Vaccination or NPI?
A Conjoint Analysis of German Citizens' Preferences

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Vaccination or NPI?
A conjoint analysis of German citizens' preferences

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Abstract

This research uses discrete choice-based conjoint analysis that elicits the preference structure of 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 lockdowns and social distancing measures, as well as the value of voluntary versus mandatory compliance to the citizens.

Our results, based on a recent survey of German citizens, highlight three important insights: a) regarding the baseline, with 70% effective vaccine, more than 3 out of 10 *will not* accept to be vaccinated and among those considering vaccination, 1/3 still *would prefer to be vaccinated in the next six months* rather than immediately; b) among attributes, an effective vaccine may come as a solution to compensate for the costs induced by NPI, especially when NPI are invasive and might continue for an extended period; c) voluntary compliance is highly preferred by citizens over imposed measures whether it relates to vaccination choice, lockdown measures, or work location choice during the pandemic.

Backing up those findings in monetary value, an immediate shot of a 100% effective vaccination is estimated to be worth in the range of 11,400€ but the value of the shot quickly falls to no value when effectiveness drops below 50. In comparison, the burden of extra full lockdown and social distancing is about 775€ per citizen per month, while the cost of imposing protective rules lies in the range of 1,500 to 2,500€, depending on the rule analyzed.

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 lockdowns 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-codes: I12, J22, J23, J33

1. Introduction

Covid-19 has spread worldwide and infected more than 100 million people. To limit contagion, non-pharmaceutical interventions (NPIs) such as lockdowns are now widespread, but the reality is that these measures can only be sustained temporarily, as they bring a large set of negative socio-economic effects (Coibion et al., 2020), as well as major adverse psychological effects (Shi et al., 2020).

The good news in recent months has been the speed at which new vaccines have been developed and deployed with strong claimed protection, up to 90% for Moderna and Pfizer/BioNTech, or the Russian Sputnik V. The national campaign in Israel since December 2020 confirms both the high effectiveness, as well as limited side effects, in real life. The country authorities report that the Pfizer-BioNTech shot vaccine has been 90% effective at preventing infections, and up to 99% at preventing deaths from the Covid-19 virus.[1]

Despite this evidence, the will to be vaccinated remains in the range of 60-70% of the population, in a large variety of countries surveyed for the intended uptake of the vaccine.[2] This adoption intention is not small if one compares to H1N1 uptake of 15% (see Balsi et al., 2012), and to the typical anti-flu (Guidry et al., 2020). Yet, this intention may fall short of the level to ensure herd immunity with any certainty, assuming a homogeneously mixing population, and mutations like the ones happening in the UK. Covid-19 mutant reproduction rate R_0 may expand to 6, implying herd immunity to be achieved at 85% of the population.

Strategies to find sweet spots to increase a higher conversion of citizens to vaccination are being tested, but so far, with limited effects. Recent work has already highlighted that vaccination intention may be uplifted by educating the population on the limited adverse health effects of vaccines. But, in practice, this is hampered by vaccine opponents' aggressive campaigns against vaccination and relayed on social media (Bonnevie et al., 2020).

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[1] See Fogelatti et al. (2020) and Brnaswell (2020) for limited side effects; regarding Israel insights on mass-market vaccination, see https://www.ndtv.com/world-news/pfizer-shot-results-show-vaccination-can-stop-covid-spread-israeli-study-2375695

[2] For research on Covid-19 vaccine intention, see for France, Detoc et al. (2020), for US, Fisher et al. (2020) for example.

Another route is to reboot the institutional trust to government actions, but trust has been easily lost in the recent change of policies during this year of Covid-19 pandemic, and trust will not be easy to recreate (Bughin et al., 2021b; Motta, 2020).

This research takes another view by looking mainly at two dimensions that have been overlooked as a way to boost vaccination intention. The first is that the vaccination decision is, in effect, a way to escape from the challenging lockdowns and exclusion procedures. The second is that control actions may be more or less mandatory.[3] We test those preferences via discrete conjoint choice techniques on a sample of the German population, collected in January 2021, right at the start of the global vaccination campaign across the country.

