Inframarginal Externalities: COVID-19, Vaccines, and Universal Mandates

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Abstract: SARS-CoV-2 (commonly called COVID-19) vaccine mandates are in place or being debated across the world. Standard neoclassical economics argues that the marginal social benefit from vaccination exceeds the marginal private benefit; everyone vaccinated against a given infectious disease protects themselves and protects others by not transmitting the disease. Consequently, private levels of vaccination will be lower than the socially optimal levels due to underconsumption/free-rider problems, requiring mandates to overcome the problem. We that the economic argument for mandates is less compelling for COVID-19. First, most of the benefits of the COVID-19 vaccine are internalized, vaccinated individuals are protected from the worst effects of the disease and may even exclude others from the benefits of the vaccine by transmitting the infection. Therefore, the externality may be inframarginal or policy irrelevant. Even when all the benefits are not internalized to the individual, the externalities are mainly local, even in a global pandemic, therefore requiring local institutional (private and civil society) arrangements to boost vaccine rates. We find that the economic case for universal vaccine mandates, based on externality and free-riding, is weak in the case of the COVID-19 vaccines, and that economists and politicians must justify such vaccine mandates on some other basis.

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I. Introduction

This paper studies the economic rationale for universal mandates for vaccines to battle SARS-CoV-2 (commonly referred to as COVID-19) in the United States. We examine the nature of the consumption externality of the COVID-19 vaccine and ask if the externality is policy relevant. We find that the economic case for universal vaccine mandates, based on externality and free-riding, is weak in the case of a COVID-19 vaccine and that such vaccine mandates must be justified on some other basis.

As with all goods, there is a supply side and a demand side. Vaccine research and development made freely available to all countries are often recognized as global public goods, where government subsidize or support in the form of prizes, patent buyouts, or Advance Market Commitments to help spur vaccine research and development (Kremer, Levin, and Synder 2020; Tabarrok 2020). In the United States, during the COVID-19 pandemic, the federal government procured vaccines and supplied them to the states, which then either followed or modified the guidelines of the Centers for Disease Control and Prevention (CDC)[3] for prioritizing vaccine allocation. Similar efforts have been made by the COVID-19 Vaccines Global Access (COVAX) alliance globally.

In addition to the supply side, there is still the need for demand to generate the benefits of the vaccine. For this, there has been a strong call for mandates. After an initial shortage and difficulties in getting vaccination appointments, by mid-April 2021, individuals residing in the United States who wanted to get vaccinated could do so without waiting (Howard, 2021). However, providing the vaccine at zero price with virtually no wait time has not led to near-universal adoption or, in some states, even majority adoption as of the end of 2021. For instance, in most states, a nontrivial proportion of health care workers, who were given top priority to receive the vaccine, have refused the vaccine (Shalby *et al.* , 2020). This suggests that a price of zero is not sufficiently low to ensure optimal vaccine consumption; the vaccines should have a negative price (that is, the government should pay people to get vaccinated) and/or additional mechanisms.

When a zero price does not generate a high enough demand for vaccines, by some metric, the typical response to this problem is to call for various institutions, including different levels of government, to mandate vaccination. We see this most recently against COVID-19 (Stiglitz 2021;

[3] "How CDC is making COVID-19 vaccine recommendations"(2022) *Centers for Disease Control and Prevention*. Available at: https://www.cdc.gov/coronavirus/2019-ncov/vaccines/recommendations-process.html (Accessed: March 25, 2022).

Gostin, Salmon, and Larson 2021). Even prior to the Covid pandemic, a large majority of economists argued that the benefits of mandated vaccines outweighed the cost, for example, in the case of measles (IGM Forum, 2015). Policymakers seem to agree. In the US, federal, state, and city-wise mandates for Covid-19 vaccines are in force.[4] Of the six federal mandates, three remain in effect after being challenged in the US Supreme Court.[5] These vaccine mandates apply to health care workers,[6] military personnel[7] and some categories of non-citizens traveling to the US, subject to certain exceptions.[8] In addition to federal mandates, 20 states[9] and 25 cities[10] have mandated the vaccines for different categories of workers with or without the alternative option to recurrent testing.

In November 2021, the Biden Administration announced (White House, 2021) that the Department of Labor's Occupational Safety and Health Administration (OSHA) would require employers with 100 or more employees – covering 84 million employees - to ensure each of their workers is fully vaccinated or tests for COVID-19 on at least a weekly basis. Second, the Centers for Medicare & Medicaid Services (CMS) at the Department of Health and Human Services also required health care workers at facilities participating in Medicare and Medicaid are fully vaccinated, which applies to more than 17 million workers. The goal of these mandates was to increase vaccination rates, but both were challenged in the US Supreme Court. The US Supreme Court held the former mandate unconstitutional while allowing the mandate for health care centers. Besides the US, 47 countries have issued vaccine mandates in varied forms and scope.[11] This paper explores the *economic rationale* for universal vaccine mandates, such as mandates at the federal or national level.

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[4] Data on counties and private players mandating vaccines have not been included in this compilation.

[5] Of the remaining three, two have been stayed by court orders and one has been withdrawn after the US Supreme Court ruled that the authority empowered to enforce the same did not have such authority in *National Federation of Independent Business v. Occupational Safety and Health Administration*

[6] Omnibus COVID-19 Health Care Staff Vaccination Rule.

[7] Memorandum from the Secretary of Defense of 24 August 2021.

