LUISS

Department of Economics
and Finance

Course of International Economics

Global Value Chains and COVID-19 Vaccines Distribution in Developing Countries

Prof.ssa Cecilia Jona Lasinio

SUPERVISOR

Francesca Danieli
ID No. 242061

CANDIDATE

Academic Year 2021/2022

Table of Contents

Abstract

The research focuses on the distribution of the COVID-19 vaccines as a tool for the recovery from the global economic and sanitary crises generated by the outbreak of the virus. Global Value Chains (GVCs) and their correct functioning have found to play a critical role on this matter. The research will analyze how GVCs have been affected by the crisis and how they can be reshaped to allow an equitable distribution of COVID-19 vaccines. As will be illustrated in detail, trade barriers can have critical consequences on the functioning of GVCs and on the availability of vaccines in developing countries. Moreover, to increase the global supply of vaccines, which experienced a shortage especially at the beginning of the pandemic, the sharing of Intellectual Property Rights (IPRs) has found to be crucial. Finally, the research will analyze the policy implications of the latter and the initiatives proposed so far together with the successful case of South Africa, where the production of a local vaccine has been promoted.

Introduction

The outbreak of COVID-19 pandemic in March 2020, has caused, as of today, 6.2 billion deaths globally, and millions of people under intensive care. Moreover, many countries experienced a dramatic fell in GDP growth in 2020, the European Union reached a recession with a rate of -6%, and the United States with a rate of -3.4%. The pandemic has forced countries to impose lockdowns, so to keep closed commercial activities and tourism. In turn, this has led to the failure of many stores and activities. The level of employment suffered a deterioration, in 2020 the European Union experienced a fall of almost 10% in the employment rate together with the United States.
A glimmer of hope has been found in the anti-COVID-19 vaccine, which allowed countries to re-open, and tourism to restart.

The COVID-19 vaccine supply can be broken up into three main stages: drug substance and drug product formulation, fill and finish and distribution (manufacturing and delivery). The crucial issue of the analyzed supply chain pertains the availability of production inputs. Inputs are imported by a vast set of countries. Moreover, vaccine production is highly specialized, therefore subject to comparative advantage: not all countries are able to produce a particular component at the lowest opportunity cost, thus countries must engage in trade with one another to access the final and intermediate goods. Consequently, the production of vaccines is highly reliant on the correct functioning of Global Value Chains (GVCs). In turn, the latter depends on the presence of barriers to trade, which can seriously hamper this strictly interdependent network.

Global Value Chains are an effective tool to break down products' supply chain to allocate production of the various inputs where it is most efficient. During the COVID-19 pandemic the discussion on GVCs has been widely brought up due to the disruptions the crisis has led to. Thus, it is worth understanding first their functioning and then why the crisis caused malfunctioning in production and distribution chains causing serious concerns on the global sanitary and economic recovery. This research will focus mainly on the distribution of COVID-19 vaccines in developing countries.

Developing countries rely on high-income economies for accessing to vaccines, as the European Union is the main exporter and that is where the most part of production is located. The issue on this matter is not only that more manufacturing facilities are needed in developing countries but also that there should be a patent holder who is willing to share the vaccine's intellectual property rights (IPRs) for them to be able to take part in the production process exploiting their existent plants.

Beyond widening the gap between high- and low-income countries, these barriers limit the supply of vaccines generating an excess of demand that cannot be satisfied. The solution inevitably traces back to the concept of GVCs. The goal of this thesis is to analyze the COVID-19 vaccines supply chain to understand how these can be reshaped to provide an equitable distribution of vaccines. More specifically, the research focuses on the centralized production and the concentration of exports towards a limited part of the world, both of which arise from barriers to trade and the lack of sharing of IPRs.

Since the first vaccine administration, in December 2020, as of today, according to WTO, nearly 8 billion vaccine doses have been administrated, and almost 64% of the world population has received at least one shot. Although, breaking down the data by country income groups, less than 14% of people in low-income countries have received at least one shot, despite the ACT- accelerator (Access to COVID-19 Tools Accelerator) and COVAX initiatives[1].
Thus, the pandemic seems to have broken the world up even more, emphasizing the inequality between developed and developing countries: those who have the vaccines and those who don't.
Making vaccines more accessible is crucial to contain the pandemic and to sustain economic recovery worldwide.

Furthermore, in the early stages of the vaccine development, high income countries' governments reserved and purchased large part of the expected early supply and engaged into agreements with pharmaceutical companies resulting in the so called "vaccine nationalism". Consequently, investing in R&D became a race between powerful countries, like USA, UK, Italy, and China, instead of being a collective action for global health and safety (as the United Nations' SDGs and WHO's initiatives suggest). This concept goes beyond the field of study of the thesis, however, it is worth mentioning as it created winners and losers in the context of an economic and sanitary crisis, where, as long as there are losers there are no winners.

After a review of the significant literature supporting the role of GVCs on the matter, the thesis will explore the evolution of the concept of GVCs, and the disruptions caused by COVID-19. The latter should help to define the importance of GVCs for the recovery and to understand how to adjust accordingly also vaccines value chains. The focus will then shift to the actual composition of the COVID-19 vaccines supply chains, namely the inputs of production needed together with

[1] The ACT- accelerator and COVAX are two global cooperation initiatives led by the World Health Organization aiming at accelerating the development, production and equitable access of COVID-19 treatments and tests

manufacturing infrastructures. Lastly the thesis will investigate how and why the vaccine GVCs can be modified to ensure vaccine access globally.

Literature Review

The following literature has found common factors that led to the unequitable distribution of COVID-19 vaccines. The main issues are related to the structure of the vaccines GVCs. The literature below underlines the concentration of the vaccine production in high income countries, that is mainly due to higher availability of inputs of production, trade barriers concerning those inputs and the constraint of IPRs. This centralization has in turn led developing countries to be dependent upon high income countries, which projected a product upon the market characteristic of the "Global North", impeding the access to vaccines to the "Global South".

Paiva & Miguel (2021), analyzed the COVID-19 GVC and found the main complication for COVID-19 vaccines distribution to be the centralized product development and production. In fact, being the "Global North" the main producer and exporter, vaccines production follows northern market standards, for example distribution requirements for specific infrastructures. Amongst others, the Pfizer vaccine needed to be stored at very low temperature and the "Global South" lacks the infrastructure to store vials at such temperatures. Also, prices set were unaffordable for the governments of such countries. As a consequence, developing countries are extremely dependent on developed countries, which, also looking at the phnomenon of "Vaccine Nationalism", have not been cooperative. Thus, the authors suggest a reconfiguration of GVCs, by allowing emerging economies to become larger players in the process, both through national governments fostering production, and local enterprises developing innovation and market capabilities allowing to develop new technologies and products.

Elgar *et al* (2021), find four main challenges to the equitable distribution of COVID-19 vaccines, namely, *Availability, Cost, Barriers to local production,* and *Logistics and infrustructure challenges.* The authors mark as well the existence of the so-called "vaccine nationalism" and the unaffordable costs for developing countries. Moreover, they find the main constraint, for the vaccine distribution in emerging economies, to be Intellectual Property Rights (IPRs). A larger sharing of IPRs might stimulate larger global production. However, according to the authors, developing countries are still lacking behind of human capacities and infrastructures, namely low number of health workers per capita and insufficient supplies of sanitary products needed to administer vaccines.

Hussman (2021), founds a lack of transparency along the the vaccine value chain, which actually turns out to be pivotal for better policies around the development, production and distribution of the

vaccines. In particular, the author describes the COVID-19 vaccine market as *a seller's market where oligopolistic vaccine supplier structure with limited production capacity is facing an enormous and pressing demand for vaccines.* The direct consequence is the need to enlarge manufacturing production. On this regard transparency and access to information is crucial. Technology transfer and property-right suspensions during public health crisis would allow to expand the vaccine production, also in low and middle income countries, where the vaccine production capacity does exists, or could be set up within three to four months, according to the author.

Andrenelli *et al* (2021) further underlines the existence of a centralized and concentrated production of COVID-19 vaccines, comparing exports and imports data and observing 90 exporting economies against 208 importing economies, with the top 10% exporters accounting for 93% of the total value. Being countries with higher GDP per capita the main exporter and the prevailing location for manufacturers and producers, it comes as a direct consequence that developing countries rely on high income countries. Here, the authors, focus on trade implications, namely tariffs on inputs, exports restrictions and coordination along the value chain. Policies on these matters would allow the better functioning of the vaccine global value chain and enable developing countries to acquire the needed doses.

The following research wants to support the idea that the solution reside in the promotion of production in the Global South through the sharing of technologies, IPRs, and inputs of production, leveraged by the revision of trade implications.

1. Global Value Chains

1.1 GVCs history and stylized facts

Gareffi and Fernandez-Stark (2016), together with the vast majority of the literature, describe a value chain as "the full range of activities that firms, and workers perform to bring a product from its conception to end use and beyond". Value chains are referred as global (GVC) when the activities of firms and workers occur across countries: this allows countries to specialize in different tasks and activities rather than in the production of specific goods and services (De Backer & Miroudot, 2014).

