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COVID-19 and its Impact on Global Value Chains:

The Case of the Medical Devices Sector and the Fight against Global Epidemics

Lilac Nachum, Baruch College, City University New York[1]

Global value chains (GVCs) are challenged by COVID-19 and the pandemic it provoked in unprecedented ways around the globe.[2] These challenges are probably nowhere more apparent than in GVCs producing medical devices[3], specifically equipment related to the treatment of infected patients and the prevention of the spread of the virus. These devices are at the forefront of the fight to eradicate the virus and minimize its deleterious ramifications. Not only do they hold the key for the recovery; they will also shape the way by which the new normal of the post-crisis world evolves. Furthermore, in the face of plummeting demand and slowdown across industries, the medical device sector offers an area of growth and vitality and may lead the economic recovery from the crisis. The shape of the supply chains that provide these essential products and their geographic scope will be at the center of these developments, and the policymakers that oversee these supply chains will play major roles in determining these outcomes.

Indeed, the future supply of medical devices needed to fight the epidemic has been the subject of major political deliberations around the world since the outbreak of the epidemic, and significant changes in the global organization of the medical device GVCs are already notable. The initial steps embraced by most governments have demonstrated inclination towards self-sufficiency and attempts to increase local production capacity. The Strengthening America's Supply Chain and National Security Act, which received wide political support, was designed towards this end. The EU call for repatriation of production from China back to Europe, and for safeguarding the production of essential products from the risk inherent in GVCs, offers another example of such attempts.[4] WTO/UN International Trade Center data show that trade restrictions related to the COVID-19 pandemic have been spreading around the world, and a variety of policy instruments have been applied towards both exports and imports.[5] Unlike most other trade policy measures, these policies have been introduced almost exclusively on a unilateral basis, and were directed towards all countries.

[1] This paper originated from a research project for UNIDO Industrial Analytics Platform. UNIDO support of the original piece is gratefully acknowledged.
[2] See, e.g., https://iap.unido.org/articles/managing-covid-19-how-pandemic-disrupts-global-value-chains; see also analyses of shipping data by S&P Market Intelligence Division that offer an instantaneous indication of economic activities: https://www.spglobal.com/marketintelligence/en/news-insights/research/quantamental-research-brief-cold-turkey-navigating-guidance-withdrawal-with-supply-chain-data.
[3] The medical device sector includes diagnostic and therapeutic equipment used for medical purposes and treatment of disease (with subtle differences across regulatory authorities in different countries regarding the exact definitions). The global medical devices market size was valued at USD 425.5 billion in 2018 and is expected to reach USD 612.7 billion by 2025, according to Fortune Business Insight: https://www.fortunebusinessinsights.com/industry-reports/medical-devices-market-100085.
[4] https://cen.acs.org/business/outsourcing/COVID-19-reshaping-pharmaceutical-supply/98/i16
[5] https://www.macmap.org/covid19

These policies were justified by the urgent need to control the spread of the virus and reduce its devastating consequences, but it is not clear that they serve the best interests of countries and the world. Two major issues appear to undermine their effectiveness in securing sufficient and timely supply under the best economic terms. One is that they do not seem to account for the distinctive nature of the medical device sector. The other is that they have been applied to all products in this vast and diverse category, with minimal differentiation.

In this article, I seek to advance the debate regarding the policy response to medical device GVCs by addressing these two issues. I begin by discussing the distinctive nature of medical device GVCs compared to other GVCs and articulate the unique forces that drive the economic rationale for their existence. I show that these vary a great deal from the drivers of GVCs in other industries, and manifest particularly strongly during times of global epidemics. I continue by developing a framework for policy responses towards different medical device GVCs, taking account of the heterogeneity of this sector. Based on the trade-off between the benefits of production and trade cost differences and the imperative of security and speed of response, the framework advances a differentiated policy approach towards different types of medical device products, and offers a road map for policymakers, as they design their policies towards this sector. Below I develop these ideas in detail.

