On Mask Wearing in Environments With and Without a Mask Mandate

Amitrajeet A. Batabyal[1]

1 Rochester Institute of Technology

Funding: No specific funding was received for this work.

Potential competing interests: No potential competing interests to declare.

Abstract

We analyze an office environment with two types of workers. The first type believes that masks offer little or no protection against Covid-19 and hence this type does not wear a mask. The second type wants to protect itself from Covid-19 and therefore this type does wear a mask. By not wearing a mask, the first type of worker imposes an externality on the second type of worker. In this setting, we accomplish five tasks. First, ignoring the externality, we compute the number of hours during which the first type of worker does not wear a mask. Second, we ascertain the socially optimal number of hours during which a worker of the first type ought not to wear a mask. Third, we determine the optimal tax needed to decentralize the social optimum. Fourth, assuming that there is no mask mandate, we analyze the outcome when we allow for Coasian bargaining between the two types of workers. Finally, assuming that there is a mask mandate, we study the outcome when, once again, there is Coasian bargaining between the two types of workers.

Amitrajeet A. Batabyal

Departments of Economics and Sustainability, Rochester Institute of Technology, 92 Lomb Memorial Drive, Rochester, NY 14623-5604, USA. E-mail: aabgsh@rit.edu

Keywords: Covid-19, Externality, Mask, Social Optimum, Tax.

JEL Codes: I12, I31

1. Introduction

We now know that the cause of the severe acute respiratory syndrome or SARS-like illness that later came to be known as Covid-19 was a new coronavirus, in particular, the SARS-CoV-2.[1] On 30 January 2020, Covid-19 was declared by the World Health Organization (WHO) to be a Public Health Emergency of International Concern (PHEIC). The first case of

Covid-19 resulting from local person-to-person spread in the United States (U.S.) was confirmed in mid-February 2020. On 11 March 2020, the WHO declared Covid-19 a pandemic.

The U.S. Centers for Disease Control (CDC) and other health agencies endorsed the large-scale wearing of masks by citizens[2] before the arrival of the various vaccines that are now being standardly used to inoculate citizens against Covid-19. The venerable Cleveland Clinic suggested that even vaccinated citizens ought to continue to wear their masks in public settings.[3] The logic behind wearing masks is uncomplicated. Wearing masks can help communities decelerate the spread of Covid-19 when they are worn consistently and correctly by a majority of the people in public settings.[4] In other words, wearing a mask protects not only the individual wearing the mask but also those nearby.

In spite of the existence of these health benefits, many individuals in the U.S., who are sometimes referred to as anti-maskers, are opposed to wearing masks. In this regard, McKelvey (2020) and others have noted that some anti-maskers do not want to wear masks because they believe that being asked or required to do so would be an unacceptable intrusion on their personal freedoms and, more generally, their civil liberties. Others, as pointed out by Gillespie (2021), think that by not wearing a mask, they are in control and still others are simply in denial.

This state of affairs gives rise to three noteworthy questions. First, with regard to mask wearing, what kind of behavior can we expect to see in an office environment in which workers hold *heterogeneous* views about the efficacy of masks? Second, how does this behavior compare with what is *socially* optimal? Finally, does the observed behavior change when there is either no mask *mandate* or a mask mandate given the possibility of Coasian bargaining between the heterogeneous workers? Although economists have recently done some work on the effects of mask wearing---see Karaivanov *et al.* (2020), Kahane (2021), Batabyal (2022)---to the best of our knowledge, there is *no* research on the three questions that we have just outlined. Therefore, our objective here is to shed *theoretical* light on the above three questions. To this end, we believe that this paper is the *first* in the literature to analyze these questions *theoretically*.

The remainder of this paper is organized as follows: Section 2.1 describes our model of an office environment in which there are two types of workers. The first type thinks that masks offer little or no protection against Covid-19 and therefore this type does *not* wear a mask. The second type wants to protect itself from Covid-19 and hence this type does *wear* a mask. We suppose that by not wearing a mask, the first type of worker imposes an externality on the second type of worker. Section 2.2 ignores this externality and computes the number of hours during which the first type of worker does not wear a mask. Section 2.3 ascertains the socially optimal number of hours during which a worker of the first type ought not to wear a mask. Section 2.4 determines the optimal “tax” needed to decentralize the social optimum. On the assumption that there is *no* mask mandate, section 2.5 analyzes the outcome when Coasian bargaining between the two types of workers is permitted. Assuming that there *is* a mask mandate, section 2.6 studies the outcome when, once again, there is Coasian bargaining between the two types of workers. Section 3 concludes and then suggests three extensions of the research described in this paper.