The development of Global Value Chains (GVCs) has had a huge impact on world production and trade, becoming a prominent feature of the current idea of globalization. International production sharing, together with the concept of comparative advantage, have always been the main features of international trade, now, GVCs shifted the focus on intermediate goods and tasks in the value chain rather than final products, and on a firms' ability to integrate value from different origins (Amador & Cabral, 2014): GVCs function as a link between geographically dispersed consumers and workers, combining them together in the same industry. This combination allows general productivity and efficiency to increase, due to the flow of resources towards their most productive use, both across countries and sectors and stages of production (Antras, 2020). Moreover, emerging economies are now able to participate gainfully in international trade and global economy, thus, become globally competitive suppliers, increasing their "upstreamness"[2], and achieve economic development, reducing unemployment and poverty (Gareffi & Fernandez-Stark, Global Value Chain Analysis: A Primer, 2016)

According to Bair (2005), the concept of GVCs can be associated with the development of the issue of "commodity chain".

In 1977, Hopkins and Wallerstein analyzed the global economy's development through the lenses of commodity chains: *"the set of inputs into each of the material processes that culminate in the ultimate consumable item"* (Hopkins & Wallerstein, 1977). That is, the authors took into account all the procedures and inputs needed for a good's production and identified in this mechanism, namely the "widespread commodification of processes" (Hopkins & Wallerstein, 1977), the economy's development (Bair, 2005). Hopkins and Wallerstein will provide a more rigorous definition of

[2] *measure of the distance of an industry from the final use in terms of the number of production stages* (Suganuma, 2016)

commodity chains in 1986: *"a network of labor and production processes whose end result is a finished commodity"*.

Gareffi in 1994, introduced the concept of Global Commodity Chains (GCC) in his publication Commodity Chains and Global Capitalism, understanding commodity chains as interfirm networks between global industries and eventually international markets (Bair, 2005).

The shift towards GVCs in literature happened in the 2000s, with the aim of capturing the "new" features of the world economy, namely the vertical fragmentation of production across countries and the specialization in the ability of performing different tasks rather than the ability of producing final products (De Backer & Miroudot, 2014).

To understand this shift, one must look at the dynamics and factors that allowed international production fragmentation, so at answering the question "What are the drivers of GVCs?".

Literature identified two main drivers: technological progress and economic and trade liberalization (Amador & Cabral, 2014).

Technological progress plays a pivotal role in the increase of GVCs. Amador and Cabral (2014) point out the key progresses in two types of technologies: information and communication technologies and transportation technology. The former allows international trade of financial, computer and innovation services, together with consenting firms to manage remotely their businesses at lower costs. The latter instead, dramatically decreased trade costs, both in the traditional and "new" sense. Expressly, both air and ocean transportation are now cheaper, but also more efficient, in the sense that they are faster, so more reliable, better trackable, and schedulable.

Trade liberalization also has significant weight on trade costs. The first step towards trade liberalization is found in China's participation in the World Trade Organization (WTO) in 2001, becoming the major assembly center and enabled also other East Asian countries to participate in several segments of the value chains, according to their competitive advantages. The significance of this event is found in the Asian tariffs on semi-processed products, which are the lowest [3]. The Asian case is also representative of the importance of Regional Trading Agreements (RTAs) in the development of GVCs. In fact, the ASEAN (Association of Southeast Asian Nations), played a crucial role in the advancement of economic interdependence in Asia, and in the strengthen of China's final

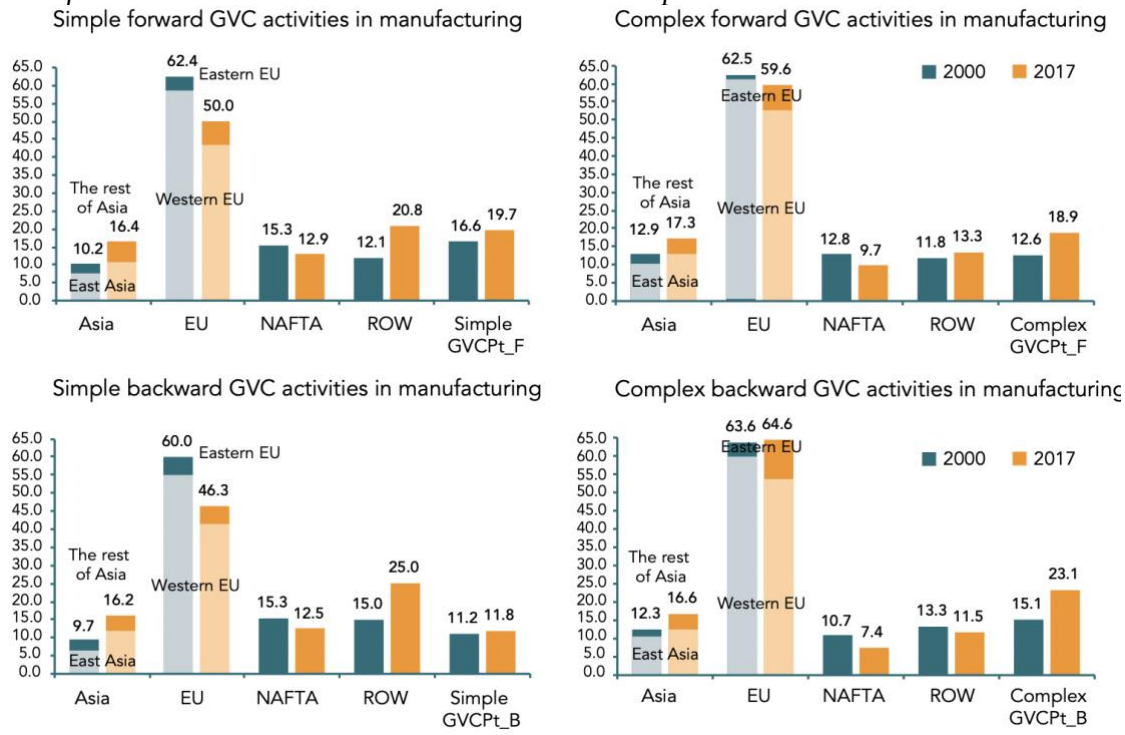
[3] Tariffs are taxes imposed by a country on goods it imports. This means Asian country were able to import semi-processed products at the lowest price and transform them into final goods.

assembly role, which allow exports cooperation with economic partners outside the regional organization (Krapohl & Fink, 2013). Moreover, the North American Trade Agreement (NAFTA) has been found to also led to an increase in cross-border trade and deepening in production sharing (Amador & Cabral, 2014).

To understand what the magnitude of the phenomena of GVCs is today, literature, in particular Hummels, Ishii, & Yi (2001), suggests measuring the vertical specialization share (VS), which indicates the backward participation[4] in the value chain, together with the VS1 share, index of the forward participation[5] in the value chain, of gross exports of a country. The combination of the two shares allows a complete assessment of a country's participation in GVCs, both as a user of foreign inputs and as an exporter of inputs. However, this analysis does not come without limitations, as this methodology may incur in the glitch of double counting, in fact domestically produced inputs may include foreign components.

As an example, the table below shows the *forward and backward GVC participation intensities and their inter- and intra-regional shares for manufacture industries in Europe in 2017* (WTO, 2017).

Table 1 forward and backward GVC participation intensities and their inter- and intra-regional shares for manufacture industries in Europe in 2017 WTO (2017)



[4] Backward participation refers to the extent by which a country relies on foreign inputs.
[5] Forward participation refers to the extent by which a country's exported inputs are used by foreign producers.

1.2 Disruptions in GVCs due to COVID-19

The outbreak of COVID-19, firstly detected in January 2020, has caused nearly global lockdowns which led to the interruption of movement of people and goods across countries, thus to the disruption of trade. Consequently, a lively debate about GVCs and their vulnerability to such crisis has been brought up.

The pandemic has firstly hit *the productive heart of the world*, namely East Asia, leading to the break of countless supply chains. Thus, countries could have started a decoupling process, with the intent to reduce economic dependence on China's inputs, which, however, might not have been a successful strategy as the country started a faster recovery than the rest of the world (Coveri, Cozza, Nascia, & Zanfei, 2020). After few months also Europe and United States suffered from lockdowns which led to the shutdown of many commercial activities, sectors, and industries. However, this supply shock provides a striking example of the fragility of current GVCs. Namely, the high supply chain risk. GVCs have increased the concentration of manufacturing production in specific geographical areas, exploiting lower costs of labor together with less strict regulations (Coveri, Cozza, Nascia, & Zanfei, 2020). Indeed, a catastrophic event (which in this case is a pandemic but could also be a natural disaster) in a specific region of the world was able to induce a contagion effect in other countries through GVCs (Miroudot, 2020).