[8] Presidential Proclamation of 25 October 2021.

[9] California, Colorado, Connecticut, Delaware, Guam, Hawaii, Illinois, Maine, Maryland, Massachusetts, Minnesota, New Jersey, New Mexico, New York, Oregon, Pennsylvania, Puerto Rico, Rhode Island, Vermont and Washington.

[10] Aquinnah, Boston, Chicago, Denver, District of Columbia, Hoboken, Jackson, King County, Los Angeles, New Bedford, New Orleans, New York City, Newark, Pasadena, Philadelphia, Portland Oregon, Providence, Richmond Virginia, Sacramento, San Diego, San Francisco, San Jose, Seattle, St. Louis and Tucson.

[11] Australia, Austria, Bulgaria, Canada, China, Costa Rica, Croatia, Czech Republic, Denmark, Ecuador, Egypt, Fiji, Finland, France, Germany, Ghana, Greece, Hungary, Indonesia, Italy, Kenya, Kuwait, Latvia, Lebanon, Malaysia, Micronesia, Morocco, Netherlands, New Zealand, Oman, Philippines, Poland, Romania, Russia, Russia, Saudi Arabia, Serbia, Singapore, South Korea, Sweden, Switzerland, Tajikistan, Tunisia, Turkey, Turkmenistan, Ukraine, and United Kingdom. This is not an exhaustive list but based on information available on vaccine plans of different countries. (Reuters, 2021)

Economists recommending government interventions to increase vaccine uptake root their policy solutions in the free-rider problem associated with vaccines. Typically, everyone vaccinated against a given infectious disease protects themselves but protects others, though the extent of the protection to oneself and others may vary depending on the type of disease and vaccine. If vaccines also protect others, the marginal social benefit from vaccination is greater than the marginal private benefit, creating the dual problem of underconsumption and free-riding by individuals. For both efficiency reasons (people will under consume because they do not internalize all the benefits of the vaccine) and distributive reasons (poor and vulnerable members of society should not be left out), economists typically suggest a government intervention to correct this problem, usually in the form of a subsidy, and if that is insufficient, mandates. The standard economic argument in favor of vaccine mandates for various infectious diseases is that they help overcome the free-rider problem (Stiglitz, 1998; Buttenheim and Asch 2013; Gostin, Salmon, and Larson, 2021).

As different kinds of government intervention to increase vaccination rates are debated, it is important to understand the nature of the externality posed by the vaccine. We put forward a simple argument in this paper: the standard economic justification for universal mandates, which is grounded in arguments of externalities and free-riding, is not compelling in the case of the COVID-19 vaccine due to the efficacy and other characteristics of the vaccine. Any call for mandates must be rooted in other justifications.

Our argument is as follows. An externality does not automatically imply free-riding. Most of the benefits for the vaccines developed to battle COVID-19 are internalized. This is because vaccinated individuals are protected from the most severe consequences of the infection, but they can transmit the infection (though at a lower rate of transmission compared to unvaccinated individuals). Any practical policy question cannot simply identify an externality and call for mandates but must examine the extent of the private and social benefits. It may be that the externality is *inframarginal*, as defined by Buchanan and Stubblebine (1962). These are cases where externalities exist, but they are policy irrelevant. Whether an externality is inframarginal or not depends on the nature of the vaccine and depends on many factors, but most importantly, it is institutionally contingent.

Second, even when the effects are not completely internalized, the external benefits are more local than global. Local public goods allow for more sorting and local "production," which in this case means local incentives to take the vaccine. Finally, if the non-universal adoption of a COVID-19 vaccine is more related to preferences and beliefs about the vaccine, the healthcare system, and

government, the argument is not about free-riding; the argument in favor of mandates must come from elsewhere.

The case for universal vaccine mandates is not strongly situated in explanations for underconsumption due to a free-rider problem. There may be other reasons not related to externalities and free-rider problems but have roots in ease, political politicization, misinformation, or paternalism, to justify vaccine mandates.

II. Externalities, Public Goods, and the Free-rider problem with vaccination

Experts, economists, and policy makers have supported government funding or other support for vaccine development because vaccine development serves as a global public good. Even in the absence of a pandemic, vaccine subsidies are ubiquitous because the development of pharmaceuticals and vaccines for infectious diseases, in general, can be very costly and subject to great uncertainty. During a pandemic, however, an early decision to subsidize the development, trial, manufacturing, and delivery of a vaccine has especially large benefits (Ahuja et al. 2021). This can be accomplished by subsidizing private development, developing contracts that guarantee a market, for example, by guaranteeing a minimum number of purchases (Kremer, Levin, and Snyder 2020), or through prizes and patent buyouts (Tabarrok 2020). For instance, in the United States, with Operation Warp Speed, the federal government invested $10 billion to fund the development of vaccines and guaranteed it would purchase a minimum amount to encourage production.

However, once a vaccine is developed and easily available, the consumption side is the relevant policy problem. There remains the question of how to incentivize individuals to vaccinate. Some authors refer to vaccines and the reduction of disease risk as public goods (Goodkin-Gold et al. 2020, p. 47). The public good argument is that vaccinations provide non-rival benefits (i.e., the benefit from a vaccinated individual do not deplete as additional people come in contact with that individual even as the benefit from her vaccination), and non-exclusive benefits (i.e., once an individual has been vaccinated, she cannot easily exclude others from benefitting from her decision) to community members.