2. Mask Wearing in an Office

2.1. The theoretical framework

Consider an indoor office environment in which there are two *types* of workers. The first type of worker does *not* wear a mask. This could be because such a worker believes that wearing a mask will do little or nothing to protect him from Covid-19. Alternately, the decision to not wear a mask could also be the outcome of a belief that having to wear a mask is an unacceptable infringement of one's personal freedom. We shall describe such a worker with the superscript *NM*. The second type of worker believes that wearing a mask will protect her from being infected with Covid-10 and, as such, she wears a mask. We delineate the second type of worker with the superscript *M*.

In what follows, we shall work with a representative type one (two) worker and, to prevent confusion, we suppose that this worker is male (female).[5] The type one worker's utility function or U^{NM} is

$$U^{NM} = \alpha + 0.1\alpha h - 0.001\alpha h^2, \qquad (1)$$

where α is a positive constant and $h \geq 0$ denotes the number of hours during which the type one worker does *not* wear his mask. The type two worker's utility function or U^M can be written as

$$U^M = \alpha - 0.1\alpha h \qquad (2)$$

and we suppose that U^M includes the cost of the masks. Inspecting (2), it is clear that the type two or mask wearing worker is adversely impacted by the decision of the type one worker to not wear a mask. This is, in fact, a result of the externality that the type one worker---who does not wear a mask---imposes on the mask-wearing, type two worker.

We now provide more detail about two aspects of the modeling strategy we employ in this paper. First, let us focus on the interpretation of α in (1) and (2). If we were to analyze the three questions of this paper in greater generality then we could say that α captures the *different reasons* that the no mask and the mask wearing workers have for not wearing and wearing masks respectively. In this case, it would make more sense to replace α in (1) and (2) with α^{NM} and α^M. The use of this more general approach would certainly prevent us from obtaining some of the clean results that we do obtain in the remainder of the paper. That said, this "different reasons" interpretation is *not* the interpretation we have in mind. To see this clearly, suppose $\alpha = 100$. Then (1) becomes $U^{NM} = 100 + 10h - 0.1h^2$ and (2) becomes $U^M = 100 - 10h$. Now, suppose that there is no pandemic and hence the question of wearing a mask is not an issue. Then the question of there being two types of workers is also irrelevant and therefore $h = 0$. In this case, what is the *baseline utility* of the workers in this office environment? The answer clearly is $h = \alpha = 100$. We contend that for workers in the *same* office environment, it is *not* unreasonable at all to think of all workers having the same baseline utility in the absence of rare events like the Covid-19 pandemic. This is the interpretation of α that we have in mind and this is also why (1) and (2) are written as they are.

Second, from (1) and (2), it should be clear to the reader that we are working with a *linear* model. We use a linear model not only because it allows us to obtain clean, analytical results but also because, as noted by Gale (1960) many years ago, it is standard to construct and analyze linear models in economics. Given our linear model, observe that writing (1) as $U^{NM} = \alpha + 0.1\alpha h + 0.001\alpha h^2$ would make the utility function non-concave and the optimal number of hours in (5) below, a negative number. Neither of these two outcomes makes sense and therefore we stay with the present formulation in (1).

With this description of the theoretical framework out of the way, let us now disregard the externality temporarily and compute the optimal number of hours during which the first type of worker ought not to wear a mask.

2.2. Optimal no mask wearing

The no mask wearing type one worker solves

$$max_{(h \geq 0)} U^{NM}(h) = \alpha + 0.1\alpha h - 0.001\alpha h^2. \qquad (3)$$

The first-order necessary condition for a maximum---the second-order sufficiency condition is satisfied---is

$$\frac{dU^{NM}}{dh} = 0.1\alpha - 0.002\alpha h = 0. \qquad (4)$$

Simplifying (4), it is clear that the optimal number of hours during which a type one worker ought not to be wearing a mask is given by

$$h^* = 50. \qquad (5)$$

Equation (5) tells us that in our model, it is optimal for a type one worker to*not* wear a mask for 50 hours. That said, note that other than constraining this optimal number of hours or h^* to be non-negative for obvious reasons, we have not added any other constraints. If, for instance, we wanted to determine h^* for either a work-day or for a work-week, then, in addition to requiring h^* to be non-negative, we would also have to constrain h^* to lie either in the interval $[0, 8]$ or the interval $[0, 40]$.

Our next task is to ascertain the socially optimal number of hours during which a type one worker ought not to wear a mask.

