Patents and the Covid-19 vaccines

by Vincenzo Denicolò*

Abstract
The Covid-19 pandemic has shown that our pharmaceutical innovation system is capable of delivering results, but it has also highlighted the possibility of a new model of innovation, in which the gap between basic and applied research is getting smaller and smaller. An analysis of the topic is provided to offer an overview and stimulate debate.

1. Introduction

The Covid-19 pandemic has posed a major challenge on the pharmaceutical innovation system.

In 2020, extensive lockdowns were the only effective tool to contain the spread of the virus. In that year, the pandemic claimed 2 million lives and caused a massive worldwide recession. Governments faced a tragic trade-off between public health and national income and were desperate for effective treatments. Any medical innovation that could help prevent or cure the disease was regarded as invaluable.

With so much at stake, the pharmaceutical innovation system undeniably delivered. The first Covid-19 vaccine was approved in December 2020, just 10 months after the breakout of the pandemic. (By way of comparison, the average time needed for the approval of new drugs exceeds 10 years). In the following months, several other vaccines have become available. More recently, antiviral drugs have been developed that seem effective against the Covid-19 disease, and they too are being approved at record speed.

Naturally, the production capacity for Covid-19 vaccines was small at first. In the first half of 2021, even rich countries struggled to procure the vaccines, and the poor ones were almost completely excluded. In a few months, however, things have changed. By the end of 2021, more than 10 billion doses will have been produced worldwide.

Today, rich countries have enough doses to vaccinate their entire population, and vaccines have started to be delivered to middle-income and poor countries.

As vaccination campaigns proceed, economies are recov-

* University of Bologna and CEPR, London.

ering. In many regions, national income will have returned to the pre-pandemic levels by the end of 2021, or at most in the first semester of 2022.

This sounds like a success story. Yet, the Covid-19 pandemic has prompted a heated debate on pharmaceutical innovation and the way it is organized and promoted. At the center of this debate is the role of the intellectual property protection granted to vaccines and drugs. Commentators, scholars, and governments have proposed a waiver of intellectual property rights on Covid-19 vaccines and the new antiviral drugs that will be available soon. So far, however, no such waiver has been agreed on.

This article reviews the policy debate and discusses possible reforms of the current system of pharmaceutical innovation.

2. The social costs of patents

A patent gives an inventor the exclusive right to manufacture, use or sell the invention for a period of time, which is usually 20 years from the date of patent application. This exclusivity period often confers to the inventor some market power. When this market power is exercised with the goal of maximizing the inventor's profit, it generally results in a contraction of output and an increase in prices. The contraction of output means that consumers will consume less, and the increase in prices means that they will pay more for what they consume. These effects represent the main social costs of patents.

2.1. *Rich countries*

In rich countries, the social costs of patents on Covid-19 vaccines have been mild in comparison to other pharmaceutical patents and to the value of the vaccines. To substantiate this claim, I consider in turn the price and output effects of the patents on Covid-19 vaccines.

a. Price

Patents on new drugs sometimes result in exorbitant prices that may significantly limit access to the medicines. For example, when the hepatitis-C drug *sofosbuvir* was first launched in 2013, it was priced at more than $80,000 per treatment. With a production cost estimated at less than $150, this represented a price-cost margin of over 50,000%.

In the case of the Covid-19 vaccines, price-cost margins appear to be much lower. Although the exact costs of production per dose are unknown, a reasonable estimate puts them in the range of €1-3. As for prices, they vary from vaccine to vaccine. The Oxford/AstraZeneca vaccine is allegedly priced at cost as per contractual clauses imposed by the University of Oxford on AstraZeneca. The price is, indeed, around €3 per dose. The Janssen vaccine is priced at around €7 per dose, with a price-cost margin in the order of 100%. The main mRNA vaccines, Moderna and BioNTech/Pfizer, are more expensive. For example, the Moderna price is now reportedly close to €25 per dose, which would translate into a price-cost margin of about 1,000%. This is high, but it is 50 times lower than that of *sofosbuvir*.