Conjoint designs have frequently been employed in survey experiments, for policy decisions and simulations of market developments (Buyer et al., 2012). As the evidence shows that attribute weights match actual choices made by respondents (Luce and Tukey, 1964; Hainmueller et al., 2015), conjoint studies have been used successfully more and more in a variety of applications in health economics (Lambooij et al., 2015; or Clark et al., 2014). Conjoint is also emerging in the context of Covid-19 studies, with a special focus on the "product" attributes, e.g. level and duration of effectiveness, and limited side effects of the vaccine. For instance, Motta (2020) has analyzed vaccine feature preferences through discrete choice modelling 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 (McPhedran and Toombs, 2021). People also prefer vaccines that carry a low risk of side effects and long protective duration, a finding that is recurrent in the literature on discrete choice experiments of Covid-19 and other viruses' vaccines (Dong et al., 2020; Guo et al., 2020).[4]

Our work, applied on a sample of the German population, only involves the most important product attribute found in early studies, vaccine effectiveness, and communicates to respondents in the survey that the vaccine has limited side effects, inconsistent with emerging evidence.[5] We focus on mandatory versus voluntary decisions as the debate is currently happening on the opportunity to make the vaccination mandatory. Likewise, there is growing

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[3] With freedom of choice comes the responsibility to follow the restrictions so as not to contaminate others. Thus the choice we measure in the conjoint is a good marker how people perceive the value of medical ethics as well, see Savulescu (2020).

[4] The authors have performed a discrete choice experiment regarding hepatitis B, and show that risk of side effects is a major attribute of uptake. They also show that vaccine intention is influenced by duration of protection and cost of vaccine.

[5] What to Expect after Getting a COVID-19 Vaccine | CDC

fatigue linked to NPI compliance in the population that may or may not, facilitate the decision to get the vaccine. We do not look at the price point of vaccination, as the strategy to date has been (in Germany) to rollout 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. Our study hence leads to the following new findings.

First, the baseline scenario, with an average of 70% vaccine effectiveness[6], suggests that 1/3 of the population might resist vaccination, in line with stated surveys (see Bughin et al., 2021b). Second, the vaccine reluctance is driven by a high effectiveness elasticity, i.e. the value of an immediate shot of a 100% effective vaccine is estimated to be above 11,400€ (in the lower side of other estimated full protection estimates against the Covid-19, e.g. Bethune and Korineck, 2020), but each 10% of effectiveness decline is worth a loss of 2,600€. This decline is large enough to explain the apparent number of citizens against lower effective vaccines.[7]

Third, in our baseline of a 70% effective vaccine, the value of getting vaccinated in a few months is lower than immediate, but remains, positive up to 6 months; it extends to 9 months in the case of 90% effectiveness. In effect, the cost of waiting is worth roughly as much as the cost of mandatory lockdown, and the two combined amount to about 1,500€ per month, still less than the decline in value for a 10% less effective vaccine in preventing the Covid-19. Fourth, freedom versus imposition of choice is highly valued, whether it relates to vaccination choice, lockdown, or work location choice.

Our simulation suggests that when maximizing vaccination scenario, vaccination may be reaching above 80% of the German population, spread over 6 months. In one way, this looks like a good minimum to reach herd immunity, and the spreading of preferences allows one to match vaccination demand possibly better with current supply chain delivery constraints.[8]

After discussing the methodology in Section 2, results are presented in Section 3, together with various simulations. The last section details our conclusions.

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[6] This is the average of 50% and 90% effectiveness attributes, as our sample average tests the same portion of attributes.
[7] AstraZeneca boycott: German and French citizens turn down Oxford jab after scaremongering | Politics | News | Express.co.uk
[8] One way to go higher might be mandatory vaccination after most of the vaccine-prone citizens [what do you mean by "vaccine prone" ? have received their shot, but it is also anticipated that this mandatory vaccination will be clearly targeting a resisting group that is mostly mistrusting government actions to date, while mandatory vaccination can only reinforce their mistrust against authorities. This calls for the latter to rebuild dialogue on the supporting role of the public authorities towards citizens (Bughin et al., 2021b).