2.3. The social optimum

The socially optimal level of no mask wearing involves maximizing the sum---or $U^{NM} + U^M$ ---of the utilities of the two types of workers. As such, we now solve

$$max_{(h \geq 0)} U^{NM}(h) + U^M(h) = 2\alpha - 0.001\alpha h^2. \qquad (6)$$

The first-order necessary condition for a maximum---the second-order sufficiency condition is satisfied---is

$$\frac{dU^{NM}(h) + U^M(h)}{dh} = -0.002\alpha h = 0. \qquad (7)$$

Simplifying (7), it follows that the optimal number of hours during which a type one worker ought not to be wearing a mask or h^{SO} is

$$h^{SO} = 0. \qquad (8)$$

A second way to obtain the result stated in (8) is to observe that the maximand on the right-hand-side (RHS) of (6) is decreasing in the choice variable h and therefore it is optimal to set its value equal to zero. This result tells us that the socially optimal number of hours during which workers ought not to wear a mask is *zero*. In other words, once we account for the externality that the no mask wearers impose on the mask wearers, everybody in our office environment, irrespective of his or her type, ought to be wearing a mask *all* of the time.

Inspecting (1) and (2), we see that the positive impact of h in (1) or the coefficient 0.1α is the same (in magnitude) as the negative impact of h in (2). We have this feature in our model because we are trying to capture the idea that mask wearing or no mask wearing in the *same* office environment gives rise to benefits and costs that are "zero-sum" in nature. In other words, the no mask wearing worker's benefit of $0.1\alpha h$ is exactly offset by the mask wearing worker's cost of $-0.1\alpha h$. In a different analysis, we could make the two coefficients dissimilar and write (1) as $U^{NM} = \alpha + \theta\alpha h - 0.001\alpha h^2$ and (2) as $U^{M} = \alpha - \gamma\alpha h$ for $\theta > 0$ and $\gamma > 0$. In this case, analysis shows that $h^{SO} = \frac{(\theta - \gamma)}{0.002.}$ Clearly, this last expression simplifies to what we have in (8) when $\theta = \gamma$. That said, for h to be non-negative, we must have $\theta > \gamma$. In words, the positive impact of h in (1) must be larger than the negative impact of h in (2). Alternately, we could also say that if $\theta < \gamma$ then it is understood, from the non-negativity constraint on h, that h must be equal to zero.

Our next task is to figure out the optimal "tax" that is needed to decentralize the social optimum that we have just identified.

2.4. The tax

We begin by supposing that the no mask wearing worker has to pay a tax $\tau \geq 0$ for every hour that he does not wear his mask to the mask wearing worker. In this case, the no mask wearing worker's utility maximization problem is

$$max_{(h \geq 0)} U^{NM}(h, \tau) = \alpha + 0.1\alpha h - 0.001\alpha h^2 - \tau h. \qquad (9)$$

The first-order necessary condition for a maximum---the second-order sufficiency condition is satisfied---is

$$\frac{dU^{NM}}{dh} = 0.1\alpha - 0.002\alpha h - \tau = 0. \qquad (10)$$

Simplifying (10), the optimal number of hours of no mask wearing as a function of the tax τ can be written as

$$h^*(\tau) = \frac{(0.1\alpha - \tau)}{0.002\alpha.} \qquad (11)$$

Comparing (8) and (11), it is straightforward to see that if we choose the tax $\tau = 0.1\alpha$ then $h^*(\tau)$ on the left-hand-side (LHS) of (11) is equal to zero and the social optimum in which $h^{SO} = 0$ is decentralized.

We reiterate that as noted clearly in section 1, this is a *theoretical* paper and our objective here is *not* to come up with an "empirically measurable" tax. Instead, our goal in this section is to show that by choosing the tax appropriately, it is possible to decentralize the social optimum identified in section 2.3. Second, our linear model is deterministic and therefore there is *no* uncertainty. This means that there is “theoretical verifiability” in the sense that the mask wearing worker knows everything about the non-mask wearing worker and vice versa. As such, the question of “empirical verifiability” is *not* an issue. Third, because our model is deterministic meaning that there is “theoretical verifiability,” there is *no* problem with proceeding with an analysis of Coasian bargaining. In this regard, note that Coase’s (1960) original paper also contained *no* analysis of uncertainty. Finally, the preceding three points notwithstanding, we acknowledge that the clean, analytical solutions we obtain in this paper do depend on the assumptions we have made in section 2.1 of the paper.

Moving on with our analysis, we now suppose that there is *no* mask mandate in our office environment. In addition, to keep the problem interesting, we also suppose that Coasian bargaining between the no mask wearing and the mask wearing workers is permitted. Our goal in the next section is to determine the outcome as far as mask/no mask wearing in our office environment is concerned.