The Fundamentals of GVCs and the Case of Medical Device GVCs

The rationale for GVCs rests on a combination of two economic forces, related to the production (differences in comparative advantage and production costs) and the delivery (trade cost, broadly defined to include the costs of transport and those of crossing borders). Countries' variations in the former create economic benefits for the spread of value-creating activities across them, and lower costs of the latter enable to connect diverse production locations and geographically dispersed markets at low cost. Producing firms are thus driven to move facilities to low-wage countries that offer production for much reduced costs than feasible elsewhere. Technological development, coupled with liberalization of markets, make it economically feasible for these firms to organize production on a global level and link separate parts of production via trade. These two forces gave rise to the emergence of GVCs as the predominant mode of organizing production.[6]

Examination of trade data of medical devices prior to the onset of the virus suggests that GVCs in this sector were largely based on these broad principles. **Table 1** lists the top 10 importing and exporting countries for several categories of medical devices related to the fight against pandemics.

A note of caution regarding the interpretation of the data appears in order. For one thing, classifications of multiple products into broad categories is subject to distortions, even at the most disaggregated level, as a single category may include products that vary in terms of the characteristics I sought to highlight in the classification. Often a single product group combines products and components with different characteristics. For instance, the standard face masks of the type that the general public wears, a lower-tech product, and face

[6] For reviews of these dynamics, see UNIDO. 2015. Global Value Chains and Development. UNIDO, Vienna; Baldwin R. E. 2016. *The Great Convergence: Information Technology and the New Globalization.* Harvard University Press, Cambridge, Mass.; Milberg W. and Winkler D. 2013. *Outsourcing Economics: Global Value Chains in Capitalist Development.* Cambridge University Press, Cambridge, UK.

Table 1. GVCs in Medical Device Categories, Trade Flow Worldwide, 2018

IMPORTS				
	Medical Supplies	**Anti-epidemic Goods**	**Medicines**	**Medical Equipment**
Product categories (HS #)	Immunological products (300); Photographic and articles (35-38, 392); Protective garments, gloves, face masks (401-650); Laboratory equipment/ materials (701, 841-902)	Sanitizers and disinfectants (220-390); Raw material for masks (391-761) equipment/materials (701, 841-902)	Medicaments not for retail sale (3003); Medicaments for retail sale (3004)	Diagnostic or laboratory reference materials (382, 841-847); Apparatus used in medical and surgical sciences (901); Apparatus based on the use of radiations (902, 903-940)
1	United States	United States	United States	United States
2	Germany	Germany	Germany	China
3	Belgium-Luxembourg	China	Belgium-Luxembourg	Germany
4	Switzerland	France	United Kingdom	Netherlands
5	Italy	United Kingdom	Switzerland	Japan
6	Netherlands	Netherlands	Italy	France
7	Japan	Mexico	China	United Kingdom
8	France	Japan	France	Belgium-Luxembourg
9	United Kingdom	Italy	Japan	Italy
10	China	Belgium-Luxembourg	Netherlands	Mexico

EXPORTS				
	Medical Supplies	**Anti-epidemic Goods**	**Medicines**	**Medical Equipment**
1	Germany	China	Germany	United States
2	United States	Germany	Switzerland	Germany
3	Switzerland	United States	Ireland	China
4	Ireland	Italy	United States	Japan
5	Netherlands	France	France	Mexico
6	China	Japan	Italy	Netherlands
7	Belgium-Luxembourg	Belgium-Luxembourg	United Kingdom	Ireland
8	Italy	Netherlands	Belgium-Luxembourg	United Kingdom
9	Korea, Rep.	Korea, Rep.	Netherlands	Korea, Rep.
10	United Kingdom	Saudi Arabia	India	Italy

http://www.cepii.fr/CEPII/en/bdd_modele/presentation.asp?id=37, HS12_BACI
The analysis is based on CEPII data, which provide disaggregated data on bilateral trade flows for more than 5,000 products and 200 countries. The database is built from country data reported to the United Nations Statistical Division (Comtrade). Products are defined as items from the Harmonized System nomenclature, at the 6-digit level. For the sake of parsimony, we aggregate the 6-digit categories into fewer broader ones.

masks used by healthcare workers in intensive care units that require more sophisticated devices with a higher technology content are in the same category. Thus, while the latter are produced predominantly in China, they employ sophisticated filters imported from Denmark. Furthermore, trade data combine intra- and inter-firm trade, challenging the ability to associate trade flows with country of origin. For instance, substantial parts of US imports consist of exports by US companies producing overseas and shipping their output to be sold in the US. With these reservations in mind, the data give some suggestive indication of trends and directions.