To minimize the exposure to shocks hence to make GVCs more resilient, most literature has found *redundancy* to be the most effective tool ((Miroudot, 2020), (McKinsey Global Institute, 2020)). *Redundancy* in suppliers may be exemplified by saying supplier diversification. According to Kamalahmadi (2022) *Redundancy refers to practices in which a firm takes action in advance of a disruption, incurring the cost of the action regardless of whether a disruption occurs,* that is to adopt a mechanism which would impede a single disruption along the supply chain to hamper the whole production. Relying on a single supplier, or more than one supplier located in the same geographical area, is a great source of vulnerability in case of external shocks. Instead, the possibility to switch supplier allows firms to have a backup in the event of a crisis (McKinsey Global Institute, 2020). However, *redundancy* in suppliers comes at high costs, such as loss of long-term relationships with suppliers and switching costs (Miroudot, 2020). A further application of *redundancy* concerns inventories and production capacity, having a sufficient backup inventory allows firms to minimize the impact of the disruption of suppliers. Thus, literature suggests a switch from Just-in-Time to Just-in-Case strategies (McKinsey Global Institute, 2020) (Miroudot, 2020). Still, the costs of this management strategy are notable, and can significantly lower efficiency (Miroudot, 2020).

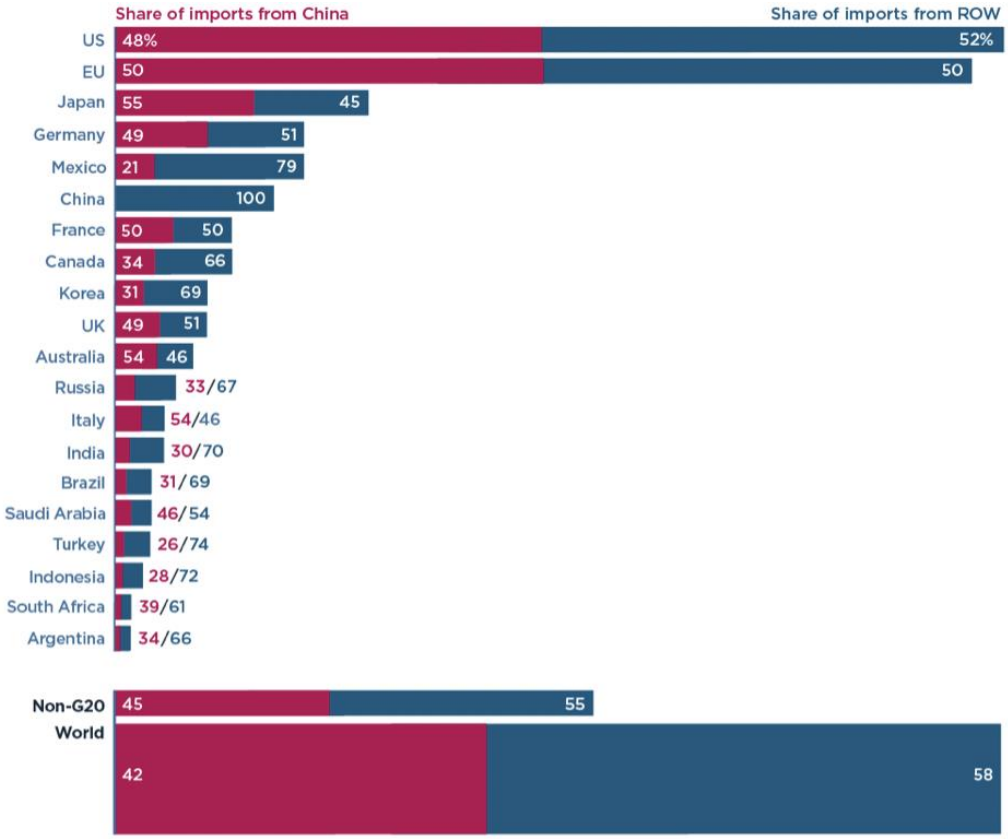
Due to the limits of *redundancy*, Coveri *et al* (2020) suggest an alternative solution, namely a partial shortening of GVCs, which would reduce dependence upon imports without giving up the productivity gains from specialization and trade. To clarify the aforementioned process, it is worth mentioning the phenomenon of the decline of China's vertical specialization. As mentioned before vertical specialization (VS) is a crucial factor for the measurement of a country's participation in GVCs (Hummels, Ishii, & Yi, 2001), and starting from 2016 China has experienced a decline in the VS share (Duan, Dietzenbacher, Jiang, Chen, & Yang, 2018). Duan *et al* found, through an empirical study, the driver of this phenomenon being, rather than the *productive heart of the world* moving out of China, the changes in input structure and a consequent upgrading of the country's production along the GVCs. In fact, Chinese production switched imported inputs with domestically produced inputs, this was due to improvements of quality and competitiveness of the domestic intermediates and allowed the country to enter the process of becoming a *GVCs' top player*.

1.3 The case of PPE

In the context of a sanitary crisis, demand for medical supplies, equipment and medicines has notably spiked. In particular, countries experienced shortages of PPE[6] (personal protective equipment) which turned out to be crucial for the protection of sanitary workers and to combat the virus. China was the main exporter of protective garments, accounting at that time, for 42% of global exports, followed by Malaysia, Germany, Vietnam, and Thailand with significant lower shares (OECDa, 2020). Moreover, 90% of PPE sold in the EU is imported (Stellinger, Berglund, & Isakson, 2020). The table below shows the share of the world's imports of PPE coming from China in 2018.

[6] PPE include face and eye protections, gloves, disposable hair nets and protective garments for surgical/medical use

Table 2 Share of the world's imports of PPE coming from China in 2018 (Bown, 2020)



As already mentioned, China was the first country affected by the pandemic, which led to a dramatic increase in domestic demand for PPE, especially for face masks which demand was estimated at 240 million masks per day, against the production capability of 20 million masks per day (OECDb, 2020). After few months demand surges expanded globally, solutions involved increased production but also export restrictions.

China put extensive efforts to increase face mask production, especially enhancing the production of key inputs such as non-woven fabric and melt-blown polypropylene (OECDb, 2020). However, other main face masks exporters, such as United States and Germany (which together accounted for 25% of exports), facing more modest increases in production, have put in place restrictions on exports (OECDb, 2020). Inconveniently, data shows a very high level of interdependencies in COVID-19 related goods[7], in fact a country can be a top supplier of one good and an importer of others (OECDa, 2020), and the case of face masks demand surges can be extended to COVID-19 goods in general. The table below shows the top exporters and importers of COVID-19 goods in 2018.

[7] COVID-19 goods refer to sanitary products crucial to fight the virus, thus these include PPE but also test kits, disinfectants, medical consumables, vehicles, and other medical devices (OECDa, 2020)

Table 3 Top exporters and importers of COVID-19 goods in 2018 (OECDa, 2020)

Test kits / instruments and apparatus in diagnostic testing		Protective garments		Disinfectants and sterilisation products		Oxygen therapy and other medical equipment		Medical consumables		Vehicles		Other items	
Exports													
DEU	**21.0%**	**CHN**	**41.0%**	**DEU**	**15.3%**	**USA**	**17.6%**	**CHN**	**16.5%**	**DEU**	**15.0%**	**DEU**	**18.4%**
USA	16.3%	MYS	10.1%	CHE	13.0%	DEU	13.5%	DEU	12.4%	USA	14.5%	CHN	11.9%
CHE	13.7%	DEU	5.2%	IRL	8.9%	CHN	9.0%	USA	9.8%	CHN	13.0%	USA	9.6%
IRL	10.4%	VNM	4.2%	USA	8.1%	MEX	8.8%	MEX	4.5%	ITA	11.4%	MEX	6.1%
NLD	5.7%	THA	3.7%	FRA	5.7%	JPN	5.7%	NLD	4.4%	FRA	4.6%	GBR	5.1%
Top 5	67.2%	Top 5	64.2%	Top 5	50.9%	Top 5	54.6%	Top 5	47.5%	Top 5	58.5%	Top 5	51.1%
Imports													
USA	**12.9%**	**USA**	**28.2%**	**USA**	**19.6%**	**USA**	**22.9%**	**USA**	**14.7%**	**USA**	**9.2%**	**USA**	**15.7%**
DEU	9.6%	DEU	7.4%	DEU	8.0%	DEU	8.0%	DEU	9.1%	CAN	7.8%	DEU	11.9%
NLD	8.8%	JPN	6.3%	NLD	4.8%	CHN	7.1%	NLD	5.7%	FRA	6.3%	CHN	5.3%
BEL	5.8%	FRA	4.7%	CHE	4.8%	NLD	6.8%	CHN	5.1%	DEU	5.2%	GBR	4.4%
ITA	5.8%	GBR	4.0%	GBR	4.7%	JPN	5.1%	FRA	4.7%	GBR	4.4%	CAN	3.9%
Top 5	42.8%	Top 5	50.7%	Top 5	41.9%	Top 5	49.9%	Top 5	39.2%	Top 5	32.9%	Top 5	41.0%

Given these considerations trade and GVCs efficiency plays a fundamental role in the fight of the virus and consequent crisis. First, given the interdependences among COVID-19 goods, and the fact that exports are very much concentrated (OECDa, 2020), trade policies and openness are crucial to give every country the tools to beat the virus. Second, due to the spikes in demand, the functioning of GVCs is also pivotal to increase production but also to ensure effective distribution.

