Vaccination or NPI? A conjoint analysis of German citizens' preferences in the context of the COVID-19 pandemic

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Abstract
This research uses discrete choice-based conjoint analysis that elicits the preference structure of German citizens when it comes to their timely intention to vaccinate. The focus is on the trade-offs between pharmaceuticals (vaccine) and “non-pharmaceutical interventions” (NPIs) such as lock-downs and social distancing measures, as well as the value of voluntary versus mandatory compliance to the citizens. Our results highlight three critical insights: (a) value of waiting: at 70% effective vaccine, 1/3 of citizens still would prefer to be vaccinated in the next 6 months rather than immediately; (b) costs of NPI constraints: an effective vaccine may come as a solution to compensate for the costs induced by invasive NPI imposed for an extended period; (c) freedom of choice: voluntary compliance is preferred by citizens over imposed measures whether it relates to vaccination choice, lock-down measures, or work location choice during the pandemic. Backing up those findings in monetary value, a quick shot of a 100% effective vaccination is estimated to be worth in the range of 11,400€. Still, the value of the shot quickly falls to no value when effectiveness drops below 50. At the same time, the cost of imposing protective rules lies in the range of 1500–2500€, depending on the rule analyzed. In comparison, the burden of extra complete lock-down and social distancing is about 775€ per citizen per month. As most current vaccines are being proven to have high efficacy, a strategy that selects the most effective vaccine candidates while emphasizing how the vaccine may stop the pain of lasting lock-downs will be appropriate to nudge the population towards vaccination. Control measures that are too restrictive may be welfare-deteriorating, but enough NPI measures must be recommended as long as vaccination adoption is not sufficiently large.

Keywords COVID-19 · Vaccine strategy · Non-pharmaceutical interventions · Conjoint analysis

JEL classification I12 · J22 · J23 · J33

Introduction
COVID-19 has spread aggressively worldwide, infecting more than 400 million people for about 5.9 million official deaths, 600 days after the WHO declared a pandemic.¹ In the absence of vaccinal solutions, non-pharmaceutical interventions (NPIs) such as lock-downs had been aggressively implemented, effectively slowing down the pandemic diffusion. Still, the reality is that these measures can only be sustained temporarily, as they bring a large set of negative socio-economic effects such as forced unemployment and large supply chain and distribution restrictions [17], on top of severe psychological effects, such as mental illness linked

¹ www.worldometers.info/coronavirus/
to social exclusion, or major fear of going to work for front-
line workers, among others [37].

Effective vaccines are often the only route to kill a pan-
demic, and the good news has been the speed at which new
vaccines were developed and deployed with strong claimed
protection against the COVID-19 only a few months after
the pandemic was declared. The first national campaign was
conducted in Israel starting in December 2020; authorities
reported that the Pfizer-BioNTech shot vaccine has been
90% effective at preventing infections and up to 99% at pre-
venting deaths from the COVID-19 virus. What is more, the
vaccine has exhibited limited side effects in real life [8, 22].

Despite this robust evidence, the will to be vaccinated has
remained in the range of 60–70% of the population in a large
variety of countries surveyed for the intended uptake of the
vaccine [19, 21, 40], or [11–14]. Countries with more uptake
intent are located in (South-East) Asia, essentially because
of high population trust in how institutions have managed
the covid-19 crisis [34]. This adoption intention is not small
if one compares it to the H1N1 uptake of 15% (see [5]) or the
typical anti-flu vaccine adoption rate [23]. Yet, this inten-
tion may fall short of the level to ensure herd immunity with
certainty. Assuming a homogeneously mixing population
and an effective vaccine at 80–90%, vaccination may have to
reach most of the people to secure given large $R_n$ reproduc-
ion rate, especially for recent COVID-19 virus mutations
such as Omicron, which is much more contagious than the
original virus at the start of the pandemic [18].

Strategies to find sweet spots to increase a higher conver-
sion of citizens to vaccination have been tested, but so far,
the anti-vax segment remains significant and vocal against
mandatory vaccination. Recent work has highlighted that
vaccination intention may be uplifted by educating the popu-
lation on minor adverse health effects of vaccines. But, in
practice, this is hampered by vaccine opponents’ aggressive
campaigns against vaccination and relayed on social media
[6]. Another route is to reboot the institutional trust to gov-
ernment actions. Still, trust has been easily lost in the recent
change of policies during this year of COVID-19 pandemic,
and confidence will not be easy to recreate [12, 29].

This research offers two important contributions.

1. First, compared to the current literature looking at fac-
tors affecting vaccine preferences such as socio-demo-
graphics, trust in institutions, vaccine quality, among
others, we include two overlooked dimensions that may
affect vaccination intention. The first dimension is that
the vaccination decision is, in effect, a way to escape
from the challenging lock-downs and exclusion proce-
dures. The second dimension is that actions launched by
the authorities to mitigate the COVID-19 diffusion may
be more or less mandatory and may affect citizens’ wel-
fare. With freedom of choice comes the responsibility
to follow the restrictions to avoid contaminating others,
especially for healthcare occupations such as nurses and
doctors [31]. Thus measuring this freedom choice is a
good marker of how people perceive the value of med-
cal ethics [36].

Our main hypotheses (and related subsidiary ones
further laid out in the "methodology" section), are that
NPI fatigue may trigger broader (and faster) vaccination,
and the "threat" of lasting NPI is possibly a better nudge
to support higher rate of vaccination, than the strategy
to further impose vaccination, where people have been
already much constrained, and because in general, peo-
ple value freedom of choice.

2. The second contribution to the literature is to test citi-
zens’ preferences in discrete conjoint choice techniques.
Conjoint techniques are a way to look at parametrizing
preferences based on choice trade-offs. Those trade-
offs are of particular relevance in the case of vaccine
preferences as, for instance, non-vaccination may lead
to stronger and longer NPI measures imposed on the
population to flatten the pandemic curve. Likely, people
may also trade-off the timing of vaccination with waiting
to be vaccinated, which provides more background as
to the side effects of a vaccine but exposes possibly to
contamination with side effects now. Conjoint designs
have frequently been employed in survey experiments
for policy decisions and simulations of market devel-
lopments [15]. Furthermore, as the evidence shows that
attribute weights match actual choices made by respond-
ents [25, 27], conjoint studies are successfully applied
in a variety of applications in health economics [26],
or [16]. Conjoint is also emerging in the context of
COVID-19 studies. Still, the focus has been only on the
"product" attributes, e.g., level and duration of vaccine
effectiveness and cost of side effects of the vaccine. For
instance, Motta [29] has analyzed vaccine feature prefer-
ces through discrete choice modeling on US citizens
and concluded that they prefer to wait for high effective
dose vaccination over being vaccinated right away at
a low level of vaccine effectiveness. Similar findings
emerge for the UK [28]. People also prefer vaccines
that carry a low risk of side effects and long protec-
tive duration, a finding that is recurrent in the literature
on discrete choice experiments of COVID-19 and other
viruses (e.g., hepatitis B) vaccines [20, 24].

Our work, applied on a sample of the German popula-
tion, collected in January 2021, right at the start of the
global vaccination campaign across the country, only
includes the essential product attribute found in early
studies, vaccine effectiveness, and communicates to respondents in the survey that the vaccine has limited side effects, in consistency with emerging evidence\textsuperscript{3}. We also do not look at the price point of vaccination, as the strategy to date has been (in Germany) to roll-out vaccination for free. We, however, can derive estimates of monetary value from the discrete options tested on the conjoint respondents, which allows us to bring the estimated value of vaccination against the COVID-19.

After discussing the methodology in “Scope and methodology”, results are presented in “Results” and various simulations. The last section details our conclusions.

Scope and methodology

Scope

The geographical focus of our study is on Germany. This is the largest country of the European Union, and one which has been perceived as successful in controlling the disease spread in the first wave of the COVID pandemic, but one which has now been under stress of rapid COVID-19 expansion\textsuperscript{4}. Vaccinations started with mRNA vaccines by BioNTech/Pfizer by late December 2020, and about 2.5 million German citizens got vaccinated by completing this field study.

Germany is an interesting case as mandatory vaccinations have been rare, except for measles for reunified Germany since March 2020\textsuperscript{5}. In the field by January 2021, this study is thus at the right time to test the value of choice versus mandate in the context of COVID-19. One caveat may be low awareness of vaccine safety and effectiveness. Still, at the same time, it is relatively known that vaccination success depends on sooner than later roll-out [35]. Understanding citizens’ preference trade-off is a piece of valuable information to inform best vaccination strategies. Furthermore, at that time of the survey collected, a new year was starting (2021). Citizens are taking stock of their restraints imposed by the COVID so that the conjoint preferences should be powerfully informative.

Regarding vaccine intention, it seems that the German attitude is relatively close to other European countries, and if anything, on the lower side (see [30]). Germany has, for instance, a relatively large portion of citizens hesitating to get vaccinated, and most studies conclude a vaccination intention, systematically below 70% [12].

Data collection

The sample has been collected online from January 25th to 28th, 2021 and involves 1556 participants originating from a quota sample that is representative for age, gender, and region of German adult citizens (Table 1). Fieldwork was supported and conducted by the international panel provider Dynata as part of a pro bono project.

DCE methodology

The conjoint method we use is one called discrete choice experiment (DCE). Survey participants are presented with 10 test screens, with the task to choose their preferred scenario among three choices involving a hypothetical vaccination strategy.

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Table 1 Distribution of controlled demographic variables

| Demographics | % in the study | % in population |
|--------------|---------------|----------------|
| Gender       |               |                |
| Female       | 48            | 49             |
| Male         | 52            | 51             |
| Age          |               |                |
| 18–25        | 9             | 10             |
| 26–35        | 15            | 15             |
| 36–49        | 23            | 21             |
| 50–64        | 27            | 27             |
| 65 years or older | 25 | 26 |
| Location     |               |                |
| Baden-Württemberg | 12 | 13   |
| Bayern       | 15            | 16             |
| Berlin       | 5             | 4              |
| Brandenburg  | 3             | 3              |
| Bremen       | 1             | 1              |
| Hamburg      | 3             | 2              |
| Hessen       | 8             | 8              |
| Mecklenburg-Vorpommern | 2 | 2 |
| Niedersachsen | 9            | 10             |
| Nordrhein-Westfalen | 22 | 21 |
| Rheinland-Pfalz | 4            | 5              |
| Saarland     | 1             | 1              |
| Sachsen      | 6             | 5              |
| Sachsen-Anhalt | 3          | 3              |
| Schleswig-Holstein | 4 | 3   |
| Thüringen    | 3             | 3              |

Sample’s size: 1556 citizens

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\textsuperscript{3} What to Expect after Getting a COVID-19 Vaccine | CDC.

\textsuperscript{4} Germany’s Winning Covid-19 Strategy Has Stopped Working—WSJ.

\textsuperscript{5} https://www.deutschland.de/en/topic/politics/corona-pandemic-compulsory-vaccination-in-germany.
The user choice we measure is twofold— it is about (a) the acceptance of the vaccine by German citizens, and if they accept it, (b) whether they will prefer to be vaccinated now or later. We choose this measure for two main reasons. The first is that, especially in the early days of a vaccination campaign, risks exist of supply chains being constrained. This has been the case for COVID-19 ([2], [32]). In general, the mainstream healthcare strategy (at least in Europe) was then based on prioritization in the function of individuals’ contamination/health severity risk. Still, this strategy may not fit preferences, and the value of waiting may be harmful to some individuals. The second reason for allowing for delayed uptake is that this preference may be broader than just refusing the vaccine [38], while either choice may stand for very different population segments [11–14]. Finally, with our outcome vaccine intention measure, we can look at the possible trade-off between taking a less effective vaccine today versus one which is more effective later or the value of time. Here, the value of waiting has been seen to match the value of gathering more information regarding the actual effectiveness and common side effects of a new vaccine [29]. We hypothesize that the expectation value is not low and may lead to a large share of citizens wanting to be vaccinated as early as possible at the beginning of the vaccination campaign (H1).

| Table 2 | Attributes regarding COVID-19 DCE, Germany, Jan 2021 |
|---------|------------------------------------------------------|
| 1       | I will get vaccinated as soon as possible            |
| 2       | I will get vaccinated after a while (e.g., 6 months) |
| 3       | I will not get the vaccine                          |
| 1       | Obligatory vaccine for healthcare workers           |
| 2       | Obligatory vaccine for the public                    |
| 3       | Voluntary vaccine                                   |
| 4       | Voluntary vaccine and a 500€ bonus for vaccination  |
| 1       | Effective at 90%                                     |
| 2       | Effective at 50%                                     |
| 1       | Mandatory full lock-down for 1 month                 |
| 2       | Mandatory full lock-down for 6 months                |
| 3       | Mandatory social distancing and wearing facemasks for 1 month |
| 4       | Mandatory social distancing and wearing facemasks for 12 months |
| 1       | Possibility to travel freely for the vaccinated      |
| 2       | No limits for public events for the vaccinated       |
| 3       | Forbidden to travel freely for not vaccinated        |
| 4       | Forbidden participation in public events for not vaccinated |
| 5       | Recommended social distancing and wearing masks      |
| 1       | Obligation to work onsite                            |
| 2       | Choice to work onsite or home office                 |
| 3       | Obligation to work onsite but with a 10% wage increase during the pandemic |

Conjoint attributes

Examples of screenshots of the conjoint treatments are presented in Appendix 1.

A conjoint is robust to the extent that we identify a reasonably salient but short set of criteria reflecting users' choice. Table 2 summarizes the attributes selected for the conjoint. Those have been selected, based on the purpose of the research (here: the value of freedom of choice, and the trade-off between pharmaceutical (vaccine) and non-pharmaceuticals interventions (masks wearing, etc.) and based on necessary calibration of the conjoint (in our case, effectiveness level of vaccine is a critical predictor of vaccine preferences). More details on each of the conjoint attributes are discussed hereafter.

We have thus considered five core input attributes for our analysis. 5–7 attributes are usually optimal for a conjoint design as this avoids people being overwhelmed by a list of characteristics to choose from.

Vaccine effectiveness As already stated, we have discarded product features that have already been proven to impact vaccination choice. Among others, Motta [29] shows a home bias in vaccine choice, but there is little preference difference between a traditional weakened-virus and the recent ones, based on mRNA. Side effects limit, but only marginally, the uptake of the vaccine.

Here, we consider vaccine effectiveness as a core attribute driving the extent of vaccination intention. The health
benefits of a vaccine should balance the health risk of the virus [12]. We consider two extremes and plausible cases in the conjoint, e.g., we consider effectiveness at a level of 90% (in line with results above 90% for Moderna and Pfizer/BioNTech—see Polack et al. [33]—and the claim made over the effectiveness of the Russian vaccine, Sputnik V[b]), and a case of just 50%. This threshold is motivated by existing rules: In the US, the FDA has put 50% as the minimum threshold to get approved by government authorities and is just below the likely performance of the current vaccine if taken with only one shot. In line with other research, we hypothesize that 90% effectiveness is primarily preferred over the 50% one (H2).

Free choice to get vaccinated The debate whether one should mandate the population to be vaccinated, rather than leaving the choice to each individual, is passionate [1, 7]. The rationale for imposing the vaccination is that the health costs are high enough [13] to bypass personal choice. Still, it is essential to know how much value people assign to their own choice. We thus hypothesize that mandatory vaccination brings a negative perception in the population (H3) and that the value of freedom of choice is lower than the health cost (H4).

Privilege to the vaccinated Instead of imposing mandatory vaccination, an alternative might be to restrict the non-vaccinated or provide benefits to the vaccinated. This is an important issue as the Nordic countries in Europe were the first to impose a vaccination passport. The German government was reported to support the introduction of an EU-wide "vaccination passport" during the conjoint data collection. France set a sanitary pass by June of 2021. The hypothesis is that people may prefer this form of restriction to imposition mandatory vaccines (H5). Hence, we also hypothesize that, given a sense of freedom, people would prefer the value of privilege when vaccinated over the imposition of barriers if not vaccinated (H6).

NPI Currently, NPIs have been the rule, more or less imposed on citizens, to flatten the curve of the COVID-19 diffusion. While effective, those NPI measures have significant adverse effects on both economic and socio-psychological sides [37]. We hypothesize a negative utility towards those NPIs, and the more so, the more stringent they are and the longer they are imposed (H7). One extra hypothesis we want to test is whether the most stringent NPI, e.g., lock-down, bears so much penalty that it can boost people to accept to get vaccinated (H8).

Work from home (WFH) Social distancing measures are not only about limiting shopping, eating outside, or meeting friends. For workers, 50% of their physical contact arises from work [9]. Many companies have adopted WFH as an effective way to protect against infection while continuing to work, but in the meantime, many people have complained about the integration of work into the private home space [3, 11]. We hypothesize that people may want to have the choice of where to work (H9).

Finally, there is also a sense that work on-premises can still be of interest if people are sufficiently compensated for the risk they take. Bughin and Cincera [10] demonstrate in a labor market-clearing model that equilibrium wages should likely increase by a few points in the function of the interplay of health risk, the stage of contagion, and the prevalence of non-work allowance. A case in point is that many major US retailers have given a base salary increase, on average 7% in 2020, for front-office workers. We hypothesize that a sufficient wage increase (say > 10%) may be relatively attractive to compensate at least in part the obligation to work on-premises (H10).

Estimation method

Conjoint analyses were performed using the ChoiceModelR package [37]. A hierarchical multinomial logit model was computed, using 4000 iterations of the Markov Chain Monte Carlo (MCMC), 2000 of which were utilized to estimate parameters. Beta coefficients at the individual level were then aggregated for all respondents to derive part-worth utilities for each level of the attributes.

Using Table 2 again, we have enough degrees of freedom to estimate all attribute preferences. There are 1319 possibly different vaccine combinations that respondents could potentially be asked to rate. As one collects 180 attributes per individual, and the sample is composed of more than 1500 respondents, every level of most attributes is placed at least 212 times on average, providing enough of a large sample to evaluate attribute-level effects.

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[b]https://globalnews.ca/news/7613903/russia-sputnik-vaccine-effec tiveness/

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7 Large retailers are making record profits but not paying workers more (cnbc.com).
8 1320 = 3 × 4 × 2 × 4 × 3 designs minus one prohibited pair: “I will not get vaccinated” did not show up together with “Obligatory vaccine for the public”.
9 Each respondent evaluates ten test screens with three scenarios each presenting six attributes (see Appendix 1).
10 180 × 1556 / 1319 = 212.34.
Table 3  Conjoint results—average base case

| Level                                                                 | Part-worth utility | Relative importance (%) |
|----------------------------------------------------------------------|--------------------|-------------------------|
| I will get vaccinated as soon as possible                           | 1.22               | 37.22                   |
| I will get vaccinated after a while (e.g., 6 months)                | 0.65               |                         |
| I will not get the vaccine                                         | −1.88              |                         |
| Vaccine is mandated for healthcare workers                          | −0.11              | 13.71                   |
| Vaccine is mandated for all                                         | −0.37              |                         |
| Vaccination is discretionary                                       | 0.18               |                         |
| Vaccine is discretionary and a 500€ bonus for vaccination           | 0.30               |                         |
| Vaccine is effective at 90%                                         | 1.04               | 18.58                   |
| Vaccine is effective at 50%                                         | −1.04              |                         |
| Mandatory full lock-down for 1 month                               | 0.11               | 14.19                   |
| Mandatory full lock-down for 6 months                              | −0.70              |                         |
| Mandatory social distancing and facemask wearing for 1 month       | 0.29               |                         |
| Mandatory social distancing and facemask wearing for 12 months     | 0.02               |                         |
| Recommended social distancing and wearing masks                    | 0.28               |                         |
| Those vaccinated may travel freely                                  | 0.11               | 8.74                    |
| Those vaccinated may attend any public events                       | 0.04               |                         |
| Forbidden to travel freely for not vaccinated                       | −0.09              |                         |
| Forbidden participation in public events for not vaccinated         | −0.07              |                         |
| Obligation to work onsite                                          | −0.23              | 7.56                    |
| Choice to work either onsite or home office                         | 0.17               |                         |
| Obligation to work onsite but with a 10% wage increase during the pandemic | 0.07               |                         |

Results

Path worth utilities

Table 3 displays the part-worth utilities for each level of the attributes, while the last column computes the relative importance of attributes in explaining the variance in vaccine choice.

As expected, the ranking of attribute response choices in order of preference is first about choosing when to get vaccinated (as soon as possible, after 6 months or never) and the vaccine's effectiveness (50% vs. 90%) in preventing the COVID-19 infection. This combined weight is about 55% of the importance of the decision. But that also means that 45% of the difference in vaccination intention is linked to the other attributes and confirms the influence in vaccination choice of NPIs (close to 15%) and of the freedom of choice regarding obligation or not to get vaccinated and differentiation in social measures pending on vaccination choice. Looking now at the level and sign of utilities, we confirm most of our hypotheses:

1. The hierarchy of vaccine preference in the baseline is getting vaccination as soon as possible, then after a while, and finally, vaccine rejection. The first two have a positive utility in contrast to the last one, demonstrating a bias towards vaccination. We also see that the part-worth utility value of getting a vaccine in a while is positive, confirming H1.

2. The utility attached to the vaccine effectiveness is largely negative at 50% and is close to being as much as the utility of getting vaccinated. Otherwise, the vaccine's effectiveness is a key driver of the intention to be vaccinated, confirming other studies [29]. We not only confirm H2, but we also can see in linear approximation that people would prefer to wait for a vaccine at 90% than being vaccinated with a 75% effective vaccine now (utility = 0.65 + 1.04 = 1.69 > utility = 1.22−1.04 + (2.08×60%) = 1.43). H3 is confirmed but shows that vaccine delay quickly becomes an effective strategy if the vaccine effectiveness is uncertain or not well documented. This corroborates the recent sorting behavior of people in terms of which vaccine to accept.

3. People do not want to be mandated to be vaccinated. They instead value their own choice, confirming H4. Likewise, they do not like to have restrictions if not vaccinated (and instead prefer some privilege of being vaccinated), but this seems to bear less burden than the obligation to be vaccinated (H5–H6).
4. Regarding NPI, H7 is more or less verified; lock-downs bring negative path-worth utilities, social distancing, and wearing masks seem to come as an acceptable social norm, especially when it is recommended, rather than mandated, by authorities. We finally note that the mandatory complete lock-down leads to a negative utility that is just about the opposite utility of being vaccinated after a while, putting some merits to H8. That is, people might consider vaccination for too long restrictive NPIs.

5. Focusing on workers, we find a negative utility to imposing rather than letting them choose their work location (H9). This gap in utility presumably reflects in part the fear of being exposed at work, which can be more than compensated by a higher salary (H10).

**Monetary values**

As the vaccine is being distributed free, we did not test different willingness-to-pay for the vaccine, so we cannot directly translate path-worth utility into monetary value.

However, two attributes may be used to derive a monetary value, even if this should be considered as only directionally right, and not be taken as "face value," let alone that those monetary values are fitted only to the context of the German economy. Keeping in mind those caveats, the first is that an incentive of 500€ to get vaccinated translates into an increase of 0.12 of utility, implying that a point of utility is worth 500/0.12 = 4160€ in the conjoint. The second attribute, with a financial metric, relates to the 10% increase in wage salary during the pandemic (running for 2 years). Based on the utility level of this wage incentive, the 10% increase would translate into 5000€ per year, and this seems in line with the mode of 50,000€ gross salary per year observed in Germany by 2020.11

This value metric per point of conjoint utility would entail that the difference between a vaccine effective at 90% versus 50% would be worth (2.08 × 4160) = 8652€. A linear approximation would entail that the decision to take a 100% effective vaccine shot incurred right away (versus no vaccination) is worth 11,400€. This figure is also in line with US estimates of protection value, estimated at 18,000$ (see [4]).

From that triangulation, we then compute illustrative value metrics:

1. At the baseline, the value of being vaccinated one month earlier is derived as (1.22 − 0.65)/3 (months) × 4160€ = 800€, or 16% of the value of the vaccine shot taken right away (= 800/(1.22 × 4160)). Thus, 6 months of waiting for the vaccine may take out all the value of the vaccine.

2. The personal freedom to comply with any protection measure amounts to about 1,500€ (per measure). In fact, from the largest to the lowest value, the value of choice is worth 0.45 × 4160 = 1870€ for the voluntary choice to be vaccinated; 0.4 × 4160 = 1665€ for the choice of location to work, and to 0.31 × 4160 = 1290€ when it comes to the privilege (public events and travel) of the vaccinated. As the three measures are being discussed today, accepting that authorities leave the freedom of choice to citizens is worth 5000€ per person.

3. The difference in utility between 6 versus 1 month of full lock-down, or 5 extra months of lock-down is worth −0.81 from Table 2, or a monthly cost of (0.81/5 × 4160) = 670€. By the same token, the cost of 1 extra month of social distancing and mask-wearing is just above 100€, or a fraction, 15%, of the lock-down perceived costs. We can then derive from this that 1 year extra of respecting all NPI measures is worth about (6700 + 100€) × 12, or above 9000€, and more than 10,000€, if one is imposed to comply with those measures, instead of freely choosing her level of non-pharmaceutical protection. We conclude that the cost of NPI is as much as the value of a fully effective vaccine, and thus that the signal of continued strict NPI rules can be a good incentive for people to choose for vaccination.

**Attributes significance**

An alternative way to present the results in terms of worth-path utilities is to show the parameters estimated directly from the logit regression model on vaccination intention (Table 4). Through this alternative, one also can confirm the level of statistical significance of attributes as driving vaccination decisions.

The default baseline is the obligation to be vaccinated for the health workers only; the vaccine is effective at 70%; lock-down is necessary for 1 month, and obligation to work on site.

We note that there is no statistically significant difference between the vaccination mandate imposed on healthcare workers versus everyone on the will to vaccinate. Likewise, limiting public events attendance to the non-vaccinated has a different impact than allowing attendances for the vaccinated. All other elements are strongly significant and confirm our list of hypotheses; in particular, vaccination intents are positive (and thus refusal is a minority), freedom of choice is positive (therefore, any restraint is perceived as welfare reducing). NPI compliance acceptance is reduced with the length of time.

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11 Average is 62,000€ for 2020, while the mode is at 52,000€. See Germany | 2020/21, Average Salary Survey.

12 3 months is the mean in the interval between 0 and 6 months for either choice in the conjoint.
Discussion

Results above concern the marginal value of attributes. Now, those values can be used to discuss which strategies can be sufficiently strong to be widely accepted by citizens and secure herd immunity. To this aim, we also have run multiple sensitivity analyses on the mix of vaccination patterns among German citizens.

Table 5 synthesizes the results at the baseline average (with thus 70% vaccine effectiveness), plus two extreme scenarios (explained hereafter). More sensitivity details are displayed in Table 6.

Considering our baseline and summing the marginal probabilities (sum = 97% to re-calibrate them to 100%), just below 21% of German citizens would refuse to be vaccinated. This is in line with other preference studies regarding German citizens, conducted as early as of April 2020 (see [12, 30]), even if that research has some shortcoming (e.g., preferences were stated, and not derived from preference trade-off in a conjoint, and were expressed at a time where no vaccine was in sight). But all those studies converge to the true importance of the value of waiting in case of a new vaccine: It can represent 1/3 of the implied citizens’ preferences. This delay is ok to the extent that it may alleviate supply chain constraints at the start of vaccine roll-out, but it

Table 4 Results of the logistic regression

| Variables                                             | (1) Coeff   | (2) Se    |
|-------------------------------------------------------|-------------|-----------|
| I will get vaccinated as soon as possible             | 1.048***    | (0.0278)  |
| I will get vaccinated after a while (e.g. 6 months)   | 0.754***    | (0.0278)  |
| Obligatory vaccine                                    | −0.0231     | (0.0302)  |
| Voluntary vaccine                                    | 0.157***    | (0.0291)  |
| Voluntary vaccine and a 500€ bonus for vaccination   | 0.273***    | (0.0288)  |
| Effective at 90%                                      | 0.776***    | (0.0206)  |
| Mandatory full lock-down for 6 months                | −0.301***   | (0.0328)  |
| Mandatory social distancing and wearing facemasks for one month | 0.0787**    | (0.0318)  |
| Mandatory social distancing and wearing facemasks for 12 months | −0.0397    | (0.0320)  |
| Recommended social distancing and wearing masks       | 0.0806**    | (0.0319)  |
| Forbidden to travel freely for not vaccinated         | −0.0499*    | (0.0289)  |
| No limits for public events for the vaccinated        | 0.0397      | (0.0288)  |
| Possibility to travel freely for the vaccinated       | 0.0627**    | (0.0288)  |
| Obligation to work onsite                             | −0.173***   | (0.0250)  |
| Obligation to work onsite but with a 10% wage increase during the pandemic | −0.0428*    | (0.0247)  |
| Constant                                              | −1.773***   | (0.0427)  |
| Observations                                          | 46,680      |           |

Standard errors clustered by participant in parentheses; socio-demographic control do not change the picture

***p < 0.01, **p < 0.05, *p < 0.1

Table 5 Marginal probabilities (delta method) of baseline, best and worst scenarios, %

| Scenario                                             | Baseline | Best  | Δ%   | Worst | Δ%   | Δ%   |
|------------------------------------------------------|----------|-------|------|-------|------|------|
| I will NOT get the vaccine                           | 20.2     | 16.9  | −17.7| 22.1  | 9.2  | −27.0|
| I will get vaccinated as soon as possible             | 41.9     | 36.7  | −13.2| 44.8  | 6.6  | −19.8|
| I will get vaccinated after a while (e.g. 6 months)  | 34.9     | 30.2  | −14.6| 37.7  | 7.5  | −22.1|

Best scenario: Voluntary vaccine and a 500€ bonus for vaccination; effective at 90%; Recommended social distancing and wearing masks; possibility to travel freely for the vaccinated; the choice to work onsite or home office.

Worst scenario: Obligatory vaccine for the public; effective at 50%; Mandatory full lock-down for 6 months; forbidden to travel freely for not vaccinated; obligation to work onsite.

Delta to 100% among the three columns is the constant.

Δ= difference with baseline scenario in %

Δt= difference between the best and worst scenario in %
| Scenario                                                                 | Obligatory vaccine for healthcare workers | Δ                  | Obligatory vaccine for the public | Δ                  | Voluntary vaccine | Δ                  | Voluntary vaccine and a 500€ bonus for vaccination |
|-------------------------------------------------------------------------|------------------------------------------|--------------------|----------------------------------|--------------------|-------------------|--------------------|--------------------------------------------------|
| I will NOT get the vaccine                                              | 18.5                                     | −8.5               | 18.2                             | −10.3              | 21.0              | 4.0                | 23.0                                             |
| I will get vaccinated as soon as possible                               | 39.4                                     | −6.2               | 38.8                             | −7.7               | 43.2              | 3.1                | 46.0                                             |
| I will get vaccinated after a while (e.g. 6 months)                     | 32.6                                     | −6.9               | 32.1                             | −8.5               | 36.1              | 3.3                | 38.8                                             |
| Effective at 50%                                                        |                                          |                    |                                  |                    |                   |                    |                                                  |
| I will NOT get the vaccine                                              | 14.6                                     | −32.4              | 27.2                             | 29.9               |                   |                    |                                                  |
| I will get vaccinated as soon as possible                               | 32.9                                     | −24.2              | 51.5                             | 20.6               |                   |                    |                                                  |
| I will get vaccinated after a while (e.g. 6 months)                     | 26.7                                     | −26.9              | 44.2                             | 23.5               |                   |                    |                                                  |
| Mandatory full lockdown for 1 month                                     | 20.8                                     | 3.0                | 16.2                             | −22.0              | 22.1              | 9.1                | 20.1                                             |
| Mandatory full lockdown for 6 months                                    | 42.8                                     | 2.1                | 35.6                             | −16.3              | 44.7              | 6.5                | 41.8                                             |
| Mandatory social distancing and wearing facemasks for 1 month           | 35.8                                     | 2.4                | 29.2                             | −17.9              | 37.6              | 7.3                | 34.9                                             |
| Mandatory social distancing and wearing facemasks for 12 months         |                                          |                    |                                  |                    |                   |                    | −0.1                                             |
| Mandatory social distancing and wearing facemasks for 12 months         |                                          |                    |                                  |                    |                   |                    | −37.6                                            |
| Recommended social distancing and wearing masks                         |                                          |                    |                                  |                    |                   |                    | −7.3                                             |
| Forbidden participation in public events for not vaccinated              | 20.0                                     | −0.9               | 19.2                             | −5.0               | 20.6              | 2.1                | 21.0                                             |
| Forbidden to travel freely for not vaccinated                            | 41.6                                     | −0.7               | 40.4                             | −3.6               | 42.5              | 1.4                | 43.1                                             |
| No limits for public events for the vaccinated                           | 34.6                                     | −1.0               | 33.5                             | −4.2               | 35.5              | 1.6                | 36.1                                             |
| Possibility to travel freely for the vaccinated                          |                                          |                    |                                  |                    |                   |                    | −3.3                                             |
also shows that the debate is not only about vaccine acceptance or not but about how acceptance builds up with time.

Let us now contrast private utility-maximizing and minimizing scenarios. The first scenario takes as a case to maximize the individual utility of each feature. This means a world where the German authorities would let people freely decide on their vaccination (voluntary vaccine); would further grant a 500€ bonus for quick vaccination; would supply a vaccine that is proven effective at 90%; while authorities would only recommend (not impose) social distancing while stopping any further lock-down, and giving the possibility to travel freely for the vaccinated on top of WFH choice.

The intuition would be that vaccination intent will significantly increase, but the answer from the simulation shows that this is only marginally true. The reason is as follows. As the most prominent driver in utility is vaccine effectiveness, a more effective vaccine relatively decreases both the reluctance and the delay to be vaccinated. Still, the value to choose to comply to, as well the release of, constraining NPI measures, would reduce the will to get vaccinated. Net both effects play equally in both directions, even if at the end the marginal probability of refusing the vaccine decreases. Otherwise stated, private preferences go against the planner’s preferences to secure vaccination and limit the development of the disease. NPIs are thus not only important to keep the protection until vaccination is rolled out, but also NPI restrictions act as an incentive to stimulate vaccine uptake. This confirms other simulations in other settings by Abo and Smith [1] and shows the importance of continuing NPIs on top of vaccination during the vaccination campaign roll-out.

In the other extreme, the least favorable scenario from a citizen perspective is one where the authorities would oblige citizens to take an ineffective vaccine shot while further expanding full lock-down for 6 months and obligation to WFH. The only positive incentive would be a travel allowance, but only for those vaccinated. In this case, all those NPI obligations push the motivation to get vaccinated faster, but the effect of an ineffective vaccine reverses this incentive.

The scenarios illustrate the critical trade-off between vaccine effectiveness and imposition or not of continued strict (or lighter) NPIs. This implies clearly that the best win–win model, which meets social and private utilities, is one where some freedom and privileges are kept, but not all, in favor of the citizens (possibly those vaccinated, hence the idea of a vaccine certificate). At the same time, one rolls out the most effective vaccine.

In this case, the refusal portion becomes closer to 15%, or 85% of citizens may be vaccinated across the next 6 months. However, such a scenario of relevance to reach herd immunity requires that the most effective vaccines are being proposed. If this is not enough to bring herd immunity, the fringe may be imposed to get vaccinated in the medium
term. The only challenge is that refusers are likely to be those already feeling at odds with the over-ruling of actions by their authorities, and further imposition may only but increase their suspicion against the authorities [12]. This leads to another significant insight: building trust in actions against COVID-19 remains a large imperative [41].

Conclusions

The discrete conjoint experiment in this study suggests that the intention to vaccinate must consider both vaccine features, the cost of NPIs, and the degrees of freedom left to citizens in how the COVID-19 crisis is being managed. As for other studies, we confirm that vaccines must be highly effective at warding off the infection if one hopes that citizens will embrace the shot. Vaccines with lower effectiveness are expected to be resisted by part of the population. They may impose other negative externalities to impose NPI longer or stronger to compensate for the deficit in the vaccine’s effectiveness. In any case, while vaccines may be accepted to be put in the market with 50% effectiveness (e.g., the FDA in the US), the population reluctance to get vaccinated is a roadblock already below 75% effectiveness, according to our estimates.

Furthermore, results suggest that imposing NPIs may lead to high costs, with 1 month of strict lock-down being a burden worth more than the value of waiting to get vaccinated. But imposing NPI is necessary until herd immunity is achieved and may act as a powerful incentive to alleviate those costs. There is no point in imposing too restrictive rules on citizens, as this freedom cut can be perceived as too dramatic, even if it increases appetite to fast vaccination. At this stage, the portion of those willing to vaccinate is far above the supply chain constraints. Still, too much freedom also boosts the will of people not to be vaccinated, so the key is to find the right balance of freedom left to citizens.

Lessons from this research are that vaccination intention must consider the whole picture, e.g., both NPIs and vaccines, as people balance the two types of interventions to protect against the virus. Finally, while social and individual choices may be conflicting, authorities may be wise to consider the level of choice left to the citizens. Too much and too long can backfire, but enough of it is an excellent incentive to push vaccination.

This study has some clear limitations. As a conjoint, it is based on the assumptions that people can make conscious trade-offs among the options presented. Second, we have voiced to participants that side effects are limited from the vaccine. We did not explicitly test different vaccine solutions, let alone the fact that some vaccines may need a second shot to be fully effective. Third, we remind the reader that the valuation method is at best illustrative, as we could not have a direct measure of value (the vaccine is distributed free). In contrast, the value should be compared to the level of development of the country case study.

Also, as we use metrics such as 10% of salary increase or the value of 500 euro as a financial incentive to get vaccinated to derive a monetary value, there is the danger that those valuation metrics may not be directly transferrable to all citizens, e.g., what does a 10% salary increase mean for someone not active in the labor market, what does 500€ extra mean for someone badly in need to get vaccinated.

Finally, the geographical focus of our study is Germany, the largest country in the European Union in terms of population. To ensure the international transferability of our results and their implications, it would be helpful to replicate the same analysis with other surveys from other countries.

Those caveats call for additional research, but the results also suggest that if an effective vaccine is a powerful tool to stopping a pandemic, the traction is highly dependent on other alternative measures (NPIs) to limit the spread of the virus and how authorities decide between the stick (mandate) and the carrot (free to chose, with privilege). Along the way, NPIs remain essential to push for the alternative of vaccination and stabilize the pandemic. The question is that both must be integrated to manage the right path of success of killing the pandemic.
### Appendix 1 Example of the conjoint test screens

#### Which scenario would you prefer? *

| Time of Covid vaccination | Vaccine | Vaccine effectiveness | Restriction Level | Advantages/ penalties | Work |
|---------------------------|---------|----------------------|-------------------|-----------------------|------|
| I will get vaccinated as soon as possible | Voluntary vaccine | Effective at 50% | Mandatory social distancing and wearing facemasks for 1 month | Possibility to travel freely for the vaccinated | Obligation to work onsite |
| | Voluntary vaccine and a 500 euro bonus for vaccination | | | | |
| I will NOT get the vaccine | Obligatory vaccine for healthcare workers | Effective at 50% | Mandatory full lockdown for 6 months | No limits for public events for the vaccinated | Choice to work onsite or homeoffice |
| | | | | | |

#### Which scenario would you prefer? *

| Time of Covid vaccination | Vaccine | Vaccine effectiveness | Restriction Level | Advantages/ penalties | Work |
|---------------------------|---------|----------------------|-------------------|-----------------------|------|
| I will get vaccinated after a while (e.g. 6 months) | Voluntary vaccine and a 500 euro bonus for vaccination | Effective at 50% | Recommended social distancing and wearing masks | Forbidden to travel freely for not vaccinated | Choice to work onsite or homeoffice |
| | | | | | |
| I will get vaccinated as soon as possible | Voluntary vaccine | Effective at 90% | Mandatory full lockdown for 1 month | Forbidden participation in public events for not vaccinated | Obligation to work onsite but with 10% wage increase during pandemic |
| | | | | | |
| I will NOT get the vaccine | Obligatory vaccine for healthcare workers | Effective at 50% | Mandatory full lockdown for 6 months | No limits for public events for the vaccinated | Choice to work onsite or homeoffice |
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