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Access to Medical Equipment in a Pandemic Situation: Importance of Localized Supply Chains and 3D Printing

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The response to the COVID-19 crisis highlighted the weaknesses of the free trade system and failures of the traditional supply chains. Public health preparedness for future pandemics demands nation-states to increase their local production of medical supplies in order to reduce their dependence on third countries. Globally connected local production, enabled by digital fabrication tools, is arguably the best policy response to collaboratively address supply-chain vulnerabilities. 3D printing technology, which is the most prominent manifestation of digital fabrication ecosystems, can play a key role in enhancing the local production capacity in a time- and cost-efficient manner. This paper calls for an increased focus on local production and proposes a more systematic use of 3D printing capabilities to address shortages of critical medical equipment in a health emergency.

Importance of Localized Supply Chains in a Health Emergency

Free trade, a policy of minimizing restrictions on imports or exports, lies at the heart of the 21st century global trading system. The World Trade Organization (WTO) came with the promise of rules-based free trade. The key objectives of establishing the WTO include the "optimal use of the world's resources" and the promotion of multilateral trade liberalization through "reduction of tariffs and other barriers to trade".[1] Global cooperation is the essence of multilateralism.

The response to COVID-19 was, however, marked by trade restrictions and protectionism. In many cases, nation-states responded to the crisis individually, not collectively. When demand outstripped the supply of personal protective equipment (PPE) and other medical supplies, countries placed their focus on protecting their own nationals' health without considering the humanitarian needs of other nations.[2] Many countries chose to restrict exports of medical goods

[1] World Trade Organization, "Agreement Establishing the World Trade Organization".
[2] Christopher Stothers and Alexandra Morgan, "IP and the Supply of COVID-19-Related Drugs", *Journal of Intellectual Property Law & Practice* Vol. 15, No. 8 (August 2020), pp. 590-593.

- like testing kits, PPE, respirators and ventilators - to secure them for national use.[3] The U.S. purchased all supplies of Remdesivir, a drug that offered hope against COVID-19, making the rest of the world wait for months.[4] Richer countries were reported to have offered a higher market price to private manufacturers for testing equipment and facial masks. Poorer countries, with already fragile economies and health systems, were given wait times because supplies spanning months of production had been pre-purchased by countries having more purchasing power.[5] This approach seriously undermined trust in the WTO as the global institution failed to assert its leadership role.

Moreover, there can be natural or practical hurdles to free trade during an emergency. Even when the needed resources are available overseas, they may not be delivered on time – especially to geographically remote countries - because of closed borders and transport restrictions. To curb the spread of COVID-19, more than 7 million flights were cancelled worldwide. Even several cargo flights were cancelled which adversely impacted the delivery of much-needed medical equipment.[6] Supplies of urgently needed medical equipment can be potentially disrupted by natural disasters like an eruption of volcanos, earthquakes, floods, and hurricanes.[7] It is estimated that about half of the world's face masks are manufactured in China.[8] One can imagine the costs, delivery times, and vulnerabilities of long-distance shipping to far-off countries.

COVID-19 is neither the world's first pandemic nor the last. The challenges to free trade will re-emerge whenever demand will outstrip supply in a future health emergency. Public health preparedness for future pandemics demands well-thought-out policy measures. Nation-states need to increase their local production of medical supplies in order to reduce their dependence on third countries. There is an urgent need for localization of key lines of production even if those controlling the existing global framework try to maintain the status quo despite obvious failures of the WTO-led multilateral trading system.

Potential Role of 3D Printing

The three-dimensional (3D) printing technology brings new possibilities to promote agility in dealing with health emergencies. This unique manufacturing method allows the rapid conversion of information from digital 3D models into physical objects. 3D Printing technology is perfect for localized manufacturing and problem-solving innovation in a crisis situation. Joel Cutcher-Gershenfeld and others rightly noted, "(a)t a time when global supply chains and large-scale manufacturing are being revealed as fragile and vulnerable, the role played by digital

[3] Organisation for Economic Co-operation and Development (OECD), "COVID-19 and International Trade: Issues and Actions" (2020). Available from https://read.oecd-ilibrary.org/view/?ref=128_128542-3ijg8kfswh&title=COVID-19-and-international-trade-issues-and-actions.
[4] Thomas J. Bollyky and Chad P. Bown, "The Tragedy of Vaccine Nationalism: Only Cooperation Can End the Pandemic", *Foreign Affairs* Vol. 99, No. 5 (September/October 2020). Available from https://www.foreignaffairs.com/articles/united-states/2020-07-27/vaccine-nationalism-pandemic?utm_medium=social.
[5] "Fair and Equitable Access to COVID-19 Treatments and Vaccines", Nuffield Council on Bioethics Policy Briefing (2020).
[6] Aamer Nazir *et al.*, "The Rise of 3D Printing Entangled with Smart Computer Aided Design during COVID-19 Era", *Journal of Manufacturing Systems* (2020). Available from https://doi.org/10.1016/j.jmsy.2020.10.009.
[7] Mika Salmi *et al.*, "3D Printing in COVID-19: Productivity Estimation of the Most Promising Open Source Solutions in Emergency Situations", *Applied Sciences* Vol. 10, No. 11 (2020).
[8] Mostapha Tarfaoui *et al.*, "3D Printing to Support the Shortage in Personal Protective Equipment Caused by COVID-19 Pandemic", *Materials.* Available from http://www.mdpi.com/journal/materials.

