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Optimal Patent Protection Length for Vital Pharmaceuticals in the Age of COVID-19

Alexis Habiyaremye

DSI/NRF SARChI Chair in Industrial Development, University of Johannesburg, Auckland Park, Johannesburg 2006, South Africa; habiyaremye@merit.unu.edu

Abstract: The highly unequal access to COVID-19 vaccines observed at a critical moment of the pandemic coupled with the considerable profits cashed by the main vaccine producers have brought the debates on patent protection back into sharp focus. The trade-off between the need to encourage innovation through patent protection and the right of populations across the world to access life-saving pharmaceutical products raises important concerns that go beyond innovation stimulation. This paper leans on the inclusion of non-economic considerations based on social identity theory in optimization strategies to analyze the arguments underlying the patent length in the pharmaceutical industry and questions the measurement of social benefits of innovation in the Nordhaus's model in its applicability to the case of vital pharmaceuticals. It proposes some new considerations akin to extra welfarism in the microeconomic analysis of the social welfare underlying traditional arguments in support of long patent protection periods. Simplified comparative statics are employed to show that, from the social welfare point of view, an incentive system in which a reward equivalent to the discounted profits is remitted to the innovator yields higher social welfare than monopoly protection without diminishing the incentive to innovate. These results suggest that in the case of vital medicines such as vaccines and antiretroviral drugs for HIV/AIDS treatment, social welfare is maximized by imposing compulsory licensing and making treatment accessible to all (potentially) infected citizens.

Keywords: patents; social welfare; innovation; R&D incentives; pharmaceutical industry

Citation: Habiyaremye, A. Optimal Patent Protection Length for Vital Pharmaceuticals in the Age of COVID-19. *Sustainability* **2022**, *14*, 9799. https://doi.org/10.3390/su14169799

Academic Editors: Panagiotis Petrakis, Pantelis Kostis and Elias Carayannis

Received: 31 May 2022
Accepted: 3 August 2022
Published: 9 August 2022

1. Introduction

The outbreak of the COVID-19 pandemic and the subsequent hoarding of COVID-19 vaccines by rich countries have brought the problematic nature of patent protection back into sharp focus and reignited the debate on the trade-off between the protection of intellectual property rights and the right to life in the face of a deadly pandemic [1–4]. The magnitude of profits generated by patented pharmaceuticals has equally raised significant concerns about the appropriation of innovation benefits, especially considering public investments made to support the underlying innovations. The Moderna COVID-19 vaccine, for example, generated a total revenue of USD 18 billion for the year 2021, with a corresponding pre-tax profit of USD 13 billion (good for a 70 percent profit margin), while the Pfizer-BioNTech vaccine brought in a whopping USD 37 billion over the same period [5]. The high sales prices of life-saving pharmaceuticals during life-threatening situations such as those seen in the sale of COVID-19 vaccine for USD 37 per dose to some developing countries also raise ethical concerns [5]. In addition to high monopoly profits, the strategic use of patenting in the pharmaceutical industry as a tool to fend-off competition has also been increasingly questioned, not only because of its potential harmful impact on innovation diffusion, but also for its role in restricting access to affordable medicines [5–12]. This paper revisits the debate on optimal patent protection based on the Nordhaus [13] model and presents an alternative static welfare analysis tool for innovations with an inelastic demand, such as vaccines and vital pharmaceuticals.

Some of the negative effects of stringent patent protection on access to life-saving pharmaceuticals were on display with the highly skewed access to COVID-19 vaccines at the height of the pandemic. While more than 6.5 billion vaccine doses had been administered globally by the end of September 2021, 75 percent of all vaccines produced globally have been used by high and upper middle-income countries, with less than 0.5 percent of them going to low-income countries [14]. Most COVID-19 vaccine producers have refused to share the technology and know-how that would have enabled developing countries to produce the needed vaccine doses locally [14]. Major mRNA-based vaccine producers have also declined to support public health-oriented licensing. The World Health Organization [14] estimates that this monopolization of patented vaccines led to an effective exclusion of 56 low-income countries (most of them located in Africa) from reaching their WHO vaccination targets.

Beyond the usual considerations of innovation stimulation and inefficiencies in the productive use of patented knowledge, patent protection of vital pharmaceuticals has adverse implications for the right to life, with potentially devastating consequences [5,12,15]. As exemplified by the Doha declaration on the protection of public health or the ongoing debate about making the COVID-19 vaccine MRNA technology available to developing countries, strong patent protection clashes with the imperatives of access to vital pharmaceuticals. Lack of COVID-19 vaccine access in developing countries has led to jeopardizing the realization of multiple sustainable development goals (SDG) as their multiple objectives are often interdependent [16]. The requested sharing of vaccine-related technological knowledge with developing countries can thus be expected to act as a stimulus not only to health protection (SDG3) but also to fostering innovation and industrialization (SDG 10). The argument in support of private appropriation of publicly funded discoveries as necessary to induce innovation is considerably weakened by existing practices in the pharmaceutical industry, since the involvement of the private sector mostly occurs at the development and exploitation phase, rather than at the discovery phase. It is indeed generally admitted that the basic research that leads to the discovery of new drug lead molecules has predominantly been publicly funded, and only later licensed to private firms for development and exploitation [17].

As highlighted by Becker [18] in relation to the pharmaceutical industry, the patent system creates a tension between the effects of high prices on reducing the use of drugs by those who acutely need them, and the effect of high profit margins on helping companies recoup their large R&D spending. The resulting public policy question is therefore whether a better system can be put in place to deal with this tension more efficiently. The analysis presented in this paper discusses a theoretical approach to the estimation of optimal patent length in the pharmaceutical industry by examining the theoretical arguments underlying the patent protection and by questioning the measurement of social benefits of innovation in the Nordhaus model [13] and its applicability to the case of pharmaceuticals. The Nordhaus model is a widely recognized framework for analyzing the optimal length of patent protection that balances the efficiency loss due to the monopolies granted to patent holders for the purpose of stimulating innovation and the social welfare generated by the wide diffusion of new discoveries. That model relies on traditional welfare maximization of social welfare based on profits accruing to the innovators as well as the consumer surplus that accrue to consumers as a result of access to new products and the lowering of costs. In contrast to the neoclassical maximization approach based on pure economic aspects, this paper proposes the inclusion of non-economic considerations from social identity theory in the comparative statics of social welfare on the length dimension of patent protection [19–22]. Indeed, arguments based on social identity theory advance that, as individual and social identities evolve within social groups, depersonalization emerges and values shift increasingly towards achieving societal goals such as cooperation, altruism, environmental sustainability, and societal wellbeing, rather than individual utility maximization based on intertemporal allocation of consumption [21,23–27]. When social identity is salient in a society where the basic needs are satisfied, non-economic

considerations can mean that individuals may even be willing to sacrifice own personal rewards for the maximization of group advantage they identify with [25,27]. Such an approach is already applied by the extra-welfarism theory in health economics, which considers health maximization as the main objective irrespective of whose health receives the needed care within a society [28–30]. It provides a similar theoretical framework and constitutes the foundational argument for national health insurance schemes in countries such as the United Kingdom, France, Belgium, or the Netherlands. For simplicity, our analysis leaves out the other dimensions of patent design and uses the insights from patenting strategies and patent races to unveil the weaknesses of the patenting system in general, and patenting for pharmaceuticals in particular.

The paper also draws on arguments for an alternative incentive regime for the stimulation of research and innovation through patronage, procurement, and property proposed by David [31] to show that a reward-based system can yield better social welfare outcomes than monopoly protection. In such a system, a reward equivalent to the discounted profits would be remitted to the innovator to keep the stimulus for innovation, while allowing the benefits of innovation to diffuse immediately to the consumers without having to wait for a lengthy patent monopoly period to lapse. Hence, we propose compulsory licensing as an alternative to patenting for the cases involving innovation in essential products, with benefits that go beyond the estimated social welfare measures.

The paper is structured as follows: the next section discusses the theoretical arguments underpinning the trade-offs involved in the patenting systems while Section 3 presents the social welfare analysis for essential medicines and vaccines, taking their implications for the right to life into consideration. The fourth section sketches an analytical model based on Nordhaus [13], from which we derive the optimal patent length suitable for pharmaceutical products. It links the alternative optimization motives to the growing importance of the concept of creative economies to enhance sustainability. The final section concludes and offers some recommendations for improving access to life-saving pharmaceuticals.

2. Theoretical Considerations on Patent Monopoly and Innovation Incentives

A patent is defined by the World Intellectual Property Organization (WIPO) as "an exclusive right granted for an invention, which is a product or a process that provides, in general, a new way of doing something, or offers a new technical solution to a problem". The patent is usually granted on the condition that the applicant disclose the relevant technical information about the invention in sufficient detail to enable those who are skilled in the corresponding field to practice that invention [32]. Ever since its institution to encourage innovation in the early renaissance Europe, the monopolistic appropriation of the innovation benefits through patent protection has been the object of considerable scrutiny, inquiry, and debate (see e.g., [13,31,33–38]). The effects of patenting on knowledge diffusion and innovation performance also remain at the heart of recurrent debates. The main rationale and principal argument put forward in support of patent protection (and intellectual property rights in general) is the need to stimulate innovations and their diffusion by granting the inventors the exclusive right to appropriate the profits generated by their inventive efforts or their creativity [11,35,39–42].

In cases involving sequential innovations that build on previous discoveries, strong patent protection laws can frustrate efforts to create new technological knowledge by impeding the application of patented previous inventions. This may lead to a sub-optimal use of the new knowledge and lower investments in follow-on innovations ([36,43,44], etc.). The monopoly rights guaranteed by patents also induce static welfare losses by keeping prices above what is socially optimal ([13,41,42,44], etc.). Theories of the economics of patenting are therefore concerned with the trade-off between the short-run static welfare losses due to monopoly and the dynamic gains of innovation in the long run [31,41,45].

Mazzoleni and Nelson [46] identify four principal theories that form the underpinning of the patenting system: (1) the *invention motivation* theory; (2) the *disclosure* (or inven-

tion dissemination) theory; (3) the *induce commercialization* theory; and (4) the *exploration control* theory.

The invention motivation theory supports strong patent protection systems by invoking the high costs of research and development (R&D) as a justification for granting enough monopoly profits to encourage investments in the necessary research leading to. the invention [13,35,39,40,46,47]. It argues that patent monopolies increase the expected profits and thus make it easier to recoup those investments. Such a protection is deemed particularly essential in industries such as pharmaceuticals and fine chemicals [41,48].

The threat of COVID-19′s relentless spread in areas that are unable to access or afford the patented vaccines remains hanging over our heads; the discussion about the appropriation of the innovation benefits has therefore shifted from the economic analysis of social welfare to the question of human equity and access to health between developed nations (as innovators and patent holders) and developing countries (users of patented products or technologies). The arguments for optimal patent length based on the Nordhaus [13] model and similar arguments seem therefore insufficient to provide clarity in the current debate. The question of whether there should be any patent protection at all for pharmaceuticals, and if so, for how long, remains an object of divergence of views among innovation economists.