In view of the huge social value of the vaccines, these prices are all but exploitative. For a country such as Italy, which by the end of 2021 will have purchased around 100 million doses, the total expenditure will be less than €2 billion. This is approximately the same economic cost as just *one week* of the relatively mild lockdown we experienced in the spring of 2021. It therefore

appears that the economic benefits of the vaccines are a large multiple of the costs, even without including into the calculation the value of saved human lives. No doubt, Italy would have been prepared to pay for the vaccines much more than it actually paid.

One wonders why then prices are not higher. There are several possible answers to this question. First, the Oxford/AstraZeneca vaccine is priced at cost at the request of the University of Oxford, which originally developed the vaccine. Likewise, other vaccines received substantial public funds on the explicit or implicit understanding that the price would have been kept at reasonable levels. Second, from the outset several vaccines have been competing with one another. This competition is possible because patents are relatively narrow and confer exclusive property rights over a specific vaccine, not on all Covid-19 vaccines. Third, pharmaceutical companies may voluntarily restrain their pricing for fear of regulatory intervention in the form, for instance, of compulsory licensing, or of a suspension of patent rights[9].

b. Output

In the spring of 2021, with several Covid-19 vaccines already approved, even rich countries still struggled to procure the vaccines. Some commentators blamed patents for the scarcity of vaccines, on the grounds that one of the effects of patents is precisely the contraction of output.

But in fact, high prices and low output are the flip sides of the same coin: the patent holder contracts output only to the extent that this is necessary to keep the price at the target level. In other words, once prices are set, pharmaceutical companies have no reason to ration demand. They would have no incentive to ration even under monopoly, but this is true *a fortiori* when there is some competition among the firms, as the demand that a firm does not meet will then be satisfied by its competitors.

The initial shortage of vaccines was not, therefore, a strategic choice of pharmaceutical companies. The simple truth is these companies needed time to scale up production. Even though the manufacturing process was initiated even before the vaccines were approved, expanding the output took time because the production of vaccines is a complex endeavor, especially for the mRNA vaccines that rely on a very innovative technology. In a few months, however, production capacity has been enlarged and now in rich countries there is no shortage of vaccines.

One may wonder whether the increase in production could have been faster in the absence of patent protection. The answer is probably no. In the very short run, patents are not a crucial factor: inventors are already protected by "lead time" advantages, i.e., the simple fact that imitation takes time. Even when there are no legal barriers to the exploitation of the innovative technological knowledge, that is to say, learning to practice an innovation may be no easy task because of the need to acquire so-called tacit knowledge. Think, for instance, of the difficulty of learning new surgery techniques even if they have been described in the medical literature. (Incidentally, this explains why no firm other than Moderna has yet tried to manufacture the Moderna vaccine even though Moderna stated that it would not enforce its patents for some time).

Therefore, it seems unlikely that suspending patent rights could have helped increase the production of Covid-19 vaccines in 2021. Any expansionary effect on output would have probably taken more time.

2.2. *Poor countries*

In the previous subsection, I have argued that the prices of Covid-19 vaccines have not effectively restricted access to the treatment in rich countries. Today, all Italians, Germans and British who want to be vaccinated can get their shots almost instantly. When it comes to poor countries, however, the situation is more complicated.

In Uganda, for instance, per-capita health expenditure is about $50 per year. Purchasing the mRNA vaccines (which are, arguably, the best performing ones) at the current prices would pose a significant burden on Uganda's national health system. In addition, vaccines must be delivered to the population, and this poses further challenges in countries where sanitary infrastructures are rudimentary. It therefore comes as no surprise that only 1% of Uganda's population has been vaccinated so far.

In fact, the rate of vaccination is below 10% in most African countries, and it is just 25% even in a middle-income country such as India. Even though other factors may also play a role, it seems that a reduction in the price of the vaccines may be an important element of a successful vaccination campaign in developing countries. To the extent that patents prevent such a reduction, they may impose social costs that are not as limited as those borne by rich countries.