fabrication technologies and local ecosystems gives us a glimpse into a future in which new forms of self-sufficient production can empower communities all across the world".[9]

This disruptive technology is less affected by the ground realities of an emergency as it allows virtual data shipping instead of physical part shipping.[10] Digital files can be swiftly and economically shared over the Internet. Low-cost 3D printers, which serve as mini-factories in a box, make it possible to convert these electronic files into ready-to-use physical goods. Governments need to support decentralization of manufacturing capabilities and equip hospitals and medical centres with their own in-house 3D printing capabilities to break their dependence on global supply chains and to de-risk shortages of materials in a health emergency.

3D printing makes it possible to produce medical equipment on the spot or closer to the point of use.[11] This disruptive technology enables "products designed, customized, and produced by the individuals and communities for themselves instead of mass-produced and mass-distributed products".[12] For instance, in March 2020, because of the COVID-19 health emergency, the stock of venturi valves[13] at a local hospital in northern Italy was diminishing quickly given the unprecedented demand for ventilators to treat COVID-19 patients.[14] The manufacturing company could not supply valves because of limited manufacturing capacity coupled with supply-chain disruptions. Two public-spirited gentlemen, Cristian Fracassi and Alessandro Romaioli, tried to reverse-engineer the ventilator valve in order to combat critical shortages. Within 3 hours of studying the valve, they were able to create a valve prototype.[15] The duo used a desktop 3D printer to fabricate these replacement valves.[16] In less than 24 hours, they were able to supply valves for more than 100 ventilators to a local hospital of the town Chiari in the Province of Brescia.[17]

3D printing has a unique role in expanding the scale of production and scope of inventive activity by empowering the participation of common citizens. Fabrication using 3D printing requires the user to understand the basic details of digital designing and the basic mechanisms of 3D printing methods, 3D printers and printing materials.[18] Without needing the specialized skills, prior knowledge, or equipment traditionally needed to create professional designs, anyone familiar with 3D modelling can create digital designs from the comfort of their desktop. As noted

[9] Joel Cutcher-Gershenfeld *et al.*, "The Promise of Self-Sufficient Production", *MIT Sloan Management Review* Vol. 62, No. 2 (2021).
[10] Nari Lee, "Intellectual Property and Open Innovation in 3D Printing: A Different Form of Exclusivity", in *The Innovation Society and Intellectual Property,* Josef Drexl, Anselm Kamperman Sanders, eds. (Edward Elgar Publishing, 2019).
[11] Jim Romeo, "3D Printing Emerges as Valuable Technology to Produce Face Masks in Time of COVID-19 Pandemic", GrabCAD Blog, 1 April 2020.
[12] Cutcher-Gershenfeld *et al.*, "The Promise of Self-Sufficient Production", p. 70.
[13] A venturi valve is one of the key components of a ventilator, which is required to connect the patient's face mask to breathing machines to deliver oxygen at a variable concentration. See Aamer Nazir *et al*., "The rise of 3D Printing entangled with smart computer aided design during COVID-19 era".
[14] Dana Mahr, and Sascha Dickel, "Rethinking intellectual property rights and commons-based peer production in times of crisis: The case of COVID-19 and 3D printed medical devices", *Journal of Intellectual Property Law &* Practice Vol. 15, No. 9 (September 2020), pp. 711-717.
[15] Bankole I. Oladapo *et al*., "Review on 3D printing: Fight against COVID-19", *Materials chemistry and physics* Vol. 258 (2021).
[16] Rance Tino *et al.*, "COVID-19 and the Role of 3D Printing in Medicine",*3D Printing in Medicine* Vol. 6, No. 11 (2020).
[17] Jorge L Contreras, "Research and Repair: Expanding Exceptions to Patent Infringement in Response to a Pandemic", *Journal of Law and the Biosciences* Vol. 7, No. 11 (January-June 2020).
[18] Megha Trivedi *et al.*, "Additive Manufacturing of Pharmaceuticals for Precision Medicine Applications: A Review of the Promises and Perils in Implementation", *Additive Manufacturing* Vol. 23 (2018), pp. 319-328. Available from https://doi.org/10.1016/j.addma.2018.07.004.

by a commentator, the 3D printing *"maker movement is remarkable not because these things didn't previously exist, but because these things are now accessible to 'average people' who didn't go to art school, or trade schools, or engineering schools. The 'democratizing' component here is that previously most people needed to go through one of these channels to have access to and training on tools and technology".*[19]