Strong patent protection can also serve the goal of providing incentives to invent for individuals or small companies that are constrained in their ability to use the invention themselves, by reducing the transaction costs for the sale of the rights to exploit it [41,49,50]. This theory is however contradicted by the observation suggesting that holding patents on radical innovations (i.e., those that have a sufficiently high inventive step) allows the innovator to enjoy relatively large monopoly (quasi) rents during the patent protection period [51]. The level of monopoly rents enjoyed implies that the incumbent innovators are less motivated than their competitors to introduce a next generation radical change because of the creative destruction and the business stealing effect that may take place when the new products or the new technology replaces the existing one as in Aghion and Howitt [40]. The total benefits (after deduction of R&D costs) of a next innovation accrue to a challenger if he introduces the new generation product, while the incumbent monopolist would only gain the difference between the new generation rents and the current monopoly rents. By contrast, the incumbent patent holder has an advantage at introducing incremental innovations and improvements of his current invention (corresponding more or less to utility-models-like inventive steps) so as to reinforce his monopoly position. This lower motivation for radical innovation in the case of an incumbent patent holder with monopolistic power has been pointed out by Arrow [35] and empirically confirmed by Geroski [52].

The *disclosure* (or *invention dissemination*) theory asserts that society benefits when the knowledge contained in the new discovery is immediately disclosed for new users to apply it instead of relying on trade secrets to protect the proceeds from the innovation [41,53]. The disclosure required for patenting an invention provides details about the corresponding technical knowledge and enables licensing, thereby contributing to a more rapid diffusion of its application. In that sense, disclosure is essential for spreading the benefits of invention throughout the economy, under the assumption that involved licensing transaction costs do not distort the market [41]. The advantages of disclosure appear to be more effective for process innovations than for product innovations [53].

The *induce commercialization* theory contends that the patenting of an invention in early stages enables the inventor to go to the financial market and access the funds that may be needed to develop it further and make it ready for commercial use. The acquisition of a patent on inventions requiring large investments can also enable a small firm or non-commercial inventor to transfer them to firms with the capacity to develop them further and make them commercially profitable [54]. This theory is therefore closely related to the disclosure theory.

Finally, the *exploration control* theory proposed by Kitch [55] suggests that having a broad patent on an initial invention enabled the patent holder to structure the development of a technological prospect in a more efficient way by avoiding "invention races" and wasteful duplication of efforts [41,56]. Attempts by different researchers to be the first to reach appropriable innovations building on an initial invention as input are indeed considered to lead to a disorderly technological pathway [41,55]. Merges and Nelson [36] have however warned that granting broad patents in cumulative-system technologies may unnecessarily restrict competition in research and could result in rendering technological advance costlier and more difficult.

Patenting plays a particularly important role in the pharmaceutical industry because of the long and complex process of developing new drugs (including their approval for human use), which requires substantial investments in research and involves considerable risks [7,8,11,37,41,48]. One of the major considerations in the debate over patents comes from the pernicious effects that strategic use of patent protection to block competition can impose on the innovation performance of the economy and its social welfare. Strategic patenting has indeed come to dominate the patenting behavior of firms in general, but the pharmaceutical industry has been one of the main driving forces in that trend [10,11,15]. According to Correa [15] and Gurgula [11], the patent regime in the pharmaceutical industry seems to have moved from a system aimed at protecting inventive activity to a system enabling the protection of exploitative activity. Instead of being the symbol of inventiveness and industrial creativity patents have become the symbol of intellectual capitalism focused on the prolongation of market exclusivity [57].

The frequent recourse to Granstrand's defensive and offensive patenting strategies [58] by pharmaceutical companies poses important problems such as "nuisance patents", which are more intended to block potential competitors than to advance a company's own technological portfolios [11,51]. Exploiting the weaknesses in the patentability laws and procedures, strategic patenting in the pharmaceutical industry applies different tactics to block potential competitors [11,15]. Such tactics include "blanketing" which claims patents on minor modification of an existing patented item; "fencing", which consist in using a series of patents to block potentially competitive direction of research and R&D; and "surrounding", which aims to obtain a series of relatively unimportant patents around a central patent to block its commercial use by third parties even after its expiration [58]. Pharmaceutical companies also deploy secondary patents to protect some aspects of their products, such as their manufacturing process, their formulation, their specific form, etc. Such products may therefore remain protected by a greater scope and length by secondary patents even after their primary patent has expired, namely if the secondary patents have a later expiration date [11]. As for "flooding", it aims to accumulate multiple patents on minor variations on a technology developed by another company as if to surround it and choke its expansion [59]. The use and misuse of patenting in the pharmaceutical industry goes therefore beyond the issue of innovation stimulation versus static welfare losses due to monopolistic price setting.

3. Social Welfare Optimization and Demand for Vital Pharmaceuticals

According to the proponents of strong patent protection regimes, the pharmaceutical industry is the industry that can make the strongest case for needing patent protection because the investment required to bring a new drug to market is very high, in part because of the many "dry holes" [60–63] ("dry holes" allude to the oil industry where drilling during oil exploration sometimes yields holes that do not connect to actual oil deposits). Empirical evidence also shows that in actual practice, pharmaceutical companies make more extensive use of patent protection than other industries [11,48]. Opponents of long patent protection periods for pharmaceuticals note that the pharmaceutical industry is earning too high profits at the expense of patients (e.g., [5,6]. Angell [6], for example, pointed out that "the combined profits for the ten drug companies in the Fortune 500 for

the year 2002 (35.9 billion) were more than the profits for all the other 490 businesses put together (33.7 billion)".

Access for all to essential medicines is a crucial element of social welfare that is not fully captured by the comparative welfare statics based on the constrained demand function. From the social psychology and extra-welfarism point of view, access for the whole society can be a rallying objective to all members of such a society if it corresponds to a distinct social identity (as opposed to non-members) [25,27]. Taking the example of the deadly COVID-19 and assuming that all those who are unable get vaccinated will remain exposed to the danger of contracting the deadly disease, we can estimate the social welfare function of making vital pharmaceuticals affordable to all eligible persons at the time of the release of the vaccine as opposed to subjecting them to monopoly prices protected by patents.

For so doing, we estimate the social demand function for vital medicines and show that making them affordable to all (potential) users yields more social benefits than protecting them by patents even after taking the cost of research into account. For patented pharmaceuticals, the demand function estimated by the producer in order to set his monopoly price is determined by the horizontal summation of all quantities that individual patients are willing to purchase for their necessary doses at given prices. Taking these pharmaceuticals as vital for public health and assuming unequal income distribution, we can estimate a linear demand function that is inelastic, as represented by the blue steep line in Figure 1. The total amount people are willing to pay for vital drugs is only constrained by the aggregate income of the concerned population (and their friends and relatives willing to help them) if we assume people who are affected by life-threatening diseases would be prepared to give up most of their disposable resources in order to save their health.

We start with a society in which a limited number of people have already been infected, and their total treatment requires Q_{tot} quantity of doses of the prescribed treatment. If income distribution is such that some patients have no income at all, then Q_{tot} is the maximum quantity demanded at no cost. We note that for the case of vital drugs for which death follows if no treatment is provided, the actual demand function will over time reduce to the kinked red line if the price is maintained at the patented monopoly level. The actual demand function is therefore the black line from D to Q_{tot}. If some social security benefits are made available to support minimum income, then the demand will shift upwards to become the kinked green line P_{sec} C′ Q_{tot} in Figure 1 assuming the minimum income is just enough to afford treatment at competitive prices. Higher income support can be given to the patients so that they can afford treatment even at the monopoly prices. (In high-income countries, a solution involving income support for individuals to afford the cost of medical treatment while keeping monopoly price for domestically produced pharmaceuticals would be equivalent to universal healthcare insurance coverage and limit the loss of social welfare. For low-income countries having to import the pharmaceuticals from foreign pharmaceutical companies, monopoly patent prices can exhaust their limited resources and force them into difficult trade-offs).

Suppose now that a pharmaceutical company successfully develops a new drug/vaccine or reduces the cost of its production. At monopoly prices P_{mon} for patented drug and in the absence of income support, Q_{mon} will be produced and sold for treatment/vaccination of patients who can afford it. Over time, some patients will drop out of the demand as a consequence of falling victim to the disease. Assuming no expansion of the disease to the non-infected population and continuous treatment of patients, the demand will eventually reduce to the kinked line P_{max} D Q_{mon} (red line in Figure 1) as people who cannot afford to buy the vital medicine/vaccine die and exit the total demand. If the disease is contagious and quite deadly (as was the case for the *delta* variant of COVID-19), the lack of containment of the disease through vaccination/treatment may threaten previously uninfected people and increase the demand for treatment while its affordability remains limited.

The effect of reducing prices from the monopoly price P_{mon} to competitive price P_{comp} is, in addition to the social welfare gain represented by the green triangle Λ, maintaining a higher labor force representing Q_{comp} as compared to Q_{mon}. By analogy to the welfare anal-

ysis of the Nordhaus model for a minor innovation, if P_{mon} was the previous competitive price, the effect of reducing the cost from P_{mon} to P_{comp} is to increase the social welfare by the sum of the shaded rectangle (from the beginning of the patent) and the green triangle (from the expiration of the patent) ($\pi + \Lambda$ in Figure 1).

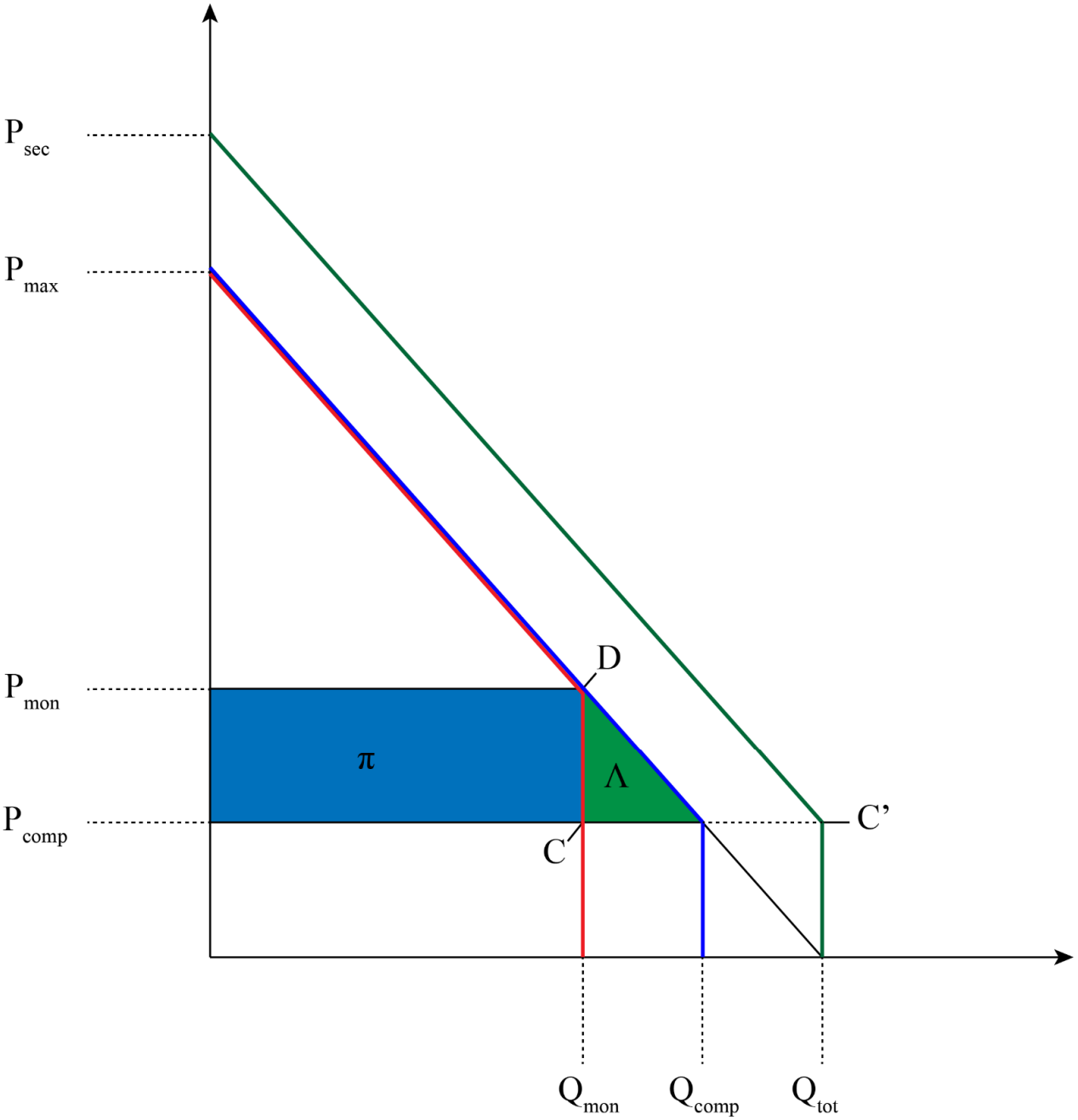

Figure 1. Change in social welfare resulting from innovation: profit and consumer surplus.

By allowing the welfare represented by the green triangle Λ to become available right from the beginning, compulsory licensing can therefore generate more social welfare than waiting for the expiration of the patent before allowing competitive prices. In the absence of an intelligent social planner (sometimes referred to as the benevolent dictator), if no measures are taken to force the price down, the society will incur a loss at least equal to the human, social, and economic value of the lives of all people who will die as a consequence of their being unable to afford the treatment/vaccine at the monopoly price of the patented

drugs (In the case of COVID-19 vaccines, while most vaccination programs were covered by government funding rather than individual, many developing countries were unable to access the desired vaccine doses, with adverse consequences for the needed access to vaccination by their residents, as exemplified by Moderna charging countries such as Botswana, Colombia, and Thailand USD 27–30 per dose and delaying deliveries compared to USD 22.60 paid by the European Union, with priority access [64]). The same reasoning as applied on the Nordhaus model suggests that the optimal monopoly length is 0 years and does not harm the incentive to innovation, provided that the society devotes appropriate resources to compensate the innovator for the forgone monopoly profits.

Let us now consider the demand function for vital medicines if we allow the benevolent social planner to be in a position to mobilize all public resources to protect the health of his/her citizens and maximize their social welfare (and public health). If we assume that keeping a citizen alive is more important for the society than having a second or a third luxury sport car for another citizen, and if we assume that all citizens are equal before the law and before the benevolent social planner, then the intelligent planner will maximize the social welfare by providing a public vaccination scheme to all eligible residents (and life-saving pharmaceuticals to infected persons). The planner will keep doing this as long as the resources of the society allow to do so without losing other citizens by lack of resources for covering other essential needs.

From that point on, if the price of life-saving pharmaceuticals goes up, the benevolent social planner cannot provide medication to all patients without taking away essential resources from equally vital needs of his citizens. The demand curve faced by the social planner is therefore only constrained by the total resources of the society and the level of resources necessary to provide all other essential needs to all citizens. When the price of the vital drugs reaches P_{surv}, the social planner faces the trade-off between paying for the medical treatment for a patient and providing equally vital resources for the life of other citizens. This is the survival price above which the society will have to lose some of its citizens. The demand curve for the social planner is therefore represented by the kinked line $P_{max\ soc\ planner}$ V Q_{tot} (bold orange line in Figure 2). It is steeper than the demand line facing individual patients, since the society has more resources (at the disposal of the social planner) to allocate to the purchase of pharmaceuticals than individual patients might have (no price discounts for large quantity purchase are taken into account here). The difference in steepness of the demand curve can also come from an uneven income distribution between infected and non-infected members of the society led by the social planner.

Based on those considerations, we note that the social benefits of reducing the cost of production of vital drugs are higher than the usual focus on profits and consumer surplus alone. Basing our analysis on the demand function of the society determined by what the intelligent social planner is willing to do in order to achieve maximum social welfare of all his citizens, we can compute the change in welfare resulting from lowering the price from the patented monopoly prince P_{mon} to the compulsory licensing price P_{comp}. When the royalties paid to the innovator are equivalent to his expected profits, then the area represented by the light blue rectangle remains a profit and the increase in social welfare is the rectangle DD'CC' in Figure 2, which is larger than the usual green triangle based on the horizontal aggregation of individual demands. The intelligent social planner provides the necessary pharmaceuticals to all persons who require them and maintains the health of his (her) compatriots intact by shifting resources from less vital consumption items. By the assumption that all citizens are equal and that a dollar spent on saving a human life brings more utility to the society than a dollar spent on acquiring luxury goods, the intelligent social planner will be maximizing the welfare of the citizens by purchasing Q_{tot} quantity of vital drugs as long as the price remains below P_{surv}. Provided the producing firms care only about their profits based on their estimation of the demand, total social welfare will be the highest when the society finances the costs of producing the vital medicines and provides treatment at no charge to all who need them in order to capture the total area under the social planner's demand function.

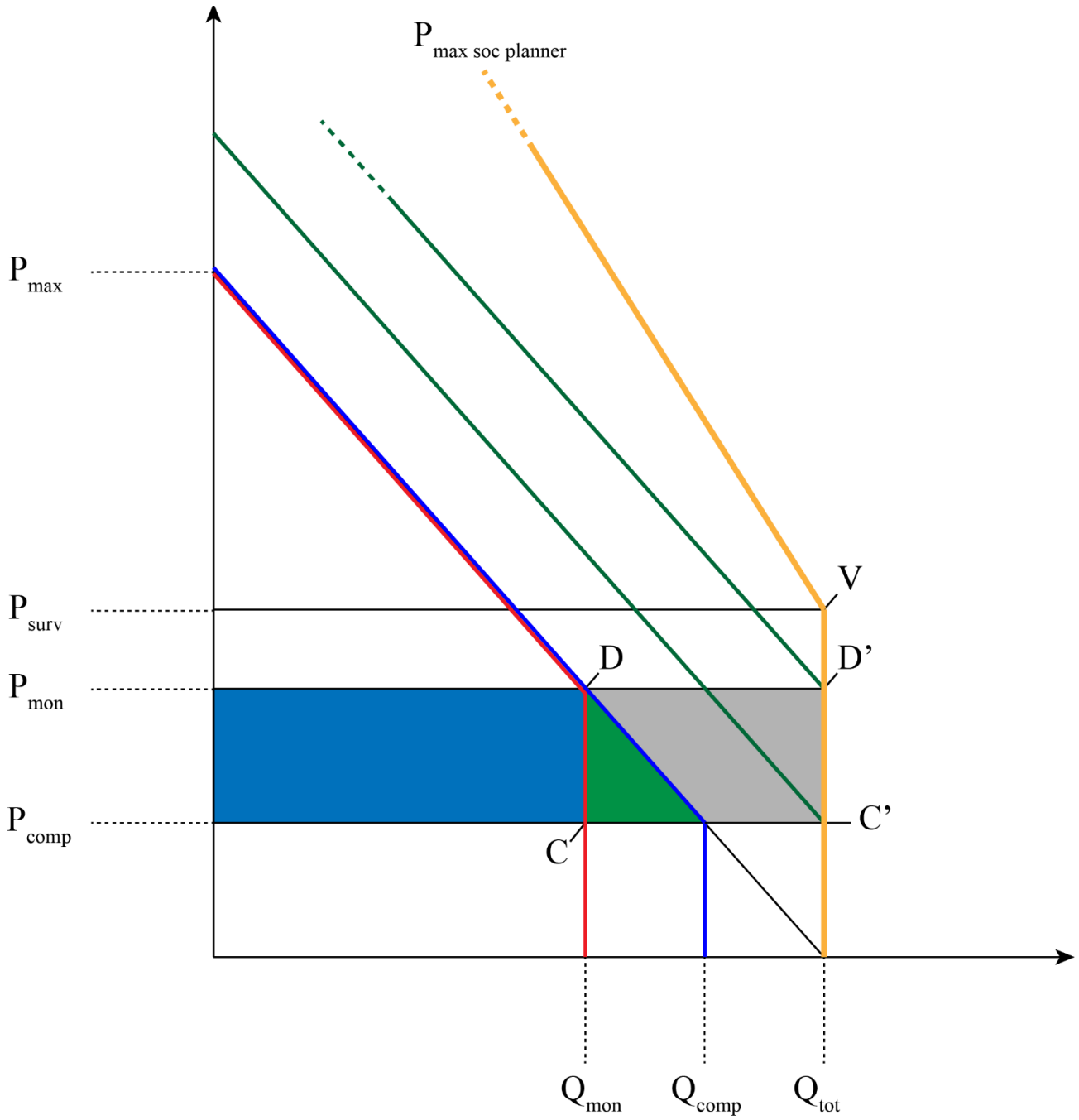

Figure 2. Demand for vital drugs by patients and by the intelligent social planner.

If we assume the initial income distribution to be such that not all patients can afford the price of the patented drugs, then the solution involving the shifting of resources could fail to be a Pareto improvement, since some citizens might end up worse off than before if they derive most utility from their consumption. However, in a society where the security and life of fellow citizens is valued above material considerations, the disutility resulting from the reduced consumption of most common goods and services can to a large extent be compensated by the increased social welfare of better health for the community. In the case of highly contagious disease such as COVID-19, the prevention of contamination for non-infected persons has direct health benefits for the entire community since the likelihood of being infected is directly related to the magnitude of the fraction of the population that is already infected and can transmit the virus. The law of mass action

predicts that the rate of interactions (susceptible to cause infections) in a given society composed of infective, immune, and susceptible individuals is proportional to the product of the numbers of infective and susceptible individuals [65]. Indeed, the view that considers citizens only as consumers who are rational agents when they maximize consumption (utility is often a monotonously increasing function of consumption) has not always been a dominant principle of social organization. When it comes to decisions involving public health, it is important to go beyond the usual logic of utility maximization based on intertemporal allocation of consumption and give precedence to saving lives without which there would not be anything to consume. This change of calculus was made clear by the unusual measures undertaken by various governments to face the threat of the COVID-19 pandemic: in imposing drastic restrictions to slow the spread of the virus and in undertaking publicly funded vaccination programs for entire populations, governments around the world behaved like intelligent social planners.

4. Discussion: Socially Optimal Patent Protection Length for Life Saving Pharmaceutical Innovations

In the debate surrounding patent protection, patent length (duration of the exclusive exploitation of the invention) occupies a prominent place. We therefore put the Nordhaus model [13] under scrutiny and apply it to vital pharmaceutical products such as antiretroviral drugs for AIDS treatment or COVID-19 vaccines. We take as objective the maximization of social welfare in which the importance of public health is preponderant and vital products are assumed to have more social value than non-essential or luxury products under the national income constraint. The Nordhaus model [13] is a useful framework to determine the length of patent life that maximizes social welfare under the assumption that monopoly is granted over a defined time span. Total social welfare is estimated by making use of the discounted profits of the monopolist innovator over the period of the patent and the discounted consumer surplus for all the periods after the expiration of the monopoly right. In the case of a minor innovation, the total profit to the monopolist whose invention reduces the production cost from C to c is

$$\mathrm{V} = \int_0^T C\beta R^{\alpha}(A - B * C)e^{-\rho T}d\tau - R = C\beta R^{\alpha}A - BC\frac{1 - e^{-\rho T}}{\rho} - R \quad (1)$$

where R represents the R&D expenditures of the firm, α and β the parameters of the invention possibility function, A and B the constant and the coefficient of the demand curve (assumed linear), and ρ the discount rate. The total increase in social welfare as a result of the innovation is calculated as:

$$W_{Nordhaus} = V + \int_T^{\infty} \Theta e^{-\rho\tau}d\tau = V + \Theta\frac{e^{-\rho T}}{\rho} \quad (2)$$

where $\Theta\frac{e^{-\rho Tb}}{\rho}$ represents the discounted increased surplus accruing to the consumers of the new technology as a result of cost reduction. The optimal duration of the patent protection obtained from this model (for given research costs and the discount rate) is positive, and its length depends on the elasticity of demand B, the importance of the invention in terms of cost reduction and the curvature of the invention possibility function β.

If we now consider an innovation policy in which a benevolent social planner maximizes total social welfare of fellow citizens while at the same time stimulating innovation to drive long-term economic competitiveness. Based on Arrow's reasoning [35] to allow competitive prices from the time when the innovation is brought to the market, the social planner can suppress the deadweight loss of monopoly straight from the beginning (This reasoning is congruent with the administrative practice of the Venetian senate in 1460 granting awards that forbade the use of patented devices without permission while obligating the patent holder to grant licenses to others when reasonable royalties were offered [31,66]). According to this approach, incentive to innovate can exist even under perfect competition

in the product market, provided only that suitable royalty payments are made to the inventor. If the proceeds from exploiting the patent could be efficiently estimated, then the inventor would theoretically be able to receive a return equivalent to the monopoly profit without disturbing the competitive nature of the industry. Using an analogous calculation to the Nordhaus model, the total consumer welfare is thus obtained by:

$$W_{social\ planner} = V + \int_0^{\infty} \Theta e^{-\rho\tau} d\tau = V + \Theta \frac{1}{\rho} \geq W_{Nordhaus} \tag{3}$$

for all positive discount rates.

For product innovations, the Nordhaus model also suggests that the optimal patent length must be short, especially when the new product has an inelastic demand as is often the case for crucial pharmaceuticals. (For run-of-the mill innovations, Nordhaus (1969) [13] suggest that compulsory licensing cannot be more efficient if there is a fixed maximum on the fee and the fair fee is less than the royalty. For drastic innovation, however, the optimal patent life is much shorter than the protection length granted ordinarily under patent laws, because of the greater deadweight losses due to monopoly. Such a problem would however be eliminated if the royalty could be fairly estimated). The optimal patent life is reduced to zero when the prevailing production cost of the old product is significantly high. The optimization under the constraints of the similar research costs and discount rate implies that a greater welfare is achieved when consumer surplus is achieved from the beginning and the inventor receives the equivalent of the discounted profits that he would otherwise get by exploiting the invention. Adding the positive economic and social spillover effects of having a healthier population without waiting for the expiration of the patent, we have an important argument for compulsory licensing of at least the vital pharmaceuticals, as stipulated in the Doha ministerial declaration. This suggests that the optimal patent length can be brought to zero if a fair royalty could be estimated in a way that preserves the incentive to innovate. It is assumed that the innovators should be indifferent between earning profits from exercising their monopoly right in the market (discounted over the life of the patent) and receiving an equivalent sum as royalty or as reward given by the society. Their innovative efforts are not affected by the form under which the returns come if the net present value is the same. By imposing the competition right from the beginning and allowing the right royalty to be paid to the inventor, the benevolent social planner can increase the total social welfare by:

$$\mathrm{W}_{social\ planne} - \mathrm{W}_{Nordhaus} = \mathrm{V} + \theta/\rho - \left(\mathrm{V} + \theta\ \left(e^{-\rho T}\ \right)/\rho\right) = \Theta \frac{1 - e^{-\rho\tau}}{\rho}, \tag{4}$$

which is positive for all positive discount rates. It is useful to highlight that the different optimal patent lengths computed by Nordhaus (1969) [13] for minor innovations (the so-called run-of-the-mill innovations) are based on the assumption that inventors do not pass the cost reduction on to consumers but keep the proceeds of the innovation primarily to increase their own profits. Innovations that result in lower consumer prices have shorter patent lengths in the Nordhaus model.

Equivalently, the benevolent social planner could maximize social welfare by allowing free competition and then, by a process of redistribution, reward the innovators by granting them the equivalent of the discounted monopoly profits (levied as taxes on the society or taken generously from his own wealth) or simply having the inventor's names covered with fame and glory e.g., giving them national awards and distinguished public recognitions. An ethical issue can arise around the justification of levying taxes on the society if the innovation benefits only a small number or is not essential to the society. We leave out such cases from our analysis and limit our discussion on innovations that are essential to the entire society, such as pharmaceuticals, and we leave to the benevolent social planner the wisdom of determining which innovations are essential to the society.

Assuming the demand can be correctly estimated (this is already assumed in the Nordhaus model for setting the optimal price), then the discounted profits can be calculated. The difficulty of determining the market reward for the invention is pointed out by David [31] as the major drawback that puts patenting at an advantage. This reward policy, if administered correctly and efficiently, would be as effective in stimulating innovation as a patent monopoly, but would bring more social welfare to the society. Such a system is however not Pareto-optimal as it may shift resources between citizens from the initial allocation without offsetting compensation for each individual.

The practical difficulties of determining the compensation fee can be assumed away if we suppose that our benevolent social planner has perfect foresight and can negotiate persuasively with the inventors to determine an appropriate reward. If such were the case, it would have the advantage of removing the monopolist disincentive to innovate. Indeed, the inventor, no longer focused on the market exploitation of his invention will in this case maximize his returns by immediately engaging in research for the next rewards and so, specialize in important developing innovations.

The possibility of enabling inventors to specialize in innovations rather than on exploiting patents has the advantage of stimulating creative economies [21]. The emphasis on intellectual property rights and behaviors is indeed aimed at life satisfaction rather than at individual utility maximization is at the heart of creative economy, which implies an economic organization based on post-materialistic values, distinct from the traditional concept of knowledge economy and a structure based on physical capital [21]. In such a structure, the deployment of creativity generates new intellectual capital, which operates as a dynamic factor of production [67,68].

However, it is important to recall that all arguments in the patent protection debate are bound to be based on partial analysis, as the complexity of the subject does not make it likely that anyone can capture the issue wholly in a single analysis. That is why, while recognizing the limitations of this partial analysis, it is pertinent to stress Machlup's remark [34] on the suboptimality of the patent system, as quoted by Paul David:

> *"If we did not have a patent system, it would be irresponsible, on the basis of our knowledge of its economic consequences, to recommend instituting one. But since we have had a patent system for a long time, it would be irresponsible, on the basis of our present knowledge, to recommend abolishing it".* ([31] p. 43)

5. Conclusions

The protection of intellectual property rights aims to stimulate research and innovation, but creates inefficient monopolies and welfare losses, while policies aimed to increase competition are considered to reduce profitability, and thus constitute disincentives to invest in innovation. Unimpeded competition is however indispensable for the maximization of social welfare and for speeding up technology diffusion. Beyond the rationale of encouraging inventive activities, arguments for patent protection extend to increasing disclosure and controlling an orderly technology evolution by avoiding wasteful innovation races. For the case of life-saving pharmaceuticals, especially when public health is under threat, the trade-off between encouraging investment in R&D through patent protection and the imperative of making the vaccine technology available to multiple producers to save lives becomes more acute. The hoarding of billions of vaccine doses in rich countries (some of which are also home to the major companies that produced the most widely used vaccines) and price discrimination against low-income countries have raised the concern that profits, rather than optimal social welfare may be the dominant factor in restricting access to vaccine technology.

Using a modified social welfare analysis based on the Nordhaus model [13], this paper has shown that for the case of process innovation on products with an inelastic demand curve, social welfare is maximized when the innovation is produced under compulsory licensing and made available to the public at competitive prices from the beginning. To keep the incentive to invest in R&D, a fair compensation (based on the estimated net

present value of future profits) can be given to the inventors, who would then specialize in innovation rather than in market exploitation of their inventions. For product innovations that generate life-saving pharmaceuticals, our analysis indicates that social welfare is maximized when an intelligent social planner ensures unrestricted access to vital pharmaceuticals to all eligible residents at competitive prices. This approach corresponds to the extra-welfarism approach already in use in health economics, but also to the organization system proposed by the emerging approach of creative economy, where intellectual capital and creativity form the basis of dynamic production system. By allowing the prices to be set immediately at a competitive level, such a scheme yields more social welfare than the temporary monopoly under patent protection if it includes measures to compensate innovators for the forgone monopoly profits. This approach would also have the advantage of rendering drug development more competitive by focusing the activity of inventors on innovations rather than on exploiting the economic rents of patented products.

Remarkably, many developed countries acted like intelligent social planners in rolling out their COVID-19 vaccination programs with public funds, but Western countries that successfully financed (part of) the development costs of vaccines chose to favor unprecedented levels of monopoly profits for their pharmaceutical companies with dire consequences for many developing countries.

Several observers have noted that the profits generated by the pharmaceutical industry remain considerably high, even after compensating for the R&D expenditures and the risk inherent in the drug development process. Existing patent protection periods under patent laws (typically 20 years) are much longer than what Nordhaus estimated as optimal [13] for the case of product innovations with inelastic demand and serve more to protect excessive profits rather than to stimulate investment in research and development. The frequent use of strategic patenting to fend off competition and restrict access to useful knowledge in the pharmaceutical industry is considered as being harmful to technology diffusion and produces sub-optimal social welfare. We have therefore argued that while patent protection finds its justification in compensating the inventors in order to stimulate research and innovation, the increasing use of patenting to protect outsized profits and block competition imposes such a heavy loss in social welfare that the length of patent protection in current IPR regimes needs to be constantly questioned.

For developing countries that are importers of foreign patented pharmaceutical products, patent protection laws that result in sizeable profits on essential pharmaceuticals have far-reaching implications for public health as it has been painfully reminded by their inability to access COVID-19 vaccines at the time they needed them the most to protect their citizens. That is one of the reasons why South Africa and India have spearheaded a call to the WTO to demand a temporary waiver on TRIPS Agreement provisions, in order to facilitate access to affordable pharmaceutical products for the prevention and treatment of COVID-19 for all its member countries. For developing countries with manufacturing capabilities, a waiver of COVID-19 vaccine patent protection could facilitate technology absorption and speed up local production of the needed vaccine, which would also enhance their preparedness to future pandemics. While rich countries could afford to purchase the vaccines at monopoly prices and cash in on the large profits flowing into their pharmaceutical companies, many low-income countries were only left with the options of either spending a considerable fraction of their resources to acquiring the necessary life-saving vaccines or leaving most of their residents without access to vaccines. As a result, many African countries have a COVID-19 vaccination rate that is still under 20 percent of their population. As they develop their innovation capability for the future it will be crucial for them to consider the optimal welfare choices in the way they approach patent protection and R&D investment stimulation.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Not applicable.

Acknowledgments: I wish to thank Victor Habiyaremye and Thomas Habanabakize for the technical support they provided for this study. A word of gratitude to the anonymous reviewers whose valuable suggestions helped me improve the clarity of this article. All remaining errors and/or omissions are my own.

Conflicts of Interest: I declare that no known conflict of interest is involved in this study.

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