However, more than public goods, it is helpful to start with the more general language of externalities. Externalities can come in the form of net costs (negative externalities) or net benefits (positive externalities) that an individual's behavior imposes on others and that the individual does

not account for. When any individual gets vaccinated against an infectious disease, this typically reduces (or eliminates) *their* chance of getting the disease. But it may also reduce the chance of *others* getting the disease, as the vaccine recipient is less likely to transmit the disease. Therefore, the social benefit from a dose of a vaccine is higher than the private benefit.

Though an individual benefits through protection from infection, getting vaccinated is not costless to the individual. The costs are usually internalized, even if the vaccine is subsidized or at zero price. There are logistical costs of getting vaccinated as well as costs related to pain or side effects (if any) from the vaccine. These costs are nontrivial to the individual, is seen in vaccine adoption when they are delivered through drops (polio) versus injections (measles).

Therefore, for vaccines that are highly effective against infection, due to private costs, there may be incentives to free-ride. For instance, in the case of the combined MMRV vaccine that protects against measles, mumps, rubella, and varicella. 1-year antibody persistence rates were each greater than 95% (Lieberman et al. 2006). Many modern-day vaccines exhibit similarly high effectiveness against other diseases (Amanna and Slifka 2020). The children vaccinated against MMRV protect themselves from these infectious diseases and protect others from infection by reducing transmission. The percentage of breakthrough infections is extremely low. Therefore, the marginal social benefit from vaccination is greater than the marginal private benefit and may create the dual problem of underconsumption and parents free-riding community protection leaving these children unvaccinated from MMRV. Kennedy (2008) documents that among church members reporting religious, safety, or philosophical objections to vaccination, vaccine hesitancy and intention improved following a local measles outbreak, an action that is consistent with free-riding.

In the face of free-riding, people have called for mandates at different levels of government across the world. Browne (2016) analyzes California's 2015 mandatory vaccine law and concludes that it is justified in overcoming the free-rider problem and sharing the vaccination burden. Giubilini (2020) and Flanigan (2014) defend compulsory vaccination related to pertussis, measles, and mumps with analogies to taxation and gun control. van den Hoven (2012) and others contend that, owing to the unfairness of free-riding, parents have a moral duty to vaccinate their children.

However, in the case of Covid-19 vaccines, efficacy is lower, there is a high percentage of breakthrough infections, especially for newer variants. This means that the vaccinated individuals protect themselves against the most severe form of the disease. But they can still transmit the infection (though at a lower rate) to others. This makes the externality arising from COVID-19

vaccines different from other vaccines that are currently mandated. The next section discusses the nature of the Covid-19 eternality in detail.

While this framing of externalities has critics (Cowen 1985, p. 58), it succinctly frames the collective-action problem a society faces in the case of vaccines. The Pigouvian solution is a subsidy and/or a mandate for getting vaccinated. This is considered the optimal policy response (for example, Francis 2004, and Goodkin-Gold, Kremer, Snyder, and Williams 2020). Stiglitz (1998) argues that vaccine mandates are a potential solution to the free-rider problem because they urge people to assume collective responsibility in preventing and eliminating infectious diseases.

Therefore, we can think about the problem through either lens since externalities and or free-riding are considered "two sides of the same coin" (Cowen, 2002). The positive externality provided by vaccinated individuals, in sufficient numbers, can lead to free-riding by unvaccinated individuals. However, this rationale breaks down if the positive benefits are excludable due to technology or institutional instruments. Even in cases where benefits are not completely internalized and are excludable, there may be cases where there is no free-riding. Not all vaccines are highly effective, at 95% rates, or may not be durable, and effects may wear off over time. COVID-19 vaccines fall in this category.

Though vaccine externalities are ubiquitous, the evidence for a free-rider problem does not always exist. McKillop et al. (2019) do not find any evidence of free-riding in HPV vaccination drives in Dallas, Texas, but instead, observe a positive and significant relationship between individual vaccine choices and average neighborhood vaccine rates. In other words, they observe clusters. Individuals were more likely to complete the HPV vaccination series when others in their neighborhood had already completed the series. Holland and Zachary (2014) find that free-riding does not drive individual vaccine decisions and call the free-rider problem viz-a-viz mandatory vaccinations a "red herring."

Even if there is no free-rider problem, vaccine mandates may be called for where vaccines have helped eliminate an infectious disease. In some cases, such as smallpox, the disease was eradicated globally through vaccination; it is a global public good, i.e., the benefits of vaccination are not just partially, but wholly non-excludable and non-rival. Even when a disease is locally eradicated, such as polio or measles in specific countries, the benefits are non-excludable and non-rival.

This brings us to the question of herd immunity. The herd immunity threshold is defined as "the proportion of a population immune to a communicable disease, either from innate immunity, natural infection, or vaccination, that prevents or significantly reduces serial transmission of its

infectious agent." The "herd immunity threshold" is different for different infectious diseases. These thresholds are predicted mathematically using a transmissibility estimate called the reproductive number (or R_0), but they also depend on the efficacy of the vaccination/natural immunity, the durability of the protection, asymptomatic infections/occult transmission, population heterogeneity, and new mutations of the virus. COVID-19 vaccines have low efficacy and durability compared to, say, the MMRV vaccine, where protection through the vaccine or natural immunity post-infection tends to be lifelong. The argument, therefore, is that to reach the herd immunity threshold required higher rates of vaccination, justifying mandates with few exceptions.

But due to the same factors, Giurgea and Morens (2022) argue that in the case of COVID-19, herd immunity is neither easy to estimate nor reach through interventions because susceptibility to infection increases with increasing time since vaccination. Herd immunity estimates for COVID-19 must account for partial vaccine efficacy, waning immunity, heterogenous population, dynamic, mutating virus, etc. they conclude that "current vaccine strategies may be able to slow down COVID-19 spread and are likely to alleviate the burden that waves of severe cases can inflict on limited health care resources, but they are unlikely to lead to COVID-19 eradication." Therefore, universal vaccine mandates to reach herd immunity thresholds to serve as a non-excludable and non-rival public good do not apply to COVID-19 vaccines.

III. Is the positive externality from COVID-19 vaccines inframarginal?

Not every externality generates a free-rider problem. More generally, if most of the benefits are internalized, free-riding is less of a problem than commonly acknowledged. We argue that the current vaccines for COVID-19 do not pose a free-rider problem, especially against some variants. While unvaccinated people are by far at the highest risk for catching and spreading Covid-19, fully vaccinated persons can develop symptomatic or asymptomatic infections with COVID-19. And though the risk of transmission is much lower (half by some estimates; see Eyre et al. 2020), fully vaccinated individuals can transmit the infection to both vaccinated and unvaccinated individuals.

Scobie et al. (2021) study 13 U.S. jurisdictions from April 4–July 17, 2021, when the Delta variant COVID-19 infection was predominant, found that age-standardized rates of reported cases were much higher among persons not fully vaccinated (112.3 per 100,000) than those fully

vaccinated persons (10.1 per 100,000) for hospitalizations (9.1 versus 0.7 per 100,000), and deaths (1.6 versus 0.1 per 100,000). Country-wise data on death rates by vaccination status across different variants of the infection also show that unvaccinated persons are far more likely to die (Mathieu and Roser 2021).

Using CDC data from the 26 states and two cities, the New York Times compared age-adjusted average daily case and death rates for vaccinated and unvaccinated people in the 26 states and two cities that provided this data.[12] For example, during the Omicron wave, between December 19 - 25 2021, unvaccinated persons were twice as likely to contract COVID-19 and twenty times as likely to have a fatal infection, compared to fully vaccinated individuals.

It is now well established that even fully vaccinated individuals can get infected, even before the Omicron wave (Moghadas et al. 2021). Breakthrough infections across different variants and different parts of the world have been recorded (Araf et al. 2022). Researchers have found that the Omicron variant is more skilled at evading immunity, i.e., the antibodies produced after vaccination. The Omicron wave is seeing record numbers of breakthrough infections, though fully vaccinated individuals are still protected from the most severe consequences.

Therefore, the benefits from the COVID-19 vaccines, mainly lower risk of hospitalization and much lower risk of death, are excludable, although not perfectly. And while the social benefit from each vaccine dose exceeds its private benefits, there may not be a free-rider problem. The unvaccinated cannot derive much protection from the vaccinated during the COVID-19 pandemic. In fact, the case might be the opposite. If vaccinated individuals are asymptomatic and out and about, they may place unvaccinated individuals at greater risk since they are harder to detect as spreaders.

Again, externalities are ubiquitous, but not all of them require policy intervention. For instance, a well-kept front yard produces benefits in the form of viewing pleasure. And while there are various institutional mechanisms to internalize the spillover benefits to, say, neighbors, it is difficult to exclude an occasional passerby from the benefits of a beautiful yard. However, the decision of the homeowner to have a beautiful front yard may not be affected by the inability to exclude or charge the occasional bystander for "viewing/enjoying the view." This is a case of an inframarginal externality, where interventions will not increase the supply on the margin. Private

[12] "Coronavirus in the U.S.: Latest Map and Case Counts" *The New York Times*. Available at: https://www.nytimes.com/interactive/2021/us/covid-cases.html (Accessed: March 25, 2022).

incentives to maintain a beautiful front yard (personal enjoyment, increase in the value of the property, viewers' approbation, etc.) are sufficiently high for most homeowners. The optimal amount of the good gets produced and consumed; that is, an externality exists, but it is inframarginal and not Pareto relevant (Buchanan and Stubblebine 1962).[13]

That an externality is inframarginal depends on various factors like technology, local context, institutional arrangements that may exclude participation, and is subjective to the individual, since some individuals may desire very high marginal private benefits.

However, individuals in the general population have strong private incentives to vaccinate themselves against COVID-19. First, vaccination will protect them from the worst effects of the disease. Vaccinated individuals are likely to have mild infections or remain asymptomatic. Second, it will help them engage in social activities that were either not possible or too costly because of the transmission risk. Third, it will allow them to participate gain entry in social groups and clubs that require participants to be vaccinated; for example, they can work at a grocery store or, fly on an airplane, or attend a sports game.

With COVID-19, the impact of infection is not uniform across all individuals and groups. Those with comorbidities, especially heart disease, hypertension, or diabetes, are affected more severely.[14] For the Alpha and Delta variant, hospitalizations and fatalities are higher among individuals over sixty-five.[15] For individuals in this age group or with comorbidities or other health conditions, getting vaccinated is likely privately and socially optimal. It is similar for individuals in occupations that face a much higher risk of contracting the virus, such as Uber drivers or checkout clerks. There are individuals who also encounter more people, thereby passing on the benefits of their vaccination to others. But the private incentives to get vaccinated may be sufficiently high that the benefit to others is not relevant on the margin. If this is the case, the economic case for universal vaccine mandates is weaker than commonly acknowledged because the externality may be inframarginal and that undermines that the case for interventions to solve a free-rider problem.

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[13] Buchanan and Stubblebine distinguish between inframarginal and irrelevant externalities, a distinction that turns on whether one considers only marginal changes or allows for discrete changes of people's actions. That is an important theoretical distinction but not important for the applications in this paper.

[14] "People with certain medical conditions", *Centers for Disease Control and Prevention.* Available at: https://www.cdc.gov/coronavirus/2019-ncov/need-extra-precautions/people-with-medical-conditions.html (Accessed: March 25, 2022).

[15] "Risk for COVID-19 infection, hospitalization, and death by age group," *Centers for Disease Control and Prevention*. Available at: https://www.cdc.gov/coronavirus/2019-ncov/covid-data/investigations-discovery/hospitalization-death-by-age.html (Accessed: March 25, 2022).

IV. Internalizing Local Externalities and Institutional Responses

If the benefits are of a vaccine are not immediately internalized, and there are some coordination and information problems that prevent full Coasean bargaining, they can be solved through a variety of institutional arrangements. Consider a well-maintained front yard again. This generates a positive externality for the neighbors, not just because it is a beautiful sight but also because it increases their real estate values by increasing their curb appeal (Johnson, Tidwell, and Villupuram, 2020). Because not all the benefits are internalized and because yard maintenance has a cost, standard theory predicts under maintenance or underinvestment in front yards and curb appeal. But private solutions to the problem exist. One is for a single private entity to internalize the externality (Demsetz 1967, p. 348). This is typically a private developer or a closed group such as a homeowners' association that has rules about how the yard is to be maintained and collects fees to ensure its maintenance. Such entities are clubs in the sense of Buchanan (1965). Another solution is Coasean bargaining between neighbors offering to help with yard work.

In the case of COVID-19, the negative externality of the disease and the positive externality from the vaccine depend on individuals' interaction in close proximity. Some of our daily interactions take place in public spaces, where we do not voluntarily choose our interactions with strangers. An example is traveling using public transportation such as the New York City subway. One cannot choose whom they travel with on the subway and "may create cross-site externalities by increasing the infection risk of uninfected non-subway riders who later interact with subway riders at another site" (Leeson and Rouanet 2021, p. 1109). Nor can one exclude others from traveling on the subway. But a lot of interactions occur at sites that are privately owned and that individuals visit voluntarily. In the absence of a vaccine, one has the choice to patronize certain grocery stores over others that may be too crowded or to visit at a different hour.

Unlike interactions on public transportation or the grocery store, many voluntary and private interactions are small-scale and repeated. We focus mainly on three types: private firms, private clubs, and civil associations. All can incentivize vaccination to internalize externalities among their members.

First, take the case of a firm that requires employees to work in close proximity. We have evidence from pre-vaccine that firms took steps to slow the spread of the virus (Mulligan 2021). It may make sense for the owner to mandate vaccination for the entire staff to internalize all the benefits of vaccination and ensure that there is neither underconsumption nor free-riding. This may sound extreme, but there are a lot of real-world examples in which vaccines are mandated as part of

the job. For instance, some hospital wards and nursing homes make flu shots mandatory, and sex workers in the adult-entertainment industry must be vaccinated against hepatitis. There is a voluntary element to these interactions—an individual can always look for another job—but they are mandatory conditional upon working at the particular firm. Another way to think about this is that they are mandatory in the short run, when it may be difficult to find another job, but voluntary in the long run, when exit is possible. Second, the mandate is not universal. Third, there may be reasons other than free-riding for the mandate, most notably employer liability in case of an outbreak.

For privately provisioned goods that are consumed collectively—such as airline travel—the mandates may extend beyond employees. Before the existence of a COVID-19 vaccine, some airlines mandated mask-wearing and proof of a negative test result to travel with them. For international travel, some of these requirements were based on other countries' immigration mandates. But airlines also formulated their own rules for protecting passengers.

A private firm can incentivize vaccination, especially for employees. This is typically done by giving employees time off or having vaccine drives at the workplace, with monetary incentives or bonuses for getting vaccinated. During flu season, several employers incentivize vaccination by providing free vaccines at the workplace and giving employees paid time off to get the vaccine. Even with private firms mandating vaccines or providing incentives, the issue of transaction costs arises. Firms or other associations trying to internalize the externality caused by high interaction in close proximity face limitations. Consider the case of a grocery store, such as Trader Joe's. If the owners wish to internalize the externality, they have to deal with two types of groups in close physical proximity: employees and customers. They could mandate that everyone in the store get vaccinated. That would be a blunt policy that might not even be optimal for the purpose of internalizing externalities. For employees, the grocery store owners could provide free or subsidized vaccines or even mandate the vaccine; but for the hundreds of patrons visiting each day, this would be prohibitively expensive, either because it would exclude a lot of patrons or because checking vaccine certificates is too costly.

For customers, there are costs to verifying whether a subsidized individual is vaccinated. Since customers might never show up again because there are lots of other grocery stores, Trader Joe's might not be willing to check vaccine status. And the subsidy that Trader Joe's could provide to the customer (say, in the form of a discount) likely would not be enough to narrow the gap much between private and social marginal benefits. Employees of Trader Joe's are in a different situation.

They impose an externality on the store every day they work. They also spend more time in the store than customers do, a relevant consideration for infectious diseases. Moreover, there are likely bigger gains in the relationship between the owners and an employee than between the owners and a customer. All else equal, we would expect Trader Joe's to incentivize vaccination of employees to a greater extent than they would do the same for customers. And in fact, in January 2021, several retail stores, such as Trader Joe's and Dollar General, announced they would pay workers to get vaccines (Miller, 2021). In February, Kroger announced it would pay employees $100 to get the vaccine (Kroger, 2021). Other private firms are considering similar incentives. In a recent poll conducted by the Yale Chief Executive Leadership Institute, 72 percent of current and former CEOs signaled an openness to vaccine mandates (Egan, 2020). And one of the reasons private firms might not mandate the vaccine is legal uncertainty regarding vaccines approved for emergency use.

The second kind of private solution comes through clubs. Buchanan's (1965) theory of clubs explains how individuals and firms can supply goods with a high degree of publicness privately. Club goods are typically excludable but non-rivalrous (or only rivalrous beyond some congestion threshold). It is profitable for firms or individuals to privately supply these collective goods if they can persuade individuals to join the club to share the cost of providing them. The example Buchanan uses is collective goods such as swimming pools. But the same underlying logic applies to the kind of positive externality created by excluding those who are unvaccinated from a club. One of the club goods or services offered is protection from getting infected by others in the club by insisting on vaccination.

Typically, like firms, clubs have good incentive-alignment mechanisms. Clubs are the residual claimants over the revenues they generate for their services and goods. During the pandemic, assuming a general preference for remaining COVID-free, more individuals are likely to join if they can get benefits, such as protection from disease transmission. Club owners earn profits only if their patrons are willing to pay, and given a preference for protection from infectious diseases, the incentives of club owners and patrons are well aligned. Clubs are also exposed to market discipline—freedom of their patrons to enter or exit—and this puts competitive pressure on their management to cater to the preferences of their patrons. As a result, clubs consider the costs of their mandates to ensure they do not over-exclude. The threat of exit is the dominant disciplining mechanism for clubs. Finally, clubs can adapt quickly relative to other providers of collective goods such as the state since they can design contracts and amend contracts for very specific situations.

Take swimming pools, gyms, and exercise studios. They place people in close proximity while exercising and while in common areas and changing rooms. Let us stipulate that conditional upon believing that Covid-19 is an infectious disease with serious health consequences, patrons are likely to join only if all members take certain precautions. In the absence of a vaccine, this means the club will enforce mask mandates and social-distancing rules. Once a vaccine becomes available, if members have a strong preference for having the group be vaccinated, then the club can mandate vaccines as a condition for inclusion. The transaction costs grocery stores face in checking vaccine records for all their customers may be prohibitively high. But clubs have already solved that problem and only need to add one more requirement for inclusion in addition to their other requirements.

Clubs also have incentives to not over-exclude and to cater to the preferences of their clientele. If the patrons are young and healthy and willing to risk some exposure to infection, the clubs may use other kinds of mechanisms to accommodate them. For instance, these clubs may offer certain hours of operation for those who are vaccinated and the other hours for anyone, allowing patrons to take the appropriate level of exposure to infection risk. In fact, before the availability of a vaccine, many gyms and exercise studios had hours when masks were mandated and hours when no masks were required. Wearing a mask while working out intensely may be a high cost for some patrons, especially those who are young and likely to be asymptomatic or mildly symptomatic. Therefore, clubs have strong incentives to impose mandates that align well with the preferences of their patrons.

While we have laid out a few specific incentive mechanisms that we expect to see in response to a pandemic, we have seen an even wider variety of attempts by different groups to encourage vaccination. These groups recognize that vaccines have relevant externalities and want to incentivize others to change their actions.

For example, Kroger offered a lottery of 1 million USD and free groceries for a year; The Greenhouse offered pre-rolled marijuana joints under the "Pot for shots" campaign (Elassar, 2021); Krispy Kreme (Dickler, 2021), Chagrin Cinemas, and Samuel Adams (Tyko, 2021) gave out free donuts, popcorn, and beer respectively. NFL announced that it would not extend the season to accommodate a COVID-19 outbreak among unvaccinated players leading to forfeiting of games (Patra, 2021).

None of the examples imply that social or nongovernmental mechanisms will reach an optimal allocation. Instead, our argument is simply that social mechanisms turn social benefits into private benefits, allowing people to internalize externalities in creative ways. If a free marijuana joint

pushes a young person to get vaccinated, they do not need a Pigouvian subsidy/mandate. In fact, the subsidy would be wasteful to the extent it is funded by distortionary taxes somewhere else.

V. What Type of Policy Response?

We do not mean to imply that there is not an economic argument in supporting vaccines through government policy. We originally mentioned the supply side. On the demand side, policy should, first, not get in the way. Certain state and private actions can prevent private incentives from arising to make the externality inframarginal. At the time of writing, two vaccines, one created by Moderna and the other by Pfizer, have been approved by the US Food and Drug Administration for emergency use. Other vaccines, most notably AstraZeneca's, which has been adopted by several countries outside the United States, are still pending approval in the United States. Long delays in approving vaccines or approving vaccines only for emergency use after a long delay create uncertainty and fosters mistrust. If fewer people trust the vaccine-approval process, then they may wait longer for more studies, delaying the emergence of the kinds of private mandates, incentives, and nudges discussed above. Furthermore, approval for emergency use may create legal problems for private firms and clubs seeking to enforce a vaccine mandate on their employees.

On the constructive role for policy, we see two parts. First, policy can be justified if it reduces transaction costs sufficiently. While we have focused on private mechanisms instituted by firms, clubs, and civil associations, government policy and private technologies may raise the effectiveness of these private mechanisms by reducing the transaction costs faced by private actors and civil associations that check vaccines or mandate vaccines. This can be done through mechanisms such as a health pass. This is essentially a barcode that is given to every vaccinated individual and allows them access to providers of several collective goods and services, such as grocery stores, airlines, concert halls, sports centers, bars, and restaurants. The principle of exclusion at work in club goods is at work here. But monitoring and excluding can now be accomplished at lower transaction costs, without which private firms and individuals would not attempt these mechanisms. For example, in December 2020, Singapore Airlines introduced "health passports" (Thomas, 2020). This technology allows the airline to lower the cost of monitoring its own passengers, it could be used more broadly to verify vaccine status at a low cost to other organizations. Private firms and local governments have introduced such passes in New York City, to provide ease of entry to restaurants, shops, and other local establishments.

When private arrangements or the transaction cost-reducing policies above are not sufficient, there is still the question of what level the mandate should occur. It is not enough to point to the fact that one person's vaccination decision has a tiny impact on other people all over the world. In practice, we need to look at both the relative and absolute magnitudes of the externalities.

For an analogy, consider the problem of littering. Littering is an externality. When Armen throws a McDonald's cup out his window on the way home, that cup has a chance (however small) of ending up in the farthest reaches of the ocean and thus being an externality on every other person on the earth. Given it has a positive chance of occurring, it is a *global* negative externality, strictly speaking. What should be the appropriate policy response to littering? There can be social pressures against littering in response. There are private solutions by providing trash cans. While there may be a role for some international agreements, it seems implausible that the bulk of the effort should be at the national or international scale.

Public goods and externalities are "two sides of the same coin." We know from Tiebout sorting those local public goods can sometimes be dealt with through local policy. The sorting allows the local community to internalize the externality, not at the individual level but at the appropriately defined local level. More than a theoretical possibility, there is evidence that cities internalize local externalities (Shoag and Veuger 2018). The general principle is that the policy response may be dealt with at the level which experiences the bulk of the externality. Garbage thrown within someone's house can be dealt with at the household level. Garbage thrown on the street can be dealt with at the neighborhood/city level.

We can apply this logic to vaccine mandates. If most of the benefits are local in nature, the appropriate policy response would be at the local level. Again, if this is the case, the economic case for universal vaccine mandates is weaker than commonly acknowledged.

There is another kind of collective problem that we have not considered so far. Every society has a limited amount of hospital capacity, and no society develops infrastructure to treat most of the population at the same time, as it would be prohibitively costly. However, during a pandemic, a lot of people get sick at the same time, adding stress to the limited hospital infrastructure. Some aspects of the healthcare infrastructure are not elastic in the short run, and this kind of stress on the health infrastructure may result in poor quality care or, worse, a collapse of the system. This is the reason, in the absence of a vaccine, many countries mandated shutdowns and lockdowns so that the healthcare infrastructure does not collapse. Some believe that stress on the (often state provisioned or subsidized) healthcare system is a negative externality on the entire

society, and therefore vaccines should be mandated. Once again, given the presence of a vaccine, the private benefits from vaccination are very high. Therefore, in places where the vaccine supply and availability are not the problems, the proportion of unvaccinated, however large, is the relevant group that can overwhelm the healthcare infrastructure. In societies with high state capacity, this is not a problem, as the healthcare infrastructure is relatively robust. This can become a problem in areas with low state capacity and merit a vaccine mandate. However, we should caution that a society with low state capacity will also find it very difficult to enforce a universal vaccine mandate, and the intended result – 100% vaccination - may not be achieved. Furthermore, if recovering from Covid-19 provides similar protection as the vaccine (which depends on the variant; see Shane 2021) then, once again, reaching a level where the hospital infrastructure is not overwhelmed may be achieved without universal mandates, since the unvaccinated are at higher risk of contracting Covid-19 and developing natural immunity. And the COVID-19 vaccine immunity wanes over time, so reaching herd immunity is not the relevant policy goal for hospital capacity.

One last argument in favor of a universal mandate is that new mutations are mostly developed in unvaccinated populations or populations without high natural immunity (Niesen et al. 2021). While this may be true, we have argued that locating an externality is insufficient to justify countrywide or statewide vaccine mandates. To solve the problem of new mutations, a global vaccine mandate is required, which would be virtually impossible to enforce. Furthermore, in many countries across the world, especially low-income countries, the constraint is not the lack of a mandate but the lack of availability of the vaccine (Sheikh et al. 2021). Therefore, in the current scenario, it is also not feasible to mandate a vaccine that is not available!

VI. Divergent Preferences vs. Free-Riding

Our analysis so far has focused on situations in which people recognize an externality and then, depending on the nature of their collective interactions and the transaction costs involved, decide whether to take actions to internalize the externalities. Papers on optimal Pigouvian subsidies implicitly do the same thing.

We imagine these collective-action solutions as creating an incentive for people on the margin to take vaccines. For example, because each of the vaccines is relatively new, people are uncertain about the costs and benefits of getting them. For some, the expected private benefits outweigh the expected private costs. For others, the expected costs are greater, so they will not get

the vaccine. As people learn more about the vaccines, if the experimental trials capture the costs and benefits, we expect more people to get the vaccine. The sort of side payments or Coasean bargains that we discuss above can speed up this process.

In the case of the COVID-19 vaccines, there are distinct subsets of people who are unlikely to be persuaded by the mechanisms that we have highlighted so far. One group believes there is no infectious disease, and that COVID-19 is a conspiracy (see Ullah et al. 2021). Therefore, they do not consider the vaccine a desirable good because there is no negative externality from the infectious disease that needs to be overcome. Some believe that the vaccines contain mechanisms that allow government surveillance through microchips (see Berry et al. 2021). For these individuals, the vaccine is not a good but a private and social bad. More than just not getting vaccinated, these people will actively inhibit other people from getting vaccinated. For these groups, the question of underconsumption and optimal consumption is moot. For example, in January 2021, protesters forced a temporary shutdown of a vaccination site at Dodgers Stadium (Gerber and Khan, 2021).

These are not people who would receive a vaccination if it was subsidized and provided at a price of zero. And they are not free-riding on other vaccinated individuals in the absence of a mandate. Unlike the examples in previous sections, transaction costs are not the reason that these people are not convinced to take the vaccine. If the optimal policy response required 100 percent vaccination, then to persuade COVID-19 deniers would require a very large Pigouvian subsidy to incentivize them to take the vaccine, and even that may not get society to 100% vaccination. In fact, for COVID-19 deniers and those who believe that the vaccine is a surveillance instrument, a mandate will be counterproductive, further strengthening the belief that the pandemic, or its cure, is a government conspiracy.

If people refuse to take the vaccine because of their unique beliefs and preferences, that is an entirely different problem than not taking the vaccine because they want to free-ride on others. A choice between divergent preferences cannot be solved by economic analysis alone. One must appeal to something else. Philosophers may be able to help.

There are also some who argue that misinformation is the chief cause of low rates of vaccination (Loomba et al. 2021; Pierri et al. 2021). This requires intervention in the form of an information campaign, quite different than a vaccine mandate. Communication experts and influencers may be more helpful than economists.

Bradley and Navin (2021), when talking about COVID-19, claim that it is incorrect to label vaccine refusers as free-riders because their beliefs and motivations may be different from free-

riding. In practice, it may be impossible to disentangle non-vaccination because of free-riding from non-vaccination because of divergent preferences/beliefs. Either way, our main argument still holds. Given we are not certain that the reason for non-vaccination is because of free-riding, the argument in favor of mandates is weaker than commonly thought. Again, if this is the case, the economic case for universal vaccine mandates is weaker than commonly acknowledged.

Even in the case of COVID-19 deniers, most of the population will have immunity due to the vaccine or natural immunity protection before there is 100 percent vaccination. Here, again, Buchanan and Stubblebine's (1962) concept of inframarginal externalities matters. At a high-enough level of vaccination, the marginal externality disappears, and we only have an inframarginal externality. If the deniers and conspiracy theorists are not too numerous, their lack of vaccination does not generate a negative externality on the rest of the population. And this group will likely develop natural immunity after two years of the pandemic. Becchetti and Salustri (2021) find from survey data from Italy that around 21 percent of the population will not take the vaccine, regardless of new information arriving about its costs and benefits. The collective-action problem is about incentivizing those on the margin that are most open to the vaccine.

VII. Conclusion

This paper started from the widely accepted premise by economists writing on vaccines, that vaccines generate a positive externality. The private and social marginal benefits of vaccines do not perfectly align. Therefore, there is room for policy interventions to improve outcomes for everyone involved. However, we depart in that we argue that a common policy approach to the externality, vaccine mandates, is weaker than commonly acknowledged in the case of COVID-19 vaccine.

We show that the presence of a positive externality does not automatically imply free-riding. In fact, most of the benefits for the vaccines developed to battle COVID-19 are internalized. This is because vaccinated individuals are protected from the most severe consequences of the infection, but they can transmit the infection (though at a lower rate of transmission compared to unvaccinated individuals). In this sense, the externality is also partially excludable since asymptomatic vaccinated individuals may transmit to the unvaccinated. Given strong private incentives, the externality may be inframarginal, as defined by Buchanan and Stubblebine (1962) i.e. the externalities exist, but they are policy irrelevant.

Second, even when the effects are not completely internalized, the external benefits are more local than global. Family members infect each other. Coworkers infect each other. The policy response should reflect the level of the externality. Therefore, the case for universal vaccine mandates is weaker than often acknowledged within the economics literature. Local public goods allow for more sorting and local "production," which in this case means local incentives to take the vaccine.

Finally, if the non-universal adoption of a COVID-19 vaccine is more related to preferences and beliefs about the vaccine, the healthcare system, and government, the argument is not about free-riding; the argument in favor of mandates must come from elsewhere.

The case for universal vaccine mandates is not strongly situated in explanations for underconsumption due to a free-rider problem. There may be other reasons not related to externalities and free-rider problems but have roots in ease, political politicization, misinformation, or paternalism, to justify vaccine mandates.

Nothing in our argument implies there is no role for governmental policy in vaccination. Instead, we maintain that the policy response should not singularly focus on universal vaccine mandates to solve a free-rider problem if none exists. There may be other reasons, not related to externalities and free-rider problems but instead in political politicization, misinformation, or paternalism, to justify vaccine mandates.

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