2.5. No mask mandate

We can think of the situation with no mask mandate as being akin to one in which the “property right” to be mask free is assigned to the no mask wearing worker. From (5), we already know that the no mask wearing worker will want to be mask free for 50 hours. In this instance, using (2), the *loss* in utility to the mask wearer is

$$U^{M}(50) - U^{M}(0) = (\alpha - 5\alpha) - (\alpha) = -5\alpha. \qquad (12)$$

On the other hand, the *gain* in utility to the no mask wearing worker, using (1), is

$$U^{NM}(50) - U^{NM}(0) = (\alpha + 5\alpha - 2.5\alpha) - (\alpha) = 2.5\alpha. \qquad (13)$$

Inspecting (12) and (13), we infer that the no mask wearing worker will require 2.5α utils to give up his mask free status. On the other hand, the mask wearing worker will be willing to pay up to 5α utils so that the no mask wearing worker wears a mask. This means that depending on the bargaining power of the two workers, the outcome of Coasian bargaining is that the mask wearing worker will pay the no mask wearing worker an amount between 250 and 500 utils to wear a mask and the no mask wearing worker will accept this offer. As a result, the socially optimal or efficient outcome will be achieved.

Our final task in this paper is to investigate the mask/no mask wearing outcome when there is a mask mandate in the office environment under study.

2.6. Mask mandate

In contrast to the no mask mandate scenario studied in section 2.5, when there is a mask mandate, this situation is analogous to one in which the “property right” to have no worker without a mask is assigned to the mask wearing worker. When this happens, the mask wearing worker will ban no mask wearing in our office environment. With such a ban in place, (1) tells us that the no mask wearing worker’s utility *loss* is

$$U^{NM}(0) - U^{NM}(50) = (\alpha) - (\alpha + 2.5\alpha) = -2.5\alpha. \qquad (14)$$

In contrast, using (2), the mask wearing worker's utility*gain* is

$$U^{M}(0) - U^{M}(50) = (\alpha) - (\alpha - 5\alpha) = 5\alpha. \qquad (15)$$

Inspecting (14) and (15), we can deduce that to remove the ban on being mask free, the mask wearing worker will require a payment of at least 5α utils. However, we know from (14) that the no mask wearing worker will be willing to pay only up to 2.5α utils. This finding tells us that that the ban on being mask free will remain in place and the socially optimal outcome will be attained.

This concludes our discussion of mask wearing in environments with and without a mask mandate.

3. Conclusions

In this paper, we analyzed an office environment with two types of workers. The first type believed that masks offered little or no protection against Covid-19 and therefore this type did not wear a mask. The second type wanted to protect itself from Covid-19 and hence this type wore a mask. By not wearing a mask, the first type of worker imposed an externality on the second type of worker. In this setting, we undertook five tasks. First, disregarding the externality, we computed the number of hours during which the first type of worker did not wear a mask. Second, we ascertained the socially optimal number of hours during which a worker of the first type ought not to wear a mask. Third, we determined the optimal tax needed to decentralize the social optimum. Fourth, assuming that there was no mask mandate, we analyzed the outcome when it was possible to engage in Coasian bargaining between the two types of workers. Finally, assuming that there was a mask mandate, we studied the outcome when, once again, it was possible to engage in Coasian bargaining between the two types of workers.

The analysis conducted in this paper can be extended in a number of different directions. Here are three potential extensions. First, as pointed out in section 2.1, it would be useful to replace α in (1) and (2) with α^{NM} and α^{M}. and then conduct an analysis of the sort conducted in this paper. Second, it would be instructive to study a scenario in which the existence of a mask mandate results in some workers not complying with the mandate but quitting their jobs so that they do not have to wear a mask. Finally, it would be interesting to analyze what happens to worker welfare when workers can either comply with a mask mandate or get vaccinated and not have to wear a mask. Studies of mask wearing in office environments that incorporate these aspects of the problem into the analysis will provide additional insights into how workers tradeoff the health benefit from wearing a mask with the reduction in personal freedom that mask wearing entails.

I thank John P. Conley and two anonymous referees for their helpful comments on a previous version of this paper. In addition, I acknowledge financial support from the Gosnell endowment at RIT. The usual absolution applies.

Footnotes

[1] See Chaplin (2020) and Batabyal and Beladi (2022) for additional details on this point.

[2] Go to https://www.mayoclinic.org/diseases-conditions/coronavirus/in-depth/coronavirus-mask/art-20485449 for more details on this topic. Accessed on 31 January 2023.

[3] Go to https://health.clevelandclinic.org/already-vaccinated-heres-why-you-shouldnt-stop-wearing-your-face-mask-yet/ for additional details. Accessed on 31 January 2023.

[4] Go to https://www.hopkinsmedicine.org/health/conditions-and-diseases/coronavirus/proper-mask-wearing-coronavirus-prevention-infographic for additional details on this point. Accessed on 31 January 2023.

[5] In the remainder of this paper, we also drop the use of the word "representative."

References

- Batabyal, A.A. (2022) "Can not wanting to wear a mask be rational?" Forthcoming, *Economics Bulletin*. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4162089. