small particles.¹¹ Multiple layers of non-woven and textile fabrics are then assembled through ultrasonic welding into a minimum of three layers.¹² N95 respirators have a similar production process, with a couple of extra steps for added protection, involving higher-tech machines and increased production costs. After the assembly

stage, testing is required to guarantee the quality of the masks, which must be sterilized before packing and shipping.

The main bottleneck in the face mask value chain in terms of inputs has been the non-woven fabric manufactured with polypropylene (OECD, 2020a: 4). Production of this non-woven fabric is quite widespread because it is used in baby diapers, feminine hygiene products, and disposable wipes, as well as in the automotive and construction industries. However, the melt-blown non-woven is a specialized fabric, made by a limited number of companies worldwide due to the high capital investment required for heavy machinery, such as hoppers, extruders, and melt-spinning systems. For this reason, it has been difficult to quickly increase the supply of face masks during the COVID-19 crisis or to find companies that can switch to this production process within a reasonable time and without substantial new investment.

China was the main producer of surgical masks at the start of the crisis, accounting for approximately one-half of world production (OECD, 2020a: 5–6). Because China was the epicenter of the initial COVID-19 outbreak, however, its production was insufficient to meet its own demand related to the pandemic, and China imported a huge quantity of up to 2 billion masks during the crisis. Although China increased its mask production tenfold in just 2 months (January–March, 2020), it was estimated that global demand for surgical masks might be *ten times higher than world production capacity prior to the COVID-19 crisis* (OECD, 2020a). In this context, U.S. efforts to guarantee an adequate supply of surgical and N95 masks faced an uphill battle when COVID-19 infections began their precipitous rise in the U.S. in March, 2020.

A Costly U.S. Syndrome: Policy Delays and Lack of Testing

The U.S. was hit hard by COVID-19 in mid-March, 2020, about 3 months after it first appeared in China. Although the first reported U.S. case of the new coronavirus was detected in mid-January, 2020, the Trump administration minimized the seriousness of the outbreak for a full 2 months until social distancing began to be introduced in mid-March. For an exponential pandemic like COVID-19, even small differences in timing could impact many lives. According to disease modelers at Columbia University, if the U.S. had begun imposing social distancing measures just one week earlier than it did in mid-March, about 36,000 fewer

people would have died in the coronavirus outbreak, and had stay-at-home measures been in place on March 1, 2020, 2 weeks earlier than most people started staying home, 83% of U.S. deaths could have been avoided (Glanz & Robertson, 2020; Pei, Kandula, & Shaman, 2020).

There were multiple missteps by the current U.S. administration that slowed down its response to the COVID-19 pandemic in the critical weeks before President Trump issued his first direct social distancing advisories on March 16. In a detailed documentary of U.S. government decision-making related to the COVID-19 pandemic (Frontline, 2020), it is reported that President Trump's first briefing on COVID-19 by Alex Azar, Secretary of the Department of Health and Human Services (HHS), occurred on January 18, several weeks after troubling initial signals about the pandemic emerged from China. On January 29, White House economic advisor Peter Navarro wrote Trump a lengthy memo warning that there was a risk of a massive loss of life that could be caused by the pandemic, and, the following day, restrictions were imposed on some flights to the U.S. from China in an effort to quell the spread of the virus.

Although HHS Secretary Azar announced on January 28 that the U.S. Centers for Disease Control and Prevention (CDC) had developed a rapid diagnostic test for detection of the novel coronavirus, by February 8, it was discovered that the CDC test kits for COVID-19 were contaminated. This disastrous news meant that lack of U.S. testing capacity would become a major obstacle that hindered subsequent U.S. efforts to limit the exponential spread of the disease. This testing failure, along with other controversies, cost CDC its leadership role in directing the U.S. response to COVID-19.¹³

Once the U.S. government started to take COVID-19 seriously, it conducted estimates in March 2020 of how many N95 respirators – which block 95% of very small particles – would be needed monthly to protect U.S. healthcare workers to fight the pandemic. The results indicated that 290 million N95 masks would be required each month, whereas projected supply by the two leading U.S. producers of the masks, 3M and Honeywell, together with smaller suppliers like Moldex-Metrix and Prestige Ameritech, would generate only 80 million masks on a monthly basis, far below the target amount (see Figure 4). This shortfall of nearly three-quarters of the required total would have to come from the output of existing firms or new

entrants into this sector, as well as imports that were exceptionally difficult to find because of export controls imposed by virtually all PPE-producing nations (WTO, 2020).

Pressures on 3M to Ramp Up U.S. Production and Imports of N95 Respirators

The top U.S. face mask producer by far is 3M, a Minnesota-based conglomerate that makes over 60,000 different products and has 96,000 employees around the world (3M, 2019; DeRensis, 2020). While all N95 masks filter at least 95% of airborne particles, respirators are produced for both industrial (mainly construction) and medical use. Prior to the onset of the COVID-19 pandemic, only 5 million of the 35 million N95 masks that 3M produced a month were going to U.S. healthcare workers (Whalen, Helderman, & Hamburger, 2020).

3M's major N95 production facilities are located in the U.S. and China. In early 2020, 3M scaled up N95 supply in its factories in South Dakota and Nebraska, as well as its respirator production site in China, to run all of its global respirator plants 24 hours per day, seven days per week, in anticipation of higher demand from the COVID-19 virus. By early May, 3M brought its U.S. production of N95 masks to 95 million units per month,¹⁴ and doubled its global output of respirators since January, 2020 to 1.1 billion per year (400 million in the U.S.). The company expects to double its current capacity again to 2 billion respirators around the world by the end of 2020 (Whooley, 2020; Newmarker, 2020).

Apparently spurred by Fox News host Tucker Carlson's segment on 3M that criticized the company for allegedly putting consumers in other countries before healthcare workers and local governments in the U.S. (DeRensis, 2020), President Trump issued an executive order on April 2 that invoked the Defense Production Act (DPA) of 1950 to require 3M to cease its export of N95 masks. The U.S. government asserted that, due to the coronavirus pandemic, 3M must give priority to the American market, and the Federal Emergency Management Agency (FEMA) was authorized to obtain as many N95 masks as it needed from the company.

3M pushed back. It countered by saying that cutting off exports of U.S.-made respirators to foreign countries could actually worsen the U.S. situation by inviting retaliation from trade partners on whom the U.S. relies for imports of varied forms

of PPE. This sentiment was echoed by Canadian Prime Minister, Justin Trudeau, and other Canadian political leaders, who cautioned that their country's relationship with the U.S. is a "two-way street" that involves flows of both material inputs and healthcare workers from Canada that support the provision of the U.S. medical complex (Cecco and Borger, 2020; Whalen, 2020; Whalen, Morris et al., 2020).

Peter Navarro, the White House supply chain coordinator, was tasked with procuring face masks, ventilators, and other PPE products from American firms in the fight against the coronavirus. Navarro, a staunch China critic, advocated use of the DPA as a weapon against U.S. companies seen as too reluctant to expand PPE and ventilator production in the U.S., such as General Motors and 3M. "When patriotic volunteerism or the invisible hand of the market isn't working," said Navarro, "you may need the visible foot of the DPA" (Swanson, 2020). The question is whether Navarro's aggressive tactics will help the U.S. respond to its current crisis and strengthen American industry, or whether the disruption of global supply chains will cut the U.S. off from needed medicines and other supplies.

On April 6, 2020, 3M announced plans to import 166.5 million additional respirators over the next three months, primarily from its manufacturing facility in China, to support healthcare workers in the U.S. (3M, 2020b). This plan allowed 3M to continue sending U.S.-produced N95 respirators to Canada and Latin America, where 3M is the primary source of supply.

However, this agreement did not resolve an ongoing controversy within the White House about how to harness American MNEs to relieve acute shortages of PPE materials as the number of COVID-19 cases in the U.S. began their steep exponential ascent. Within the medical products industry more generally, there was also debate about the vulnerabilities of their overreliance on a cost-optimizing just-in-time (JIT) business model that prioritized foreign-made products in low-cost locations, with a focus on China and declining inventories to minimize operating costs.

JIT Business Model: Lower Inventories for All

While the political jockeying between U.S. administration officials and 3M garnered most of the headlines, there are two other significant factors that slowed 3M's ability to substantially increase its supply of N95 masks to the U.S. market: the JIT business model that prevails in the healthcare

market and prioritizes lean production and low inventories across the supply chain; and industry demands for liability waivers in shifting from industrial to medical N95 masks to combat the COVID-19 pandemic.

The steady expansion of globalization in recent decades has encouraged the adoption of lean production and JIT supply chains that encourage manufacturers to reduce inventories as much as possible in order to lower operating costs and the amount of cash tied up in inventory. In its 2019 *Annual Report*, 3M heralded its reduced inventory in order to more fully implement its "new global operating model" that expanded cash flow by 10% compared to the preceding year, increased operating margins by 22%, and reduced inventory levels by \$370 million (3M, 2019: 2). Just as manufacturers prefer to carry less inventory to be more competitive, many hospitals have also adopted JIT purchasing of items such as N95 masks as a cost-saving mechanism (Whalen, Helderman & Hamburger, 2020).

Liability Concerns: A Hidden U.S. Driver for Delays in N95 Sourcing

Because industrial and medical N95 masks are made according to different specifications, they vary in design and fit, and they are subject to different regulations. Thus, the conversion from industrial use to medical masks is not straightforward, as some retooling is required because medical masks contain an extra material that makes them splash-proof, raising long-standing industry concerns about liability lawsuits (Whalen, Helderman & Hamburger, 2020).

In 3M's negotiations with the Trump administration in early March for increasing the supply of N95 masks in the U.S., the chief concern raised by 3M chief executive officer, Michael Roman, was the need for a liability waiver from Congress to shield the company from potential lawsuits as it repurposed 3M's industrial masks for medical use. The liability waiver was included in President Trump's emergency legislation that opened the floodgates to the \$2 trillion stimulus package that included funding to produce over 1 million N95 medical masks over the next 18 months (Whalen, Helderman & Hamburger, 2020).

Market Failure or Policy Failure?

Viewed in isolation, 3M's supply response of N95 masks to meet surging U.S. demand for respirators seems woefully inadequate to the 3.29 million

confirmed cases of COVID-19 and 137,000 reported deaths as of July 11, 2020.¹⁵ with numbers continuing to soar. However, Prestige Ameritech, the last major domestic mask company in the U.S., approached senior administration officials on January 22, 2020, a day after the first case of COVID-19 was detected in the U.S., offering to ramp up production of four unused N95 manufacturing lines to make an additional 1.7 million N95 masks per week (Davis, 2020). The offer was rejected because the Department of Health and Human Services did not have the money to issue contracts at that time, despite orders pouring into Prestige from buyers in China and Hong Kong, and shrinking domestic production of medical masks, as almost 90% of all U.S. mask production had left the country in less than a decade.

By May, 2020, FEMA had issued over \$600 million in new contracts for N95 medical masks. The biggest U.S. suppliers, 3M and Honeywell, were each awarded contracts for over \$170 million for protective gear, and other large orders went to untested third-party firms willing to enter the mask market at prices many times higher than the contracts for established producers. Prestige Ameritech finally got a \$9.5 million contract on April 6 to provide a million N95 masks per month for one year at a unit price of 79 cents per mask (Davis, 2020).

On balance, the shortage of N95 masks in the U.S. COVID-19 pandemic seems more like a case of policy failure than market failure. 3M, the biggest American producer, more than quadrupled its U.S. output of N95 masks in the first half of 2020 to 95 million per month by May, and its global capacity was projected to double from 1.1 billion to 2 billion masks by the end of 2020. Honeywell and other U.S. companies were also poised to fill over \$400 million in U.S. orders. This is a very significant expansion of U.S. production capacity in less than 6 months.

The bigger problem is one of policy failure by the current administration. They did not appreciate the scale and the inevitability of the pandemic problem when the first U.S. cases were reported in January, 2020,¹⁶ and additional policy delays, related to lack of testing, bureaucratic in-fighting, and unwillingness to confront the health risks posed by the looming pandemic, wasted valuable time. To further complicate its supply-side policy agenda, the Trump administration sought to nullify 3M's

export contracts with overseas customers in Canada and Latin America, raising deeper sovereignty concerns with U.S. trading partners. The result of these and other U.S. policy shortcomings in confronting the epochal challenge of the coronavirus pandemic is that the U.S. had a record number of new COVID-19 cases in a single day on July 10, 2020 with 68,241 diagnoses reported, a startling spike that more than tripled the total in mid-June (20,114 new cases on June 15) (*New York Times*, 2020).

POST-COVID-19 SCENARIOS

Our analysis of the impact of COVID-19 on medical supplies GVCs reveals the need to view PPE and other medical products from an evolutionary and a strategic perspective. Supply chains not only became more global in recent decades but they also became increasingly dependent on key exporting economies like China, along with the JIT business model that was optimized to maintain low costs and reduced inventories. While lower inventories may be viewed as an efficient business practice when orders are steady, they make supply chains fragile and brittle in times of crisis. To prevent modern supply chains from snapping, redundancy rather than reshoring is recommended to bolster the robustness and resiliency of supply chains (O'Leary, 2020; O'Neil, 2020).

In the context of the COVID-19 pandemic, what do resilient supply chains look like? The search for resiliency encourages MNE lead firms to diversify their supply chains in multiple ways in order to retain scale economies, reasonable costs, and innovation opportunities. Strategic options could include the following measures: (1) bolster capacity in the home country to address security concerns for products deemed essential¹⁷; (2) expand the number of international production sites to avoid overreliance or dependence on one or two locations¹⁸; (3) seek large and growing end markets that can be served from an international production network¹⁹; and (4) nurture production, research and marketing partnerships with firms in related industries.²⁰

While policy interventions during a crisis seek short-run solutions, what is the enduring legacy of the COVID-19 crisis likely to be? Domestic production for many PPE products will surely increase, but it is not clear which PPE products or components will be prioritized. Nor do we know what

proportion of total supply of PPE items will come from local production versus imports. While off-shore production will continue to be a significant feature for the PPE sector, regional supply chains (or near-sourcing), along with other preferred suppliers, will be an important mechanism for diversifying risk in the future.

China in particular remains a critical strategic actor within the PPE supply chain, not merely as a source of relatively low-cost exports but even more importantly because China's healthcare market is the second largest in the world, estimated at over \$1 trillion in 2020 (Huang, 2019). U.S. medical products companies will view the China market as critical to their long-term international competitiveness.

Two additional considerations are relevant in considering post-COVID-19 scenarios for medical supplies. First, regulatory policies are crucial for all healthcare supply chains, both in the home market (such as the legal liability concern over N95 masks) and also in the transparency of international supply chains, where informal subcontracting has often compromised quality and lowered confidence in these arrangements. However, GVC studies highlight that regulations for the same products can vary in their stringency or levels of enforcement in large developing economies such as China, which could promote or hinder upgrading among GVC suppliers (Kaplinsky, Terheggen & Tijaja, 2010).

Second, contingency plans for future crises will be essential. "Black swan" events are increasingly likely, but their specific features remain unknown (Avishai, 2020). Thus, we need to incorporate a broader systemic and strategic perspective based on the principles of robust and resilient supply chains that combine the virtues of global reach and local responsiveness. For example, South Korea's exemplary performance in limiting the spread of the novel coronavirus in 2020 relied on a network of public-private partnerships that had been set up following the country's difficulties in dealing effectively with the MERS (Middle East Respiratory Syndrome) outbreak in 2015, the largest outside the Middle East, which involved 185 laboratory-confirmed cases and 38 deaths²¹ (see comment by U.S. CDC Director Robert R. Redfield, *Frontline*, 2020).

Overall, COVID-19 has revealed a great deal about the inadequacy of current policies and global supply chains to respond to the public health and economic crises unleashed by the pandemic.

However, we need to distinguish between actions in the midst of the pandemic itself, and sustainable policies and practices in the post-crisis era. Globalization in its expansionary phase in the latter decades of the twentieth century and first decade of the current century has run its course. Recent disruptions including the global economic recession of 2008–2009, the digital revolution (UNCTAD, 2017), the waves of economic nationalism and populism since 2016, and the COVID-19 pandemic in 2020 all portend a more fragmented, multipolar, and regionally oriented international system. While significant forms of reglobalization are likely to be the most constructive and sustainable responses in the post-crisis era, de-globalization is not a viable long-term vision for the future.

NOTES

¹Statistics as of July 11, 2020 – <https://www.worldometers.info/coronavirus/worldwide-graphs/>.

²World trade volumes in 2020 are expected to fall by as much as 32% (World Trade Organization estimate), global gross domestic product (GDP) will shrink by – 4.2%, a difference of 7 percentage points compared to pre-crisis expectations (International Monetary Fund estimate), and unemployment rates are skyrocketing to unprecedented levels, with working hours decreasing by around 12% in the hardest hit regions, such as the Americas, Europe and Central Asia (UNIDO, 2020).

³The U.S. Congressional Budget Office has projected new deficits of about \$5.8 trillion for 2020 and 2021, with total debt reaching 108% of GDP by the end of the latter year (Samuelson, 2020).

⁴This is typically measured in terms of value added in country input–output tables. On company balance sheets, value could be linked to profitability of specific goods or services, or, from a labor perspective, this can be reflected in relative wages or skill levels associated with different tasks or activities along the value chain (Sturgeon, 2019; Havice & Pickles, 2019).

⁵See detailed GVC case studies of the role of MNE subsidiaries in the export-oriented medical devices sector in Costa Rica (Gereffi, Frederick & Bamber, 2019) and Ireland (Ryan, Buciuini, Andersson, & Giblin, 2020).

⁶Quality control problems in the PPE segment have been reported in China due to subcontracting from unauthorized or unregistered factories that

ship goods that are contaminated (not sterilized) or of 'unsuitable' quality, and thus cannot be used by the client (Lapook, 2020; McGarry, 2020).

⁷In the introductory editorial for a special issue of *Global Strategy Journal* on "Global Value Chains, Governance and Globalization Strategies," Pananond, Gereffi, & Pedersen (2020) propose a new integrative typology that links the literature on global strategy (both lead-firm and supplier-centric variants) and GVC governance (intra-MNE and extra-MNE networks) in terms of four main themes: managed cross-border activities, network optimization, bottom-up upgrading, and strategic coevolution.

⁸The discussion of COVID-19-related medical products in this section does not include pharmaceuticals or vaccines.

⁹Once used, the outer layer of masks can become covered with germs, and humidity from the mouth alters their filtering properties. Thus, masks are considered effective for only a few hours (four hours for surgical masks and up to one day for N95 respirators).

¹⁰Before the COVID-19 crisis, a box of 100 surgical masks could be bought for less than \$4.00 (all figures in U.S. dollars) in the U.S., while, in late February, single masks were reportedly sold for as high as \$20. Similarly, the price of a box of 20 N95 respirator masks increased from \$17 to \$70 between end-January and end-February, 2020 (OECD, 2020a: 3).

¹¹The fibers are also electrically charged to increase their effectiveness (electret treatment).

¹²An inner layer in contact with the mouth absorbs moisture, the filter layer is made of melt-blown electret non-woven material, and an outer layer protects against liquid splashes.

¹³After top CDC official Dr. Nancy Messonnier issued her dire prediction that it was not a matter of if, but when, U.S. lives would be disrupted by the rapidly advancing pandemic, and the U.S. stock market plummeted by 1,000 points, Trump cancelled a key meeting scheduled for February 26 with his core team of public health advisors. Secretary Azar was removed as head of the White House Coronavirus Task Force and replaced by Vice President Mike Pence (Frontline, 2020).

¹⁴Some of 3M's expanded U.S. production capacity for N95 respirators was carried out in

partnership with other U.S. firms, such as Ford Motor Company and Cummins Corporation (3M, 2020a).

¹⁵Information as of July 11, 2020, downloaded from <https://www.google.com/search?q=confirmed+cases+of+coronavirus+in+usa&oq=confirmed+cases+of+coronavirus+in+US&aqs=chrome.0.0j69i57j0l4.19218j1j7&sourceid=chrome&ie=UTF-8>.

¹⁶A 2007 presentation by one of the U.S. agencies purchasing material for the Strategic National Stockpile estimated that, in the event of a pandemic, the U.S. would need 5.3 billion N95 respirator masks, 50 times more than the number in the stockpile (Davis, 2020).

¹⁷The GVC approach highlights the need to question whether the final products themselves, or the key components or inputs in final products (such as the non-woven filters in N95 masks or the active ingredients in pharmaceutical products), should receive priority as "essential" items in discussions of reshoring (Huang, 2020; McKenna, 2020; Mullin, 2020).

¹⁸Offshore production networks have different geographies. Nearshoring, or the regionalization of supply chains, is often considered to have security advantages compared to optimized supply chains in distant locations (Shih, 2020).

¹⁹In the medical supplies industry, most of the MNEs have production locations in China because of its large domestic demand as well as its low production costs (Bamber, Fernandez-Stark, & Taglioni, 2020; Huang, 2019). Other large economies like India and Mexico can have similar double advantages as both supply base and market.

²⁰In the case of ventilators, which is a more technology-intensive item than face masks, many firm-to-firm partnerships have emerged during COVID-19. For example, Virgin Orbit, an aerospace technology firm, developed a simple way to "mechanize" normal ventilators with an easily produced pump; UK vacuum supplier, Dyson, designed a brand-new ventilator in just 10 days to supply the UK's National Health Service, with motors made in Singapore; and the Mercedes-Benz Formula 1 team partnered with University College London for mass-produced ventilators using an open-source design (Bamber, Fernandez-Stark, & Taglioni, 2020).

²¹See <https://www.who.int/westernpacific/emergencies/2015-mers-outbreak>.



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