Pandemics and the (Changing) Fundamentals of Medical Device GVCs

The spread of the virus and the pandemic that ensued challenged the logic that underlay the structure of medical device GVCs in the pre-pandemic era. The global nature of the pandemic entails that demand sprung up around the world, determined by variations in the spread of the virus among countries – as they relate to differences in the policy approaches adopted, the life cycle of the virus, and possibly variations in immunity to the virus.[7] These have come to replace demand characteristics originating in taste, preferences, and wealth that predominated in other times. Furthermore, price elasticity, a major determinant of the structure of most GVCs, is much lower in relation to the medical device GVC, notably during pandemics, where human lives are at stake and the availability of substitutions might be limited, notably for certain types of medical devices.

Furthermore, rather than country differences in costs, skills, and resource availability that determine the allocation of value-added activities in GVCs, stage of the epidemic's life cycle in a country had become a major determinant of production capacity for exports. For instance, by the time COVID-19 hit the US and Europe in earnest, China had started to show signs of recovery that reduced local demand and freed supply for exports. Being ahead of the life cycle of the virus created abundant supply at the time the rest of the world had vast demand for medical equipment, and spurred exports of medical devices from China.[8] In a similar fashion, the adoption of different policy responses and safety standards towards the virus resulted in substantial variations in the speed with which countries have been able to control its spread. This, too, led to time-related variations across countries in terms of demand and supply. For instance, after imposing strict restrictions on exports of personal protective equipment (PPE) outside the European Economic Area in March, the EU was able to modify them in April as the virus receded, and terminated them altogether by the end of May.[9]

The second way by which pandemics challenge GVCs for medical devices is by changing their logistics, that is, the ability to move intermediaries and final products around the world quickly and cheaply. Fragmented sources of supplies connected to each other via trade linkages were abruptly interrupted by production difficulties as factories confronted irregularities of labor and supply, port closures, and customs slowdown. In their attempts to arrest the spread of the virus to their countries, governments have accentuated

[7] Country differences in immunity have been documented extensively across different types of disease in the work of the World Health Organization, notably the Global Burden of Disease Project: http://www.healthdata.org/gbd. Such variations were apparent also in earlier epidemics, for instance Ebola and AIDS, which were spread unevenly around the world.

[8] China has been a major exporter of many medical device products long before the virus erupted, and leading Western companies either outsourced from China or else have had their own production facilities in this country. Philips, for instance, has six manufacturing locations in China for its medical equipment, including ventilators. However, during the abrupt spread of the virus in China all production capacity was directed locally to meet local demand.

[9] https://www.macmap.org/covid19

these logistics challenges and enacted severe entry restrictions. These have further slowed down the pace of moving products, services, and people across countries. Travel bans imposed by countries around the world on people coming from highly infected countries are cases in point. Regulatory interventions were particularly apparent in relation to medical devices, given their centrality in the fight against the virus. More than 50 governments have restricted exports of medical supplies, 33 of them since early March.[10]

In parallel, epidemics increase the importance of speed to market, making geographic proximity between production and markets more important than ever, as the current epidemic has vividly and tragically demonstrated. Speed to market has become an important competitive factor in many GVCs since long before the arrival of COVID-19, but with the numbers of infected people growing exponentially by day, speed to market became a matter of saving the lives of thousands of patients dying every day for shortage of life-saving equipment.

To conclude, these changes in the logic underlying GVCs modified the nature of comparative advantage as the guiding principle of the structure of GVCs, particularly in the medical devices sector. Factors such as costs, skills, and natural resources are replaced by a mere supply capacity, which is determined in large part by stage in the life cycle of the disease. The importance of geographic proximity, which affects speed to market, as well as trade agreements that determine the cost and speed of crossing borders, has also been magnified. **Table 2** presents a summary of the major determinants of the structure of GVCs and highlights the distinctiveness of medical device GVCs compared to other GVCs.

Table 2. Determinants of the Structure of GVCs: Medical Device GVCs versus GVCs in Other Sectors[a]

		Medical Device GVCs	Other GVCs
COMPARATIVE ADVANTAGE			
	Cost differential	low	high
	Skills differential	high/moderate	high
	Resource differential	high	high
	Product life cycle	critical	low/moderate
TRADE COSTS			
	Transportation costs	low/moderate	high/critical
	Transportation speed	critical	high/moderate
	Proximity to markets	high/critical	moderate
	Trade barriers	high	low
	Regulatory restrictions	high	low

[a]Both categories involve large and heterogeneous GVCs, introducing vast variations within them. The characterization relates to generic attributes that cut across them and set them apart from each other. We return to this issue in the discussion below.

[10] https://www.economist.com/finance-and-economics/2020/03/26/if-you-thought-the-trade-war-was-bad-for-global-commerce

GVCs of Medical Devices Are Not All Alike

Having established the underlying characteristics of medical device GVCs in relation to other GVCs, I proceed to examine this sector more closely, as the idiosyncrasies of this sector **(Table 2)** manifest differently and to varying degrees across different types of medical devices. The medical device sector includes a vast range of products that differ considerably in terms of factor intensity, production technology, and resource requirements. Variations originate also in the specificity of equipment for particular types of epidemics, the venue of the spread (e.g., Ebola versus COVID-19), cost of transportation, and the economics of inventory. These are affected differently by the idiosyncrasies of the sector as a whole.

These variations significantly affect the rationale for GVCs and the trade-off between global integration and local production, calling for a differentiated policy approach towards different product categories within this sector. Towards this end, we develop a framework that is based on the two characteristics that drive GVCs: country variations in production costs (comparative advantage) and costs of trade (including transportation costs and the costs of crossing borders). In the medical devices sector, the former issues refer to variations in factor intensity, as products included in this sector range from lower-tech PPE equipment, bandages, and temperature measures to patented drugs, immunological products, and the most sophisticated diagnostic equipment. A palpable manifestation of these differences is apparent in vast patent variations within the sector.[11]

Variations that originate in trade costs include shipping costs, measured as proportion of the value of what is being shipped, and vary by products' weight, size, fragility, and the like. Others originate in trade restrictions, including those that are not specific to the COVID-19 epidemic, with some products subject to higher levels of import (and at times, export) duties, originating in, for example, the desire to protect local producers. Variations originate also in regulatory and certification demands. Most countries in the world apply special regulatory scrutiny to the medical devices sector. While varying in the detail across countries, all regulatory authorities distinguish among different classes of medical devices based on their potential for harm if misused, design complexity, and the like, and set up levels of scrutiny accordingly.[121] ISO, which establishes international standards regarding quality and risk management as the basis for regulatory compliance in local and export markets, likewise distinguishes among different categories of medical devices.[13] Further variations across medical devices relate to intellectual property content and sensitivity to intellectual property rights (IPR) violations.

[11] http://www.samed.org.za/DynamicData/LibraryDownloads/56.pdf
[12] See the US classification as an example: https://www.fda.gov/about-fda/cdrh-transparency/overview-medical-device-classification-and-reclassification.
[13] https://www.iso.org/iso-13485-medical-devices.html

Policy Implications

Using the broad classifications we outlined above, I develop a framework that classifies medical devices based on the potential gains of specialization and comparative advantage and the cost of trade, as these manifest in relation to medical devices discussed above **(Table 2).** The Figure is underlain by the assumption that different types of combinations of these potential benefits call for different arrangements of the production and require corresponding policy response **(Figure 1)**.