2. Conjoint Methodology

2.1. Sample

Our focus 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.[9] Vaccinations started with mRNA vaccines by BioNtech/Pfizer at the end of December, with about 2.5 million people vaccinated by the time of this writing.[10]

Germany is an interesting case as mandatory vaccinations have been rare, except for measles for reunified Germany since March 2020.[11] This study thus is at the right time to test the value of choice versus mandate in the context of Covid-19.

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

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[9] [Germany's Winning Covid-19 Strategy Has Stopped Working - WSJ](#)
[10] 4.7 % of population vaccinated once and 2.4% vaccinated twice.
[11] https://www.deutschland.de/en/topic/politics/corona-pandemic-compulsory-vaccination-in-germany

Regarding vaccine intention, it seems that German attitude is relatively close to other European countries, and if anything, on the lower side (see Neumann-Böhme et al., 2020). Germany has for instance a rather large portion of citizens hesitating to get vaccinated, and most studies conclude a vaccination intention, systematically below 70% (Bughin et al., 2021b).

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.

2.2.   Conjoint design

2.1. Data sources

The conjoint we use is a discrete choice experiment (DCE). German citizens are presented with 10 test screens, with the task to choose their preferred scenario among 3 choices involving a hypothetical vaccination strategy.

A conjoint is powerful to the extent that we identify a reasonably salient, but short, set of criteria that reflects users' choice. Table 2 summarizes the attributes selected for the conjoint. Examples of screenshots of the conjoint treatments are presented in Appendix 1.

From Table 2, one can compute that there are 1,320 possibly different vaccine combinations that respondents could potentially be asked to rate.[12] As one collects 180 attributes per individual, every level of most attributes is rated at least 1,980 times on average, providing enough of a large sample to evaluate attribute-level effects.

2.2. Outcome Attribute

The outcome measure is about the acceptance of the vaccine by German citizens, and if they do accept it, whether they will prefer to be vaccinated *now or later*. The media has relayed the fact that most of the health-care strategy in Europe is based on a vaccination delivery prioritized in function of the contamination as well the health severity risks of individuals. Still, on the demand side, there is a value in testing the match of this strategy with citizens' preferences regarding vaccination, while also looking at a possible roadblock, not only in terms of refusal but also in terms of delaying the vaccine uptake. In particular, with our outcome vaccine

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[12] 1320 = 3 × 4 × 2 × 5 x 4 x 3 designs minus one prohibited pair: "*I will not get vaccinated*" did not show up together with "*Obligatory vaccine for the public*.

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 simply, the value of time. Here, the value of waiting has been seen to match the value of gathering more information regarding the true effectiveness and low side effects of a new vaccine (Motta, 2020). We hypothesize that the value of waiting is not small and may lead to a material portion of the citizens at the start of the vaccination (**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 lockdown for 1 month
2	Mandatory full lockdown 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

2.3. Input attributes

We have considered 5 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 attributes to rank.

Product effectiveness. As already stated, we have discarded product features that have already been proven to impact vaccination choice. Among others, Motta (2020) shows that there is 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, along the way that the health benefits of a vaccine should balance the health risk of the virus (Bughin et al., 2021b). 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. (2020) - and the recent claim made over the effectiveness of the Russian vaccine, Sputnik V[13]), and a case of just 50%. 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. We hypothesize, in line with other research, that 90% effectiveness is largely preferred over the 50% one (**H2**).

Vaccine as a mandate or a choice. The debate whether one should mandate the population to be vaccinated, rather than leaving the choice to each individual is passionate (Bozzola et al., 2018 and Abo and Smith, 2020.) The rationale for imposing the vaccination is that the health risk and care negative externalities are high enough (Bughin et al., 2021c) to bypass personal choice. Still, it is important to know how much value people assign to their own choice. We thus hypothesize that mandatory vaccination will bring a negative perception in the population (**H3**). Still, based on the conjoint, we hypothesize that the value of freedom of choice can be lower than the contagion cost especially if the preference of vaccination remains too low even for an effective vaccine, to prevent herd immunity (**H4**).