For what concerns trade policy, it is relevant to explore the reaction of the three main exporters, namely Germany, USA, and China. Bown (2020) explains the main reactions of these countries as described below.

Germany imposed export restrictions on masks, face shields and other PPE, starting from March 2020, with the intent of being able to cover the domestic demand as the spreading of the virus was increasing. However, the European Commission reacted promptly by establishing a temporary *emergency export authorization programme* for PPE, which prohibited any export restrictions to Member States (and European major trading partners) but put under review (and potentially declined) any sale outside the established boundaries. This in turn led to serious disruptions for importing countries outside the delimited area (in particular Bown (2020) refers to Eastern Europe, northern Africa, and Sub-Saharan Africa countries, extremely reliant on EU exports), in fact during the precarious time of the pandemic switching suppliers or suddenly increasing production could not have been possible.

The USA, under the Trump administration, followed a path comparable to some extent to the European one. At the beginning of April, the Federal Emergency Management Agency (FEMA), issued a limit on American exports on numerous PPE, the only exemption being for Canada and Mexico, which portrait the main destinations of US PPE exports. However, many Latin American countries (Jamaica, Palau and Belize being the main) are historically extremely reliable on American exports. Thus, in turn these restrictions caused several disruptions for these countries.
China followed a different, to some extent, pattern. The country faced the crisis first, and has in turn, allegedly, imposed exports limits on PPE[8]. However, the Chinese economy was able to re-emerge quickly from the crisis and scale up, even more than previously to the crisis, its exports of PPE. Yet, being China the undisputed global top supplier, it had to face a huge demand under extraordinary market conditions. In fact, COVID-19 goods, had to be shipped faster thus with more costly transportation, and at the same time local governments were bidding up prices to assure them supplies. Eventually these dynamics led to dramatically high prices, which affected the most those countries with limited public health budgets and that were possibly already facing other nations' export restriction.

The COVID-19 crisis had for sure underlined the vulnerabilities of the PPE GVCs, and export restrictions seem not to be an adequate solution. In fact, there have been identified three main dangerous consequences from this practice: they could prevent countries with no manufacturing capacity to access essential medical goods, they could cause retaliation practices by trading partners of inputs of production or other medical supplies (linked to the interdependences of COVID-19 goods), and they could push prices up and foster illegal activities (OECDb, 2020).

Eventually the main policy implications, concern trade facilitation and innovation. Trade openness is crucial not only to reach those countries which lack of manufacturing capacities, but also to facilitate the diffusion of new technologies. These new technologies can in turn be part of the solutions. Indeed, transportation costs also play a fundamental role, and innovation may be useful to improve the current logistic infrastructures. Also, in the short term, an increase in supply is required, this can be achieved with incentives to firms to build up new facilities but also through the diffusion of technologies where manufacturing infrastructures lack. Lastly, the correct functioning of GVCs is pivotal, especially for the need of access to inputs of production, which trade should be also facilitated through coordination across countries and effective division of labor (OECDb, 2020).

[8] The Chinese government has denied having imposed any export limits; however, data shows a significant drop in the country's exports during January and February 2020 (Bown, How the G20 can strenghten access to vital medical supplies in the fight against COVID-19, 2020).

1.4 COVID-19 vaccines Supply Chain

Above all the COVID-19 outbreak needed a sanitary tool to be defeated. By the end of 2020, a vaccine for the disease was found, portraying a glimmer of hope for the global population.

The development of a vaccine follows pre-clinical studies and several clinical stages only after which the manufacturing, approval and distribution stages can happen, and the overall process takes years (Bownb & Bollyky, 2021). The case of the COVID-19 was extraordinary, in fact it had progressed faster than any historical precedent, of course due to the sanitary crisis which enhanced political and economic pressure. This accelerated process was possible due to a remarkable cooperation between governments, institutions, and non-governmental organizations that gave rise to international and national initiatives such as COVAX and Operation Warp Speed[9] (Fisher, Kharenko, Ucel, & Yadav, 2021).

The image below shows a comparison between the traditional vaccine development timeline and the COVID-19 vaccine development timeline.

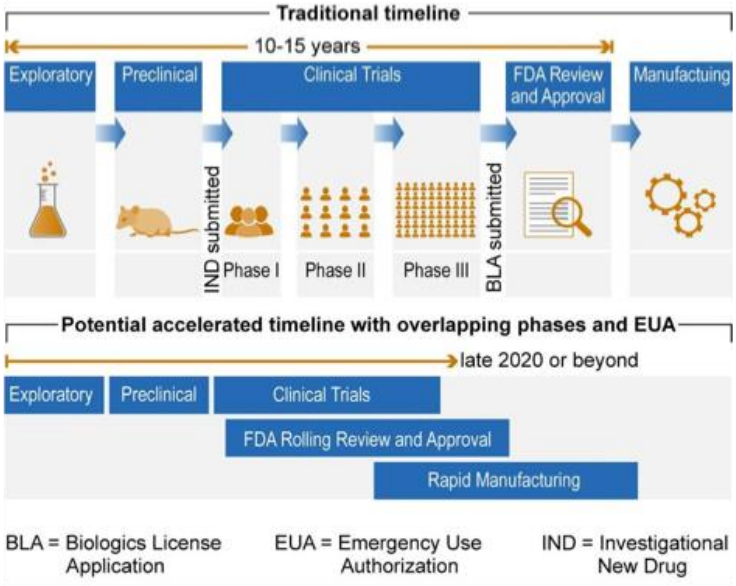


Figure 1 Comparison between the traditional vaccine development timeline and the COVID-19 vaccine development timeline (Fisher, Kharenko, Ucel, & Yadav, 2021)

The vaccine supply chain (after the R&D and clinical trials) can be broken up in three main stages: Drug substance and drug product formulation, Fill and finish and Distribution, that is, namely, manufacturing and delivery (Bownb & Bollyky, 2021).

[9] *COVAX Facility, was aimed at pooling participating countries' resources to support vaccine development and later provide subsidized access to lower income countries.* Operation Warp Speed, US initiative, which allocated public funds to support vaccine development and manufacturing efforts. (Fisher, Kharenko, Ucel, & Yadav, 2021)

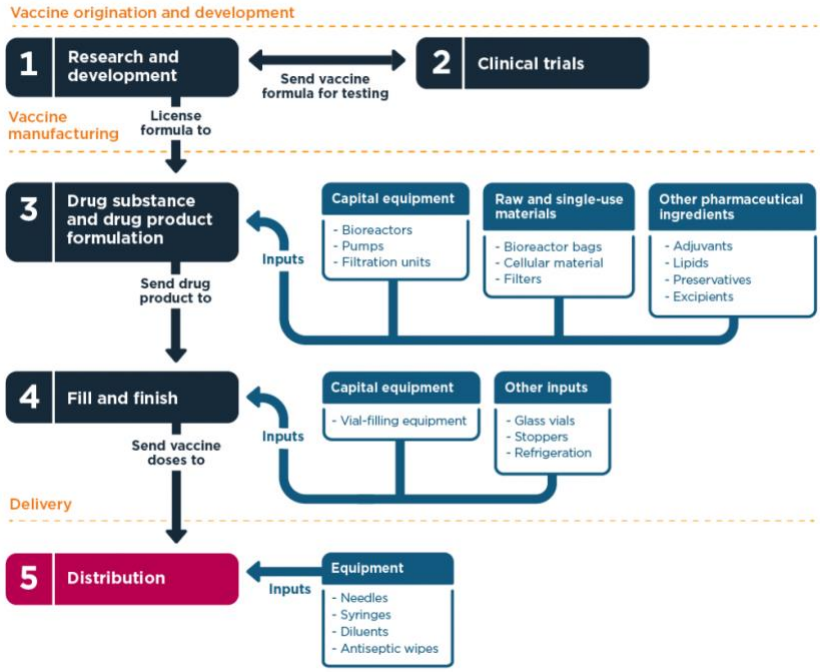


Figure 2 The vaccine supply chain (Bownb & Bollyky, 2021)

As it can be observed in the figure above the vaccine supply chain is extremely complex, each stage requiring the availability of numerous inputs. These inputs are imported from a vast set of countries. The APEC Policy Support Unit (Kuriyama, 2021) reports the following data: Pharmaceutical ingredients (Sorbitol, Thimerosal, Sterols, Formaldehyde and Antibiotics) needed for the drug substance and drug product formulation are mostly exported by China, USA, Indonesia, India, Canada and Germany;

Inputs and Capital Equipment for the Fill and Finish stage (Refrigerators, Vials, Stoppers) are mostly exported by China, Japan, Mexico and USA;