Figure 1. Policy Response toward Medical Device Production

		COUNTRY VARIATIONS IN PRODUCTION COST	
		Low	**High**
Trading Costs	**High**	**1** **Local production** [Medical devices, sophisticated diagnostic equipment, e.g. magnetic resonance imaging devices]	**2** **Regional GVCs** [Ventilators]
	Low	**3** **Location production + selective GVCs** [Medicaments]	**4** **Globally integrated GVCs** [PPE]

Thus, it appears as if GVCs offer limited, if any, advantages for medical device products in cell 1, particularly those rich in intellectual property content and subject to the costs of possible IPR violations, such as patented drugs and sophisticated diagnostic equipment. Such products are better produced locally, and inventory can be employed to safeguard against shortages caused by unexpected spike in demand. Cell-2 products are subject to trade-off between the potential benefits of cost and skill variations across countries and high costs of trade. Regional GVCs, whereby the production is spread across countries located in geographic proximity, as well as more remote ones geographically that are linked by trade agreements that reduce the cost of border crossing and regulatory hazards, appear to be most suitable for such products. Products in cell 3 appear appropriate for some combination of local production and selective use of GVCs, predominantly to secure supply in case of unexpected shortages. Low variations in production costs might favor production of these products in more advanced countries. Cell 4 represents what is perhaps the most typical case for globally integrated GVCs, whereby the production is separated across emerging and developing countries and outputs are shipped to markets at low cost.

Concluding Remarks

In this article, I identified changes caused by the global epidemic to the way production of medical devices is organized across countries, and I suggested that these do not undermine the fundamental rationale that had given rise to GVCs in this sector before the outbreak of the pandemics **(Table 1)**. To an extent, the idiosyncrasies of medical devices **(Table 2),** notably the dynamics of global epidemics as they shaped cyclical demand that sprung up at different times in different countries, and the stronger-than-usual imperative of speed to market accentuate the advantages of GVCs in enabling countries to pull capabilities from around the world and respond rapidly to changing situations. Under these circumstances, the case for open, global trade is stronger than elsewhere.

However, I suggested that the rationale for openness and global integration exhibits itself in different ways and to varying degrees across medical device product categories, calling for differentiated policy responses towards different categories. I showed that the drivers of GVCs are of varying value and that these drivers favor different forms of production arrangements, which call for corresponding policy responses **(Figure 1)**.

The merits of the nuanced policy approach that underlies this framework extend beyond the medical device sector. The underlying principle that the trade-off between the benefits of global integration and local production for self-sufficiency varies across product categories has broad validity. It is perhaps particularly valid in sectors and industries that share (some of) the distinctive attributes of medical devices, notably those with unexpected and often unpredicted spikes of demand that must be fulfilled urgently. The defense sector is a case in point. The nuanced policy approach that I advance is particularly timely in the contemporary era, given growing resentment towards globalization in many parts of the world and increasing political pressure to keep investment and jobs at home. It offers tools for thinking about those issues in relation to different product categories rather than adopting identical policy response across all products and sectors.

A study estimated that re-nationalization of GVCs does not make countries more resilient to epidemic-induced contractions. The average GDP drop would have been slightly higher in a world without trade in inputs and final goods.[14] Inadequate policies towards medical device GVCs will not only result in sacrificing global efficiencies and raising prices, as they do in most other GVCs; they will cost many lives. The stakes are thus particularly high in relation to this sector.

[14] Bonadio, B., Huo, Z., Levchenko, A.A., and Pandalai-Nayar, N. Global Supply Chains in the Pandemic. NBER Working Paper No. 27224, 2020.

Weissman Center for International Business, Director:
Terrence F. Martell, Ph.D.
Saxe Distinguished Professor of Finance

Project Editor:
Lene Skou
Weissman Center Deputy Director

Design and Layout:
Rachael Cronin

For more information about this report contact the

Weissman Center for International Business

Zicklin School of Business, Baruch College/CUNY

(lene.skou@baruch.cuny.edu)

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