Vaccination "privilege". Instead of imposing mandatory vaccination, an alternative might be to impose restrictions on the non-vaccinated or provide privileges to the vaccinated.. This is an important issue as multiple countries such as the Nordics are now looking at imposing a vaccination passport for example.[14] The hypothesis is that people may prefer this form of restriction to the imposition of mandatory vaccine (**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**).

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[13] https://globalnews.ca/news/7613903/russia-sputnik-vaccine-effectiveness/
[14] By the time of this writing German government is reported to support the introduction of an EU-wide "green vaccination passport".

NPIs extension. Currently, NPIs have been the rule, more or less imposed on citizens, as a way to flatten the curve of the Covid-19 diffusion. While being effective, those NPI measures have large adverse effects, on both economic and socio-psychological sides. 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. lockdown, 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 contacts arise from work (Bughin and Cincera, 2020). WFH has been adopted by many companies as an effective way to protect against infection while being able to continue to work, but in the meantime, lots of people have complained about the integration of work into the private home space (Argente et al., 2020; Bughin et al., 2020a). 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 (2021) demonstrate in a labor market-clearing model, that equilibrium wages should likely increase by a few points, in 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.[15] We hypothesize that a sufficient wage increase (say > 10%) may be rather attractive to compensate at least in part the obligation to work on-premises (**H10**).

3. Results

3.1. Conjoint utilities

Conjoint analyses were performed using the ChoiceModelR package (v.1.2, Sermas and Colias, 2012).

A hierarchical multinomial logit model was computed, using 4,000 iterations of the Markov Chain Monte Carlo (MCMC), 2,000 of which were utilized to estimate parameters. Beta coefficients at individual-level were then aggregated for all respondents to derive part-worth utilities for each level of the attributes as seen in Table 3.

The conjoint shows that, as to be expected, the hierarchy of choices is first about vaccination choice and the effectiveness in preventing the Covid-19 infection. This weight is about 55% of

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[15] Large retailers are making record profits but not paying workers more (cnbc.com)

the importance in 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:

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	
Obligatory vaccine for healthcare workers	-0.11	13.71
Obligatory vaccine for the public	-0.37	
Voluntary vaccine	0.18	
Voluntary vaccine and a 500€ bonus for vaccination	0.30	
Effective at 90%	1.04	18.58
Effective at 50%	-1.04	
Mandatory full lockdown for 1 month	0.11	14.19
Mandatory full lockdown for 6 months	-0.70	
Mandatory social distancing and wearing facemasks for 1 month	0.29	
Mandatory social distancing and wearing facemasks for 12 months	0.02	
Recommended social distancing and wearing masks	0.28	
Possibility to travel freely for the vaccinated	0.11	8.74
No limits for public events for the vaccinated	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 onsite or home office	0.17	
Obligation to work onsite but with a 10% wage increase during the pandemic	0.07	

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 stated, the effectiveness of the vaccine is a key driver of the intention to be vaccinated, in confirmation with other studies (Motta, 2020). 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 x 60%) = 1.43). **H3** is confirmed but shows that vaccine delay is quickly becoming an effective strategy if the vaccine effectiveness is uncertain or is not well documented. This corroborates the recent sorting behavior of people in terms of which vaccine to accept.

3. Clearly, people do not want to be mandated to be vaccinated. They rather value their own choice, confirming **H4**. Likewise, they do not like to have restrictions if not vaccinated (and rather 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; lockdowns bring negative pass-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 full 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 let the workers chose their location to work (**H9**). This gap in utility presumably reflects in part the fear to be exposed at work, which can be more than compensated by a higher salary (**H10**).

3.2. Valuing utilities

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

However, two attributes may be used to derive a monetary value. The first is that an incentive of 500€ to get vaccinated translates into an increase of 0.12 of utility, or roughly 500/0.12 = 4,160€ per point of utility in the conjoint. To get another sense of monetary value, we use the second attribute with a financial metric, that is, a 10% increase in wage salary during the pandemic (running for 2 years). This would translate into 5,000€ per year, and this seems, in line with a mode of 50,000€ gross salary per year observed in Germany by 2020.[16]

This value metric can be also assessed against other studies. For example, we find that the difference between a vaccine effective at 90% versus 50% would then amount to a value of about (2.08 x 4,160) = 8,652€. 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

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

in line with US estimates of the value of protection, estimated at about $ 18,000 (see Bethune and Korinek, 2020).

From this external confirmation, we derive also other important value metrics:

1. At the baseline, the value of being vaccinated one month *earlier* is derived as (1.22 – 0.65)/3 x 4,160€ = 800€, or 16% of the value of the vaccine shot taken right away (= 800/(1.22 x 4,160)). Thus, six months of waiting for the vaccine may take out all the value of the vaccine.

2. The private 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 x 4,160 = 1,870€ for the voluntary choice to be vaccinated; 0.4 x 4,160 = 1,665€ for the choice of location to work, and to 0.31 x 4,160 = 1,290€ when it comes to the privilege (public events and travel) of the vaccinated. As the three measures are being discussed today, leaving the total freedom of choice is worth 5,000€ per person.

3. The monthly cost of lockdown is worth (0.81/5 x 4,160) = 670€, while the cost of one extra month of social distance and mask-wearing is lower than lockdown, as expected. It is just above 100€, or a fraction, 15%, of the lockdown perceived costs. We can then derive from this that an estimated *annual* cost of a strict lockdown would thus amount to more than 10,000€, as much as the value of a fully effective vaccine.

3.3 Vaccination predictions

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). Default baseline is the obligation to be vaccinated for the health workers only; the vaccine is effective at 70%; lockdown is necessary for one month, and obligation to work on site.

We note that there is no statistically significant difference between vaccination mandate imposed on health-care workers versus everyone on the will to vaccinate. Likewise, limiting public events attendance to the non-vaccinated has no different impact than allowing attendances for the vaccinated.

Based on this regression, we can run multiple sensitivity analyses on the mix of vaccination patterns among German citizens. Table 5 synthesizes the results at the baseline average, plus two extreme scenarios (explained hereafter). More sensitivity details are displayed in Table 6.

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 for the public	-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 lockdown for 6 months	-0.301***	(0.0328)
Mandatory social distancing and wearing facemasks for 1 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	

Notes:
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

Notes:
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; choice to work onsite or home office
Worst scenario: Obligatory vaccine for the public; effective at 50%; Mandatory full lockdown 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 %
Δ'= difference between best and worst scenario in %

Concerning first 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. Stated, preference surveys performed at the early days of the pandemic (mostly by April 2020), had shown a refusal rate of 10-15 % (see Neumann-Bohme et al., 2020; Bughin et al., 2021b). At the time of this current conjoint-based research (January 2021), it is plausible to state that respondents have been aware of the pros and cons of multiple vaccine discoveries, while citizens also have been living 10 more months with the pandemic, likely understanding more of the risk of the disease, and fully grasping the possible pain of all NPI measures. One driver of higher refusal in our study is that the simulation assumes 70% effectiveness in the vaccine.

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 lockdown, and giving the possibility to travel freely for the vaccinated on top of WFH choice.

As the largest 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 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 (2020) and shows the importance to continue NPIs on top of vaccination during the vaccination campaign rollout

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 lockdown for 6 months and obligation to WFH. The only positive incentive would be travel allowance, but only for those vaccinated. In this case, all those NPI obligations push the incentive to get vaccinated faster, but this incentive is total reversed by the effect of an ineffective vaccine.

The scenarios illustrate the important 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, or the idea of a vaccine certificate), while one rolls out the most effective vaccine. In this case, the portion of refusal becomes closer to 15%, or 85% of citizens may be vaccinated across the next 6 months. Such a scenario, of relevance to reach herd immunity, requires however that the most effective vaccines are being proposed, and that supply-side bottlenecks are removed, at this time of challenging supply chain issue in Europe. 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 own authorities (Bughin et al., 2021b). Building trust in actions against Covid-19 remains a large imperative.