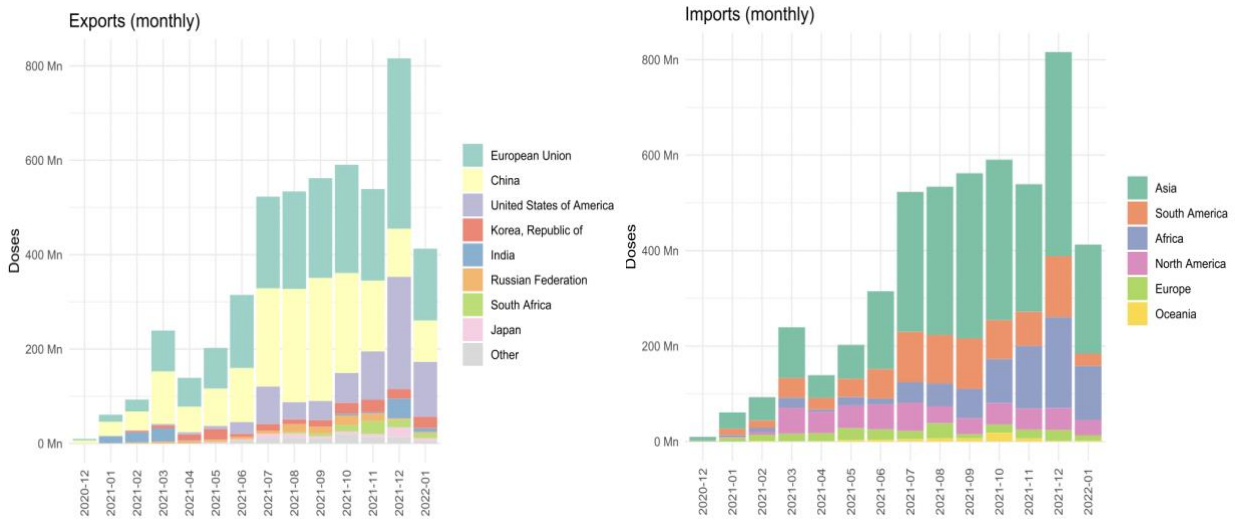
Equipment (Needles, Syringes, Alcohol Solutions) for the distribution stage is exported for the most part by Mexico, USA, Brazil, and China.

Consequently, tariffs and trade policies play a crucial role for the effective production of vaccines.

Moreover, the COVID-19 vaccines supply is highly centralized. As of today (January 1st, 2022), the main COVID-19 vaccines producing countries are EU, India, USA, Switzerland, and China, and the main manufacturers are Pfizer/BioNTech, University of Oxford/AstraZeneca, Moderna, Bharat/ICMR/NIV, Johnson & Johnson, Beijing/Sinopharm (Global Commission for Post-Pandemic Policy, 2022). Each manufacturer concentrates its supply chain locally, in fact, for example, Pfizer has both European and US firms and, accordingly, European and US production facilities which give rise to two separate local supply chains, and the same reasoning can be extended for the other

manufacturers[10] (Bownb & Bollyky, 2021). On this matter political tensions and nationalist pressure also played a role. In fact, it is worth mentioning the pre-pandemic trade war between China and USA, together with the so-called "Vaccine Nationalism" which brought governments to prioritize distribution to domestic populations (Fisher, Kharenko, Ucel, & Yadav, 2021). Because of the above considerations, COVID-19 vaccine exports (and thus distribution) are concentrated in the hand of China, EU, and USA (WTO, 2022).

Table 4 Exports and Imports of COVID-19 Vaccines (WTO,2022)



[10] University of Oxford/AstraZeneca represents an exception to this reasoning, as it owns production facilities in Asia (Japan, Indonesia, South Korea) and Latin America (Argentina).

2. How to reshape Vaccines GVCs

The following section will identify the problematics and bottlenecks of the COVID-19 supply chains which led to their unequitable distribution and illustrates why policies aimed at reducing the inequalities are pivotal for the global economy recovery.

2.1 Vaccine GVCs Bottlenecks for equitable access

The previous section explains the complex supply chain of the COVID-19 vaccines, in particular it stressed its length when it comes to the inputs of production. On this matter the WTO studied the application of the MFN[11] (most-favored-nation) tariff on the goods contained in the List of Critical COVID-19 Vaccine Inputs for Consultation[12] (WTO, 2021). The study showed that, generally speaking, tariffs on critical inputs of vaccine production are relatively high, especially in developing countries. As an example Kazakhstan, which just recently improved its economic status and is now considered by the World Bank a Middle-Income country, has developed its own vaccine (QazVac) and has to pay an MNF tariff of almost 29% on vaccine ingredients (which account for 25% of the imported vaccine inputs of the country) (WTO, 2021) (Satubaltina, 2021).
Eventually, tariffs lead to higher prices, unaffordable for developing countries, and, also, to higher costs, which are an obstacle to expand the manufacturing capacity (and thus increase the world supply) (WTO, 2021).

As already mentioned in the previous section, in times of shortages the main exporters of critical COVID-19 products applied export restrictions on those goods. The same happened for vaccines. In fact, on January 29,2021 the EU adopted a regulation which required an export authorization for vaccines against COVID-19, after a few months India followed with the same practice. Moreover, the US' practice on export bans on PPE (Section 1.2.1) was also applied on critical inputs of vaccine production (Ibrahim, 2021). It is worth mentioning that the Serum Institute of India, at that time (first half of 2021), oversaw providing nearly 75 million doses to the COVAX facility, responsible of vaccine distribution in developing countries, to destinate to the African continent (Jerving S. , 2021). In turn, the Indian export ban would cause the deterioration of an already existing disruption, caused by the unaffordability of vaccines.

[11] Normal non-discriminatory tariff charged on imports (excludes preferential tariffs under free trade agreements and other schemes or tariffs charged inside quotas). (WTO, s.d.)
[12] List of Critical COVID-19 Vaccine Inputs for Consultation can be consulted at https://www.wto.org/english/tratop_e/covid19_e/vaccine_inputs_report_e.pdf

Moreover, the geographically interdependent vaccine supply chain, as in the case of tariffs, is highly vulnerable to such export restrictions, which could lead to complications to move the product from one stage of production to the other and to shortages of crucial inputs of production (Evenett, 2021).

Over and above that, when it comes to expanding the manufacturing capacity (but also to expensive prices to some extent) tariffs and other barriers to trade are not the only concern.

In fact, COVID-19 vaccines key components are covered by IPRs (intellectual property rights) and patents, under the TRIPS (Trade-Related Aspects of Intellectual Property Rights) agreements governments need to provide exclusive sale rights to the patent holder, in turn, the holder is the price-maker (Bolle & Obstfeld, 2021). The TRIPS is a WTO's multilateral agreement on intellectual property (IP)[13], its main role is to facilitate trade in know-how and resolving potential arguments over goods protected by IP (WTO). On October 2, 2020 India and South Africa emitted a communication to the WTO and the Member States, proposing a waiver on TRIPS agreement in such period of emergency, which on the one hand would allow to increase the world manufacturing capacity and on the other hand would levy countries with insufficient or no manufacturing capacity from institutional and legal difficulties in the imports (WTO, 2021). In turn, the proposal has raised a lively debate. India and South Africa were backed up by over 80 other developing countries, however, western countries strongly opposed to it (Blenkinsop, 2021). Most of developed countries sustained that the protection of IPRs is crucial for the advancement of research and innovation and that developing countries lack of lack the know-how, facilities, and trained personnel to produce vaccines (Bolle & Obstfeld, 2021). On this matter, a striking example is the vaccine producer Moderna which in August 2020 emitted a statement declaring it would allow the use of its patented technologies to other vaccine producers (Moderna, 2020). However, without the sophisticated techniques and knowledge needed, this only allows to produce a generic version of the vaccine, which imply the lack of many clinical trials steps and quality controls; in turn this would impede improvements in the fight against the pandemic, due to possible skepticism and mistrust in these generic vaccines (Bolle & Obstfeld, 2021). In January 2022, South Africa's Afrigen Biologics and Vaccine was successful in replicating Moderna's vaccine, but, for the vaccine to gain approval, the clinical trials needed are expected to take until 2024 to be done, this timeline could have been significantly shorter if the company (Moderna) had decided to share also its technical know-how (Jerving S. , 2022).

[13] Intellectual property is referred in terms of innovation, technology, and public welfare under the TRIPS agreement (WTO).

The aforementioned have been highlighted to be the main challenges that brought to the inequality around the vaccination rates across the world. Data speak loudly and these disruptions have led to accentuate even more the break between developed and developing countries.
As of today, 64% of the world population has received at least one shot of vaccine. However, breaking data down by country income group, just 10% of the population in Lower-Middle income (LMICs) countries has received at least one shot (against the 75% rate in Upper-Middle income countries) (WTO, 2022). In turn, due to the highly infectious nature of this virus and its capacity to mutate, in today's globalized world, this situation is an impediment to the global sanitary and economic recovery (Rydland, Friedman, Stringhini, Link, & Eikemo, 2022). It comes as no surprise that the latest COVID-19 variant (Omicron), which is also the most contagious (although less dangerous) is presumed to be firstly spotted in South Africa (Mallapaty, 2022).

Although beyond the scope and field of study of the research, it is worth mentioning, as it portrays a challenge for the equitable distribution of COVID-19 vaccines, the phenomenon of *Vaccine Nationalism.* Before the COVID-19 vaccines were put on the market, the richest nations had already pre-ordered billions of doses of vaccines, in order to secure their population with protection from the virus (Kretchmer, 2021). The previous transformed into a global race for vaccines, which led to spikes in the prices. Eventually, this phenomenon brought problems to an already critical situation, also given the fact that the protection of the wealthier nations, taken alone, is not enough to cover the human and monetary losses, which will occur until a global recovery is attained (Kretchmer, 2021).

The map below shows *the number of vaccine doses administered per 100 people within a given population* (Ritchie, Mathieu, Rodes-Guirao, & Giattino, 2022).

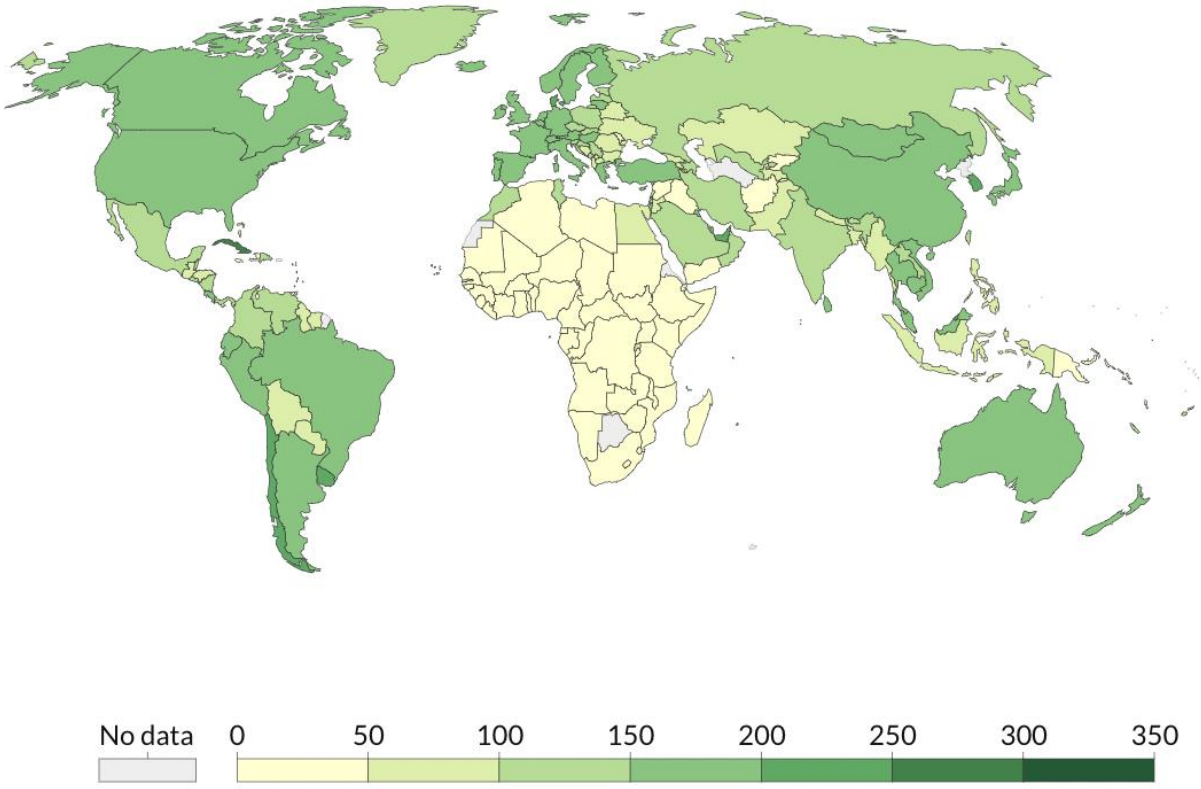


Figure 3 Number of vaccine doses administered per 100 people within a given population (Our World in Data,2022)

2.2 Policy Responses

The COVAX project was initiated by CEPI (Coalition for Epidemic Preparedness Innovations), GAVI (Global Alliance for Vaccines and Immunization), the World Health Organization (WHO) and UNICEF, with the goal of *ensure no country left behind*, namely ensuring doses to LMICs, (Ducharme, 2021). COVAX rely on HICs purchasing doses through the facility and donations from nonprofits and businesses (WHO). The initial plan was to distribute 2 billion doses by the end of 2021, however this goal turned out to be possible to reach only in the first quarter of 2022 (WHO, 2021).

COVAX participated in the above-mentioned race for vaccines against the world's wealthier nations and being a newly established facility and lacking from the same funds, it was not able to be a valuable competitor in the game[14]. Subsequently, COVAX, also faced the issue of over-demand and tried to tackle it through GAVI (which is a public-private partnership (PPP)) making an attempt at expanding the vaccine manufacturing with vaccine technology transfers and intellectual property waivers. However, as also explained earlier, the pharmaceutical private sector, together with the big and wealthy countries, curbed the practice (Medecins Sans Frontieres, 2022). Lastly, COVAX relied on

[14] Vaccine prices were spiking up, at that time, due to the phenomenon of Vaccine Nationalism.

the Serum Institute of India as primary vaccine supplier for LICs, which in March 2021 halted its vaccine exports.

It is then clear, that the main initiative for assuring an equitable distribution of vaccines faced all the challenges mentioned in the previous section. Policies should then be focused on trade barriers and the issue of the vaccine technology and know-how transfer.

On the matter of the vaccine supply chain and its smooth functioning the initiative of a COVID-19 Vaccine Investment and Trade Agreement (CVTA) has been proposed (BownC, 2021). CVTA would be a plurilateral agreement between the main COVID-19 vaccine producer and supplier countries, with the aim of increasing the availability of inputs of production. In fact, the agreement would comprehend a commitment not to place any export restriction on supplies of vaccines and related components and the possibility of exchange exported inputs with imported vaccines (BownC, 2021). Moreover, the objective of CVTA falls into the scope of COVAX, functioning as a leverage, as the production capacity increases (BownC, 2021). Of course, CVTA does not come without limitations, to implement such agreement it would be necessary to increase the transparency across the vaccine supply chains, both in terms of inputs and production processes, also to ensure their correct pricing (BownC, 2021).

Even with the attempts of reducing barriers to trade, still the problem of the lack of transparency along the value chain persists, and it could hamper the effects of trade policies. More transparency implies greater sharing of processes, knowledge, and technologies. In the context of COVID-19 vaccines transparency concerns the content of patents and IPRs but also standardized best practices to adopt (Price, Rai, & Minssen, 2020). The sharing of such could scale-up manufacturing, allowing more and more firms to produce the most effective vaccine and in turn, increase the global supply (Price, Rai, & Minssen, 2020). Most importantly, this practice would allow to exploit the existing infrastructures in developing countries and produce a product adapted to their characteristics in terms of prices and distribution.

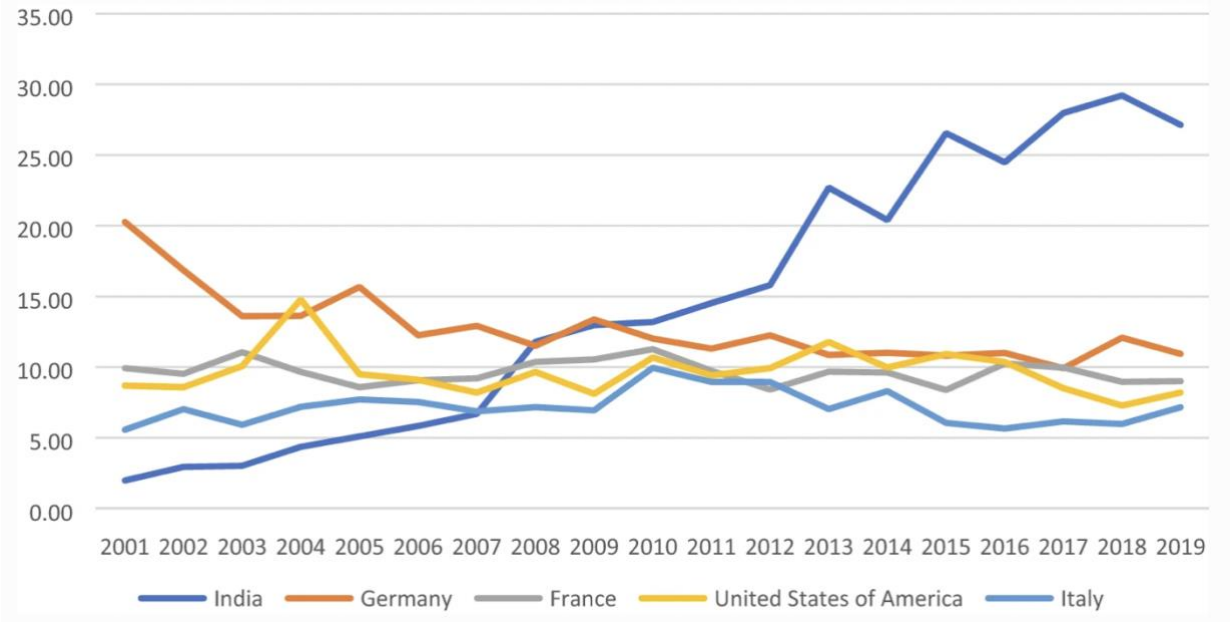
The following section will analyze a case in which the share of IPRs has been successful in allowing the production of an ad hoc vaccine for the African continent.

2.3 The case of South Africa

South Africa's pharmaceutical industry is the largest in Sub-Saharan Africa, although relatively small at the global level.

A typical pharmaceutical value chain includes three stages: the production of active pharmaceutical ingredients (APIs), the formulation of the drug (that is the process of converting the drug into consumable form) and the distribution and marketing of the final product. The South African industry is almost entirely focused on the formulation stage, in turn, APIs must be imported from abroad. (Horner, 2021). Moreover, since the liberalization from apartheid, the country has experienced a de-industrialization, due to pharmaceutical MNEs flight to economies of scale in "centers of excellence" (Horner, 2021). As it arises from the previous sections, the development of GVCs allowed the shift of the various steps of production where is the most efficient and convenient. South African outdated technologies and relative smaller volume has not only constrained the country's production of APIs but also caused foreign MNEs to transfer elsewhere. In turn, many locally owned firms acquired physical plants where the foreign MNEs were operating and became the largest pharmaceutical firms in Sub-Saharan Africa (Horner, 2021). However, the issue of the absence of the production of APIs pertains, which in turn made, according to estimates, the cost for a South African pharmaceutical product 40% domestic and 60% international (Maloney & Segal, 2007), due to the country's heavy reliance on imports. Additionally, the segment of the supply chain remained in the country (formulation) must face a harsh competition with the Indian industry. In fact, India is South Africa's main source of pharmaceutical formulation imports (Kudlinsky, 2013), this is especially due to companies supplying generic pharmaceutical which are subject to the mandatory generic substitution since 2003 (Horner, 2021). Many Indian firms have established partnership with South African entities for marketing and distribution purposes, on the other hand, there are almost no incentives to move manufacturing in South Africa. In fact, Indian firms benefit from lower input costs, and economies of scale, together with the presence of the API stage, which makes all the inputs of production locally available (Horner, 2021).

Figure 4: Top 5 source countries for South African imports in 2019



Source: (Horner, 2021)

Indeed, the South African government, especially the Department of Trade and Industry, has taken action on the matter. The initiatives comprehend tax incentives and investments to facilitate the improvement of technologies and equipment. Then, the Government tried to act as a buyer through public procurement, preferring local manufacturers by allowing price premiums and by designating specific products for local manufacturers (Horner, 2021).Lastly, the government attempted to set up state-owned companies, which would allow the country to be less dependent on imports and stable pricing (less dependent on exchange rate fluctuations).

In fact, in 2003 a public-private partnership was established between the National Department of Health (NDoH) and the private Biovac Consortium to enhance the vaccine manufacturing capacity in South Africa and to make up for the closure of the State Vaccine Institute. As of today, Biovac is a joint venture between government shareholders and supplies vaccines used by the NDoH (Tomlinson, 2021).

The Biovac Institute was the first company in Africa to get an agreement for the COVID-19 vaccines. In fact, the institute signed in July 2021 an agreement with Pfizer and Biontech, according to which the company would be responsible for the "fill and finish" process (Jerving b, 2021). Still the distribution process was not in charge of the South African company. Most importantly, in that same period Biovac signed a letter of intent together with the WHO, the Medicine Patent Pool Foundation (MPP), Afrigen, the South African Medical Research Council (SAMRC) and the Africa Centre for Disease Control and Prevention (Africa CDC), to establish a technology transfer hub in South Africa

(WHO, 2021). A technology transfer hub functions as a link between the medical technology originator and the second user, who can then manufacture the technology and sell it on new markets (WHO). The development of a mRNA vaccine technology transfer hub would allow researcher to use publicly available information on the existing vaccines to formulate a new one more suited to the geographical area where it will be used, indeed with fewer storage constraints and cheaper (WHO). Although a first vaccine approval is expected to be in 2024.

Another South African pharmaceutical company, Aspen, instead was able to conclude an agreement with the vaccine producer Johnson and Johnson in March 2022. The agreement allows Aspen to oversight the fill and finish process and then distribute, so price and sell, the vaccine under the Aspenovax brand to every country in Africa. (Reuters, 2022).
Given all the previous considerations, this agreement seems to be the turning point for the equitable distribution of vaccines. However, as of today Aspenovax has not received any order and is on the brink of closing down. The reason has been found in the increasing supply of vaccines donated by high-income countries by the Africa CDC and the globally lower rate of vaccination (Adepoju, 2022).

Still the agreement between Aspen and Johnson and Johnson is a striking example of how the sharing of technology and IPRs are a pivotal factor for the equitable distribution of COVID-19 vaccines. In fact, in principle the contract could strengthen an infant industry such as the South African one exploiting its resources and plants, which is crucial for the COVID-19 pandemic but also important for the overall condition of the country, and the African continent, in face of any possible future event.

Conclusion

Global Value Chains are found to be the most effective tool to allocate production in the most efficient way and, as the literature suggests, characterize more and more the global supply of goods and services.

The COVID-19 pandemic outbreak in March 2020 has raised a lively debate on GVCs and their vulnerability to crisis. China, the main global supplier of inputs of production, was also the first country to experience lockdowns due to the pandemic, leading to the disruption of countless supply chains. In turn, a supply chain-crisis management tool had to be found. The main solution proposed to build-up resilience in GVCs is "redundancy", namely the adoption of a Just-in-Case strategy, and the partial shortening of chains, that is the attempt to improve the production of inputs of production rather than being strictly dependent upon imports.
Moreover, in the context of the sanitary crisis, the fragility of GVCs is particularly concerning when the global demand of necessary medical supplies, equipment and medicines can not be met. Especially at the beginning of the pandemic countries experienced a dramatic shortage of PPE (personal protective equipment), crucial for the protection from the virus. Indeed, the main exporter of PPE (China, USA, and Germany) were facing both domestic and foreign spiking demand, which led the countries to adopt highly restrictive trade policies. China was eventually able to overcome the shortage and liven up production and exports, however it was still facing extraordinary market conditions which led to spiking prices. In turn, this has caused dangerous disruptions for importers countries not able to produce or access to essential medical goods.

The reasoning above applies for the most part also to the distribution of the COVID-19 vaccines. By the end of 2020, in exceptionally little time, the vaccine had been developed and producers started its distribution. The COVID-19 vaccine supply chain, besides being very complex and dependent upon many different suppliers of inputs, has found to be highly centralized, meaning that the main producers concentrate the various steps of production locally. The latter has caused the distribution of the vaccine to be concentrated in the producing countries that is mainly China, US, and USA, leaving behind the developing and low-income countries. Moreover, this was exacerbated also by political pressure, namely "Vaccine Nationalism", and the unaffordable prices set by the "Global North".

Indeed, to increase the vaccine global supply and provide access to protection from the virus to the "Global South", various considerations come together. Export restrictions on vaccines are a major concern on that but also tariffs on vaccine inputs of production play a crucial role for what it concerns the costs of producing, and so the global manufacturing capacity. Indeed, what the research has found to be pivotal are IPRs. In fact, the necessity of a patent to produce the vaccines and the lack of transparency along the supply chains has resulted to hamper the use of plants in the "Global South" for production.

To address the issue of the access to vaccines by developing countries many international cooperation initiatives have been brought up. Namely the proposal of a waiver on TRIPS agreements to allow the sharing of IPRs, the COVAX project as a vaccine supplier, the proposal of the CVTA to increase the availability of inputs of production and the establishment of a technology transfer hub in South Africa.

In every respect the case of South Africa was the most successful realization of scaling-up COVID-19 vaccines production. In fact, the agreement between Johnson and Johnson and Aspen allows the South African company to distribute the vaccine under the brand Aspenovax, thus setting prices and selling it all over Africa. Even though Aspen has not yet received any order, the agreement allows the company to strengthen in terms of technologies and know-how and to function as benchmark for any possible future event or sanitary crisis.

List of Tables and Figures

Bibliography

Adepoju, P. (2022). Lack of orders could halt COVID-19 vaccine production in South Africa. *Devex*.

Amador, J., & Cabral, S. (2014). Global value chains: A survey of drivers and measures. *Journal of Economic Surveys*.

Andrenelli, Gonzales, & Sorescu. (2021). Using trade to fight COVID-19: Manufacturing and Distributing Vaccines. *OECD Publishing*.

Antras, P. (2020). Conceptual Aspects of Global Value Chains. *World Development Report*. World Bank.

Bair, J. (2005). Global Capitalism and Commodity Chains: Looking Back, Going Forward. *COMPETITION & CHANGE, Vol. 9, No. 2*, pp. 153–180.

Blenkinsop, P. (2021). Rich, developing nations wrangle over COVID vaccine patents. *REUTERS*.

Bolle, M. D., & Obstfeld, M. (2021). Waiving patent and intellectual property protections is not a panacea for global vaccine distribution. PIIE.

Bown, C. P. (2020). How the G20 can strenghten access to vital medical supplies in the fight against COVID-19. *PIIE*.

Bown, C. P. (2021). The world needs a COVID- 19 Vaccine Investment and Trade Agreement. *PIIE*.

Bownb, C. P., & Bollyky, T. J. (2021). How COVID-19 vaccine supply chains emerged in the midst of a pandemic. *PIIE*.

BownC, C. (2021). The world needs a COVID- 19 Vaccine Investment and Trade Agreement. *PIIE*.

Coveri, A., Cozza, C., Nascia, L., & Zanfei, A. (2020). Supply chain contagion and the role of industrial policy. *Journal of Industrial and Business Economics*, 47, 467-482.

De Backer, K., & Miroudot, S. (2014). Mapping Global Value Chains. European Central Bank.

Duan, Y., Dietzenbacher, E., Jiang, X., Chen, X., & Yang, C. (2018). Why has China's vertical specialization declined? *Economic Systems Resarch*, 30:2, 178-200.

Ducharme, J. (2021). COVAX Was a Great Idea, But Is Now 500 Million Doses Short of Its Vaccine Distribution Goals. What Exactly Went Wrong? *TIME*.

Elgar, K., Lopert, R., Carey, E., & Wenzl, M. (2021). Coronavirus (COVID-19) vaccines for developing countries: An equal shot at recovery. *OECD publishing*.

Evenett, S. (2021). Export controls on COVID-19 vaccines: Has the EU opened Pandora's Box? *VOXEU*.

Fisher, Kharenko, K., Ucel, C., & Yadav, P. (2021). Building the Supply Chain for COVID-19 Vaccines. *Harvard Business Publishing*.

Gareffi, G. (2020). What does the COVID-19 pandemic teach us about global value chains? The case of medical supplies. *Journal of International Business Policy*, 3, 287-301.

Gareffi, G., & Fernandez-Stark, K. (2016). Global Value Chain Analysis: A Primer. Duke Center on Globalization, Governance & Competitiveness .

Global Commission for Post-Pandemic Policy. (2022, January 1st). *COVID-19 VACCINE PRODUCTION, TO JANUARY 31ST 2022*. Retrieved from https://globalcommissionforpostpandemicpolicy.org/covid-19-vaccine-production-to-january-31st-2022/

Hopkins, T., & Wallerstein, I. (1977). Patterns of Development of the modern world-system. *Review : a journal of the Fernand Braudel Center for the Study of Economies, Historical Systems and Civilizations.* , Vol. 1, 111-145.

Horner, R. (2021). Global value chains, import orientation, and the state: South Africa's pharmaceutical industry. *Journal of International Business Policy*, 68-87.

Hummels, D., Ishii, J., & Yi, K.-M. (2001). The nature and growth of vertical specialization in world trade . *Journal of international economics*, vol. 54, issue 1, 75-96.

Hussman, K. (2021). Global access to Covid-19 vaccines: Lifting the veil of opacity. *U4 Issue*.

Ibrahim, I. A. (2021). Overview of Export Restrictions on COVID-19 Vaccines and their Components. *insights*.

Jerving b, S. (2021). Biovac Institute to be first African company to produce mRNA vaccines. *Devex*.

Jerving, S. (2021). Export restrictions in India could stunt Africa's 2021 vaccination goals. *Devex*.

Jerving, S. (2022). 6 African nations chosen for mRNA vaccine production. *Devex*.

Kamalahmadi, M. (2022). The impact of flexibility and redundancy on improving supply chain resilience to disruptions, . *International Journal of Production Research*.

Krapohl, S., & Fink, S. (2013). Different Paths of Regional Integration: Trade Networks and Regional Institution-Building in Europe, Southeast Asia and Southern Africa. *Journal of Common Market Studies,Volume 51*, 472–488.

Kretchmer, H. (2021). Vaccine nationalism – and how it could affect us all. *World Economic Forum* .

Kudlinsky, A. (2013). Harmonizing the national policies for healthcare, pharmaceutical industry and intellectual property: The South African experience. In *Emerging Markets and The World Patent Order*. Frederick M. Abbott, Carlos M. Correa, and Peter Drahos.

Kuriyama, C. (2021). Promoting Trade in Vaccines and Related Supplies and Equipment. *APEC Policy Support Unit, POLICY BRIEF No. 40*.

Mallapaty, S. (2022). Where did Omicron come from? Three key theories. *Nature*.

Maloney, C., & Segal, N. (2007). The Growth Potential of the Pharmaceuticals Sector in South Africa . *Genesis*.

McKinsey Global Institute. (2020). Risk, resilience, and rebalancing in global value chains.

Medecins Sans Frontieres. (2022). COVAX: A broken promise for vaccine equity.

Miroudot, S. (2020). Reshaping the policy debate on the implications of COVID-19 supply chains. *Journal of International Business Policy*, 430-442.

Moderna. (2020, August 10). STATEMENT BY MODERNA ON INTELLECTUAL PROPERTY MATTERS DURING THE COVID-19 PANDEMIC.

OECDa. (2020). Trade interdependencies in COVID-19 goods. *Tackling Coronavirus contributing to a global effort*.

OECDb. (2020). The Face Mask Global Value Chain in the COVID-19 Outbreak: Evidence and Policy Lessons. *Tackling Coronavirus contributing to a global effort*.

Paiva, E. L., & Miguel, P. L. (2021). Overcoming enduring inequalities in Global Value Chains? Interpreting the case of Brazil's Covid-19 vaccine supply through a chess metaphor. *Organization*.

Price, W. N., Rai, A., & Minssen, T. (2020). Knowledge transfer for large- scale vaccine manufacturing. *Science*.

Reuters. (2022). South Africa's Aspen signs deal to package and sell J&J COVID vaccine.

Ritchie, H., Mathieu, E., Rodes-Guirao, L., & Giattino, C. (2022). *Coronavirus (COVID-19) Vaccinations*. Retrieved from Our World In Data: https://ourworldindata.org/covid-vaccinations

Rydland, H. T., Friedman, J., Stringhini, S., Link, B., & Eikemo, T. A. (2022). The radically unequal distribution of Covid-19 vaccinations: a predictable yet avoidable symptom of the fundamental causes of inequality. *Nature*.

Satubaltina, A. (2021). Kazakhstan to Supply Its QazVac COVID-19 Vaccine to Other Countries Next Year. *The Astana Times* .

Stellinger, A., Berglund, I., & Isakson, H. (2020). How trade can fight the pandemic and contribute to global health. *COVID-19 and Trade Policy: Why Turning Inward Won't Work*.

Suganuma, K. (2016). Upstreamness in the Global Value Chain: Manufacturing and Services . *IMES discussion paper* .

Tomlinson, C. (2021). After a rough 17 years, is Biovac finally on track? *Daily Maveric*.

WHO. (2021, September 8). Joint COVAX Statement on Supply Forecast for 2021 and early 2022.

WHO. (2021). MPP, WHO, AFRIGEN, BIOVAC, SAMRC, and Africa CDC sign a letter of intent towards establishing the tech transfer hub in South Africa.

WHO. (n.d.). FAQ - The mRNA vaccine technology transfer hub .

WHO. (n.d.). With a fast-moving pandemic, no one is safe, unless everyone is safe. *COVAX*.

WTO. (2017). Recent patterns of global production and GVC participation. *Technological innovation, supply chain trade, and workers in a globalized world*, 9-43.

WTO. (2021). COVID-19 VACCINE PRODUCTION AND TARIFFS ON VACCINE INPUTS. *Information Note*.

WTO. (2021, October 2). WAIVER FROM CERTAIN PROVISIONS OF THE TRIPS AGREEMENT FOR THE PREVENTION, CONTAINMENT AND TREATMENT OF COVID-19. *COMMUNICATION FROM INDIA AND SOUTH AFRICA* .

WTO. (2022). *WTO-IMF COVID-19 Vaccine Trade Tracker*. Retrieved from https://www.wto.org/spanish/tratop_s/covid19_s/vaccine_trade_tracker_s.htm

WTO. (n.d.). TRIPS — Trade-Related Aspects of Intellectual Property Rights.

WTO. (n.d.). *WTO.org*. Retrieved from Glossary: https://www.wto.org/english/thewto_e/glossary_e/mfn_tariff_e.htm