3. Remedies

What can policy do to facilitate access to Covid-19 vaccines in poor countries? This section discusses three possible strategies, which are presented in increasing order of patent-rights weakening.

3.1. *Voluntary practices*

The first strategy relies on the goodwill of pharmaceutical companies and rich-country governments. It calls for these governments to donate millions of doses to poor countries, and for pharmaceutical companies to selectively reduce the price of the vaccines in poor or middle-income countries.

In fact, these actions could be carried out even by non-altruistic agents. Given the ease of transmission of the Covid-19 virus, and the fact that the protection afforded by the vaccines is limited, vaccinating as much as possible of the world population is also in the self-interest of the rich countries. The donations of vaccines may therefore be regarded as an investment in public health by donating countries.

As for the pharmaceutical companies, the profit foregone by selectively reducing the price in middle-income or poor countries is probably small, perhaps even non-existent. For one thing, in the case of the Covid-19 vaccines the risk of parallel trade is limited, as vaccines are purchased almost exclusively by governments and public institutions. For another thing, charging different prices in different countries is a common marketing strategy, called price discrimination, which may well be profitable for the seller. One could therefore say, paraphrasing Adam Smith, that "it is not from the benevolence of the pharmaceutical companies that the poor countries may expect their vaccines but from their regard to their own self-interest".

Nevertheless, some commentators doubt that these voluntary practices may suffice to provide enough vaccines for the entire world population. More interventionist strategies have therefore been proposed.

3.2. *Compulsory licensing*

Compulsory licensing is when a government authorizes the production of a patented product even without the consent of the patent holder. Under the TRIPS agreements of 1994, compulsory licensing is permitted under some conditions. The most frequently invoked reason for compulsory licensing is public health, and there is little doubt that the Covid-19 pandemic would be a valid justification.

Therefore, a country such as India, for instance, can invoke the TRIPS agreements and right now ask for a compulsory licensing of the patents that protect the Covid-19 vaccines. If the compulsory license is agreed upon by the World Trade Organization (WTO), Indian firms could then produce the vaccines upon payment of a "reasonable royalty" to the patent holders – a royalty that would likely be quite low. Under the Doha Declaration of 2001, Indian firms could even export the vaccines to other countries that lack the technological capabilities to manufacture the vaccines and have also requested a compulsory license. However, Indian firms could not export the vaccines to other countries.

There is much to say in favor of this solution. An extensive application of compulsory licensing would be an effective way of reducing the price of vaccines in poor countries, leaving a substantial profit margin in the rich ones. The profits reaped in rich countries could allow the pharmaceutical companies to recoup their R&D costs. This solution could therefore represent a reasonable compromise between the goal of guaranteeing access to the vaccines and that of incentivizing the research on innovative drugs.

3.3. *Waiving intellectual property rights*

In October 2020, India and South Africa proposed a waiver of intellectual property rights on Covid-19 vaccines and drugs for the duration of the epidemic. Various countries, including the US, have backed this proposal. Other countries, however, are against it. The proposal is unlikely to be approved as this requires a qualified majority of countries, but nevertheless it has been extensively debated.

There are two main differences between compulsory licensing and a waiver of intellectual property rights. The first one is relatively minor: with a waiver, producers of generics will not have to pay any royalty to patent holders. Since the reasonable royalties to be paid in case of compulsory licensing are small, however, this factor seems to be of secondary importance. A more relevant difference is that a waiver of Covid-19 related patents would allow the production or import of generics also in rich countries. As noted, this would probably have little impact in the very short run, but in the longer run it could erode the patent holders' profit margins.

The problem with a waiver of patent rights is that it will significantly impair the incentives to innovate. Inventing new vaccines or new drugs is a very risky and costly endeavor. In the market economies we live in, drug innovation is largely delegated to private companies that seek to maximize their profits rather than the common good. So, who

would invest in the search for new drugs without the prospect of recouping the R&D costs and making a profit?

The need of incentivizing the investments in R&D was indeed acutely felt before the vaccines were developed, to the point that various governments entered in "advance purchase agreements" with companies holding promising candidates and directly funded some of them. Now that several vaccines are available, it may seem natural to put more emphasis on the issue of the access to the treatment. However, this approach is short-sighted. The Covid-19 pandemic may not be the last one, and we must preserve the incentives to invest in the search for the next vaccines.

More generally, it is always efficient to waive patent rights *ex post*, after the innovation has been achieved. A forward-looking policy, however, must take an *ex-ante* perspective, as if the innovation were yet to come. To put it differently, society must strike a balance between the goals of encouraging innovation on the one hand, and the diffusion of the new products on the other hand. A waiver of intellectual property rights puts all the weight on the goal of diffusion. But if the incentives to innovate are destroyed, there will be no innovative technologies to be diffused.

4. Rethinking pharmaceutical innovation

So far, I have argued that our pharmaceutical innovation system has performed well in the Covid-19 pandemic. The social costs of patents have been relatively mild, and they can be further limited within the existing institutional framework by the adoption of sensible policies.

Still, one may wonder why such an important task as that of developing new drugs is being delegated to market forces. Is a different system feasible?

To answer that question, it may be useful to note a striking feature of the development of Covid-19 vaccines, i.e., the limited role played by the so-called "big pharma". The AstraZeneca vaccine was designed by a team of researchers at the University of Oxford, and the pharmaceutical company entered into play only at the stage of clinical tests. The same is true of Pfizer with the BioNTech vaccine. Moderna and BioNTech are both, effectively, university spin-offs. Of the four major vaccines used in western countries, only the Janssen vaccine has been developed entirely by a big pharmaceutical company.

Leaving the clinical testing aside, it seems that universities and public research centers possessed all the technological capabilities required to develop the vaccines on their own. This is probably true, to some extent, of many other drugs. For example, *sofosbuvir* was invented at Pharmasset, a small pharmaceutical company founded by scientists from Emory University. Only later was Pharmasset bought by Gilead, which completed the clinical tests and commercialized the drug.

Compared to the traditional picture where pharmaceutical companies do all the R&D, a new pattern seems to emerge here. When basic scientific research shows some promise of pharmacological applications, scientists tend to leave the academy, patent the results of their scientific research, and create their own spin-offs to conduct more applied research. And when this more applied research succeeds, resulting in candidate drugs that are ready for the clinical tests, the spin-

offs enter in joint ventures with bigger pharmaceutical companies, or are acquired by them. The big companies conduct the tests and commercialize the product.

In other words, there seems to be a closer and closer relationship between basic scientific research and the design of new drugs, and the comparative advantage of big pharmaceutical companies seems to be more and more limited to the stage of clinical testing.

If this is so, then a new model of pharmaceutical innovation seems possible. In this new model, private companies would play a much more limited role than they do today. This would reduce or eliminate the many distortions that market forces may create in a sector such as the pharmaceutical one.

The first step towards the implementation of the new model is the abolition of patents on drugs. This would stop the hemorrhage of scientists from universities and public research centers to for-profit spin-offs created *ad hoc*. Without the protection of patents, scientists would have much less incentives to leave the academy; they would continue their research there.

The second step is the creation of incentives for universities and public research centers to engage into more applied research, bridging the remaining gap between purely academic research and the design of new drugs. This is probably the most critical part of the suggested reform. It raises several specific issues, which will not be analyzed here.

The third step is the nationalization of the clinical testing. Clinical tests are already heavily regulated and are often hosted in public hospitals or public health institutions. Nationalizing the entire process seems therefore relatively simple. It could create big efficiencies, eliminating the conflicts of interests between the owners of drug candidates, the doctors who are engaged in the testing, and the regulatory agencies.

Pharmaceutical companies would be responsible only for the manufacturing of the drugs. With no patent protection, all drugs would be generics. The pharmaceutical sector would be highly competitive, and the prices of new drugs would be close to production costs.

5. Conclusion

The Covid-19 pandemic has shown that our pharmaceutical innovation system can deliver, but it has also exposed a new pattern of innovation, where the gap between basic and applied research is getting smaller and smaller. This suggests that we could adopt a different system, which is not based on market forces and intellectual property rights. Perhaps the suggested reform is utopian, but it has the potential to reduce the many inefficiencies created by our current system of pharmaceutical innovation.

Notes

1. DiMasi J.A., Grabowski H.G., Hansen R.W., *Innovation in the pharmaceutical industry: New estimates of R&D costs*, J Health Econ, 2016, May; 47:20-33. DOI: 10.1016/j.jhealeco.2016.01.012.

2. See Vaccine Manufacturing, *Launch and Scale Speedometer* [available at https://launchandscalefaster.org/covid-19/vaccinemanufacturing; latest access 14/11/2121].

3. In return, the inventor must disclose the innovation fully. In pharmaceuticals, the effective life of patents is typically shorter than the statutory term of 20 years because of the time needed to pass the pre-clinical and clinical tests that are necessary to get regulatory approval. As noted, the development of a new drug takes on average more than 10 years. For this reason, in most countries there exist special provisions that extend the duration of pharmaceutical patents for some time. Even accounting for these extensions, however, the average effective patent life in pharmaceuticals is around 12 years: see, e.g., Grabowski H., Long G., Mortimer R. (2014), *Recent trends in brand-name and generic drug competition*, Journal of medical economics, 17(3), 207-214. This issue however is largely irrelevant for the Covid-19 vaccines. Given their extraordinarily fast approval, their effective patent life will be close to 20 years.

4. See the 2015 *Report of the Committee on Finance of the US Senate, The Price of Sovaldi and Its Impact on the U.S. Health Care System* [available at https://www.finance.senate.gov/imo/media/doc/1%20The%20Price%20of%20Sovaldi%20and%20Its%20Impact%20on%20the%20U.S.%20Health%20Care%20System%20(Full%20Report).pdf; latest access 30/11/2021].

5. See Hill A., Khoo S., Fortunak J., Simmons B., Ford N. (2014), *Minimum costs for producing hepatitis C direct-acting antivirals for use in large-scale treatment access programs in developing countries. Clinical Infectious Diseases*, 58(7), 928-936. Their estimate of the unit production cost of *sofosbuvir* is in the range of $68-136.

6. See Light D.W., Lexchin J., *The costs of coronavirus vaccines and their pricing*, J R Soc Med., 2021, November; 114(11):502-504; DOI: 10.1177/01410768211053006, which actually places the cost at less than $1 but probably underestimates the true cost. Note that this is the unit production cost, which does not include the costs of developing the vaccine.

7. For a more systematic attempt at quantifying the economic value of the vaccines for the US, see Padula W.V., Malaviya S., Reid N.M., Cohen B.G., Chingcuanco F., Ballreich J., Alexander G.C. (2021), *Economic value of vaccines to address the Covid-19 pandemic: a US cost-effectiveness and budget impact analysis*. Journal of Medical Economics, 24(1), 1060-1069.

8. For example, the price of the hepatitis-C drugs fell substantially as new competing drugs were brought to the market: see, for instance, Barber M.J., Gotham D., Khwairakpam G., Hill A. (2020), *Price of a hepatitis C cure: Cost of production and current prices for direct-acting antivirals in 50 countries*, Journal of Virus Eradication, 6(3), 100001.

9. In fact, a single vaccine may be protected by a number of different patents, each of which covers a specific innovative component of the vaccine. For example, Moderna claims that it holds at least seven patents that protect its vaccine. On the other hand, other patents may read on more than one vaccine. For example, all mRNA vaccines exploit a technology patented by the University of Pennsylvania, which modifies the mRNA so that it does not trigger a response by the immune system. Both Moderna and BioNTech have sub-licensed the patents that protect this technology from a licensee of the University of Pennsylvania. See Gaviria M., Kilic B. (2021), *A network analysis of Covid-19 mRNA vaccine patents*, Nature Biotechnology, 39, 546-548.

10. This explanation is sometimes referred to as the "regulatory pre-emption theory".

11. In principle, there could be another, subtler reason for the relatively low prices, which has to do with the so-called "Coase conjecture". Since vaccines are, at least partially, a durable good, even a monopolist faces the competition of its own future supply: see Coase R.H. (1972), *Durability and monopoly*, The Journal of Law and Economics, 15(1), 143-149. Under some conditions, this implies that prices should immediately fall at the competitive level. In practice, however, given buyers' impatience and firms' capacity constraints, it seems unlikely that this effect may have played a significant role.

12. See, for instance, Kisby T., Yilmazer A., Kostarelos K. (2021), *Reasons for success and lessons learnt from nanoscale vaccines against Covid-19*, Nature Nanotechnology, 16(8), 843-850.

13. On the importance of lead time, see Cohen W.M., Nelson R., Walsh J.P. (2000), *Protecting their intellectual assets: Appropriability conditions and why US manufacturing firms patent (or not)*, NBER WP 7552.

14. See Coronavirus (Covid-19) Vaccinations, Statistics and Research, Our World in Data [available at https://ourworldindata.org/covid-vaccinations; latest access 14/11/2121].

15. The risk of parallel trade is often regarded as the main reason why pharmaceutical companies refrain from

reducing prices in poor countries. Parallel trade is the practice of buying products in countries where they are sold at lower prices and selling them in high-price countries: see Danzon P.M., (1998), *The economics of parallel trade*, Pharmacoeconomics, 13(3), 293-304.

16. The WTO is responsible for the implementation of the TRIPS agreements on intellectual property.

17. See e.g. Sykes A.O. (2002), *TRIPS, pharmaceuticals, developing countries, and the Doha solution*, Chi. J. Int'l L., 3, 47.

18. The proposal may be found at Documents Online Home page (wto.org) [available at https://docs.wto.org/dol2fe/Pages/FE_Search/FE_S_S005.aspx; latest access 30/11/2021].

19. These profits are far from negligible. Both BioNTech and Moderna, for instance, have reported profits of around €4 billion in the first semester of 2021: see BioNTech Announces Second Quarter 2021 Financial Results and Corporate Update | BioNTech [available at https://investors.biontech.de/news-releases/news-release-details/biontech-announces-second-quarter-2021-financial-results-and; latest access 30/11/2021] and Moderna Reports Second Quarter Fiscal Year 2021 Financial Results and Provides Business Updates | Moderna, Inc. (modernatx.com) [available at https://investors.modernatx.com/news-releases/news-release-details/moderna-reports-second-quarter-fiscal-year-2021-financial; latest access 14/11/2121].

20. On the optimal resolution to the innovation-diffusion trade-off see for instance Denicolò V. (2007), *Do patents over-compensate innovators?*, Economic Policy, 22(52), 680-729.

21. See Garde D., Saltzman J., *The story of mRNA: How a once-dismissed idea became a leading technology in the Covid vaccine race*, Boston Globe, November 10th, 2020 available at The story of mRNA: From a loose idea to a tool that may help curb Covid (statnews.com) [available at https://www.statnews.com/2020/11/10/the-story-of-mrna-how-a-once-dismissed-idea-became-a-leading-technology-in-the-covid-vaccine-race/; latest access 30/11/2021].

22. In fact, the role of big pharma is even more limited if one considers also the Indian, Russian, Iranian and Chinese vaccines, most of which have been developed by public research centers.

23. See Gentile I., Maraolo A.E., Buonomo A.R., Zappulo E., Borgia G. (2015), *The discovery of sofosbuvir: a revolution for therapy of chronic hepatitis C*, Expert opinion on drug discovery, 10(12), 1363-1377.

24. To mention just one such distortion, pharmaceutical companies' marketing expenditure compares to their expenditure on R&D: see, e.g., Gagnon M.A., Lexchin J. (2008), *The cost of pushing pills: a new estimate of pharmaceutical promotion expenditures in the United States*, Plos medicine, 5(1), e1.

25. For an economic analysis of some of these conflicts of interests, see Henry E., Ottaviani M. (2019), *Research and the approval process: The organization of persuasion*, American Economic Review, 109(3), 911-55.