4. Conclusions

The discrete conjoint experiment in this study suggests that the intention to vaccinate must consider both vaccine features, as well as the cost of NPIs and the degrees of freedom left to citizens in the way 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 citizens will embrace the shot. Vaccines with lower effectiveness are expected to be resisted by part of the population and may impose further negative externalities as to impose NPI longer or stronger to compensate for the deficit in the effectiveness of the vaccine. In any case, while vaccines may be accepted to be put in market with 50% effectiveness (e.g. the FDA in the US), population reluctance to get vaccinated is a roadblock already below 75% effectiveness, according to our estimates.

Table 5. Scenarios for each attribute

	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%	Δ	effective at 90%	Δ			
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	Δ	Mandatory full lockdown for 6 months	Δ	Mandatory social distancing and wearing facemasks for 1 month	Δ	Mandatory social distancing and wearing facemasks for 12 months	Δ	Recommended social distancing and wearing masks	Δ
I will NOT get the vaccine	20.8	3.0	16.2	-22.0	22.1	9.1	20.1	-0.4	22.1	9.1
I will get vaccinated as soon as possible	42.8	2.1	35.6	-16.3	44.7	6.5	41.8	-0.2	44.8	6.7
I will get vaccinated after a while (e.g 6 months)	35.8	2.4	29.2	-17.9	37.6	7.3	34.9	-0.1	37.6	7.3

	forbidden participation in public events for not vaccinated	Δ	forbidden to travel freely for not vaccinated	Δ	no limits for public events for the vaccinated	Δ	possibility to travel freely for the vaccinated	Δ
I will NOT get the vaccine	20.0	-0.9	19.2	-5.0	20.6	2.1	21.0	4.0
I will get vaccinated as soon as possible	41.6	-0.7	40.4	-3.6	42.5	1.4	43.1	2.8
I will get vaccinated after a while (e.g 6 months)	34.6	-1.0	33.5	-4.2	35.5	1.6	36.1	3.3

	choice to work onsite or home office	Δ	obligation to work onsite	Δ	obligation to work onsite but with 10% wage increase during pandemic	Δ
I will NOT get the vaccine	21.4	5.9	18.6	-8.2	20.6	2.1
I will get vaccinated as soon as possible	43.6	4.0	39.5	-5.9	42.6	1.7
I will get vaccinated after a while (e.g 6 months)	36.6	4.6	32.7	-6.6	35.6	1.9

Note:
Δ= difference with baseline scenario in %

Further, results suggest that NPIs have some large costs, of about 10,000€ for a full year of mandate. Clearly, this is significant, and a vaccine may act as a great incentive to alleviate those costs. Finally, there is no point in imposing too restrictive rules on citizens, as this freedom cut can be perceived as too dramatic, even if it decreases 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 full picture, e.g. both NPIs and vaccine, as people balance the two types of interventions in their protection against the virus. Finally, while social and individual choice 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 a good incentive to push vaccination.

This study has some limitations. It is of course 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, and we did not explicitly test different vaccine solutions, let alone the fact that some vaccines may need a second shot to be fully effective.

In all cases, however, it shows that a vaccine is a powerful tool to stopping a pandemic, but the traction is highly dependent on its effectiveness, and other alternative measures (NPIs) to limit the spread of the virus. Further, along the way, NPIs remain important to both 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.

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APPENDIX 1 Example of the Conjoint test screens

Which scenario would you prefer? *

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

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Which scenario would you prefer? *

Time of Covid vaccination	I will get vaccinatated as soon as possible	I will NOT get the vaccine	I will get vaccinatated as soon as possible
Vaccine	Voluntary vaccine	Voluntary vaccine and a 500 euro bonus for vaccination	Obligatory vaccine for the public
Vaccine effectiveness	Effective at 50%	Effective at 90%	Effective at 50%
Restriction Level	Mandatory social distancing and wearing facemasks for 1 month	Mandatory full lockdown for 6 months	Mandatory social distancing and wearing facemasks for 1 month
Advantages/ penalties	Possibility to travel freely for the vaccinated	No limits for public events for the vaccinated	Forbbiden participation in public events for not vaccinated
Work	Obligation to work onsite	Obligation to work onsite	Choice to work onsite or homeoffice
	○	○	○

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