3D printing makes it possible for the concerned community members to make practical contributions on humanitarian grounds. For instance, in Canada, a 12-year-old Boy Scout, named Quinn Callander, came up with the idea of 3D printed tension relief mask adjusters or ear guards to make face masks more comfortable to wear.[20] This is a simple but valuable contribution because wearing one-size-fits-all face masks for longer periods can cause chafing and even bruises.[21] Quinn 3D printed hundreds of mask adjusters and donated them to various hospitals.[22] The digital design of the mask adjuster is available in the public domain so that anyone with a 3D printer can feel free to print the design.[23]

3D printing offers the promise of delivering lifesaving products through globally connected local production, but only a minute percentage of the global population has access to digital fabrication equipment. Lack of 3D printing ecosystem in the low- and middle-income countries should be a concern. It can be noted with caution that individuals and communities from low- and middle-income countries barely contributed 3D printed materials in response to COVID-19. Lack of access to basic digital infrastructure in economically disadvantaged countries explains this geography gap. 4.2 billion people lack regular access to the Internet.[24] People at the lower end of the economic order are disadvantaged as "there are substantial disparities in the quality and reliability of computing and Internet access, with billions of people having mobile-only access, inconsistent connectivity, or tiered access, with the faster tiers being out of financial reach".[25] Billions of people in the resource-poor countries are excluded from digital fabrication because access to computing and the Internet is a basic requirement to connect with the 3D printing community.

The economic and digital divide between the high-income and low- and middle-income countries has been a longstanding issue. The United Nations Committee on Information stressed bridging the digital divide between industrialized and developing countries in May 2001.[26] Not as many concrete efforts have been made over the past two decades to address this issue. There is a need to bridge this divide if the world wants to be better prepared for a future pandemic. Digital literacy and digital infrastructure building in the developing world should be a priority. Governments in developing countries should be supported both financially and logistically to start digital inclusion programmes with a key focus on capacity-building for 3D

[19] Esther Fuldauer, "Makerspaces for economic development and social cohesion", *Tomorrow City,* 26 February 2019. Available from https://tomorrow.city/a/makerspaces-for-economic-development-and-social-cohesion-2.
[20] Jonny Evans, "3D printing signs up to fight COVID-19", *Computerworld*, 9 April 2020.
[21] "Ricoh 3D producing 40,000 face shields a week as part of COVID-19 response", *The Prince's Responsible Business Network,* 21 May 2020. Available from https://www.bitc.org.uk/case-study/ricoh-3d-producing-40000-face-shields-a-week-as-part-of-covid-19-response/.
[22] Quinn Wilson, "Local manufacturer uses 3D printing to provide 'relief' for medical workers", The Recorder, 28 April 2020.
[23] *Ibid.*
[24] Amy Nordrum, "3 Ways To Bridge The Digital Divide", *IEEE Spectrum*, 14 April 2016. Available from https://spectrum.ieee.org/tech-talk/computing/networks/3-ways-to-bridge-the-digital-divide.
[25] Neil Gershenfeld, Alan Gershenfeld and Joel Cutcher-Gershenfeld, *Designing Reality: How to Survive and Thrive in the Third Digital Revolution* (Basic Books, 2017).
[26] United Nations, "Bridging Digital Divide Between Industrialized and Developing Countries Stressed in Committee on Information Debate", 1 May 2001. Available from https://www.un.org/press/en/2001/pi1339.doc.htm.

printing. Such policy efforts - that ensure global equity, inclusion, and empowerment through access to modern technology - are critical to tapping a tremendous amount of human capital from every part of the world. As rightly noted by William Gibson, a famous speculative fiction author, "(t)he future is already here - it's just unevenly distributed".[27] His quote best applies to additive manufacturing because 3D printers are already here, but a vast majority of the global population is excluded from using them in an emergency for the common good of humanity.

Conclusion

The COVID-19 crisis highlighted free trade setbacks and significance of domestic self-sufficiency. When logistical constraints in a health emergency required increased coordination and cooperation amongst governments to tackle COVID-19, several responsible governments preferred nationalistic approaches over global collaboration and trade facilitation. The underlying values and principles of the WTO were overlooked. There is a need to improve transparency and certainty about policy actions related to medical supplies in order to restore confidence in the multilateral trading system. Global trade and cross-country collaborations are essential as some countries lack the capacity to produce their own medical supplies.

It is equally important to look for alternative options to address the failures of global markets. Governments need to make budget allocations to boost domestic production capacity to support localized supply chains of strategic goods. 3D printing technology is best suited to reduce the infrastructural cost of developing a viable local production capacity. Public policy decisions around 3D printing in the coming years should be aimed at making this technology available for public use. Localized manufacturing, empowered by 3D printing, should be allowed to co-evolve to complement traditional supply chains in a crisis situation. There is a need to bridge the digital divide between high-income and low- and middle-income countries to fully leverage the unique capabilities of 3D printing across the globe.

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[27] "Broadband Blues", *The Economist,* 23 June 2001. Available from https://www.economist.com/business/2001/06/21/broadband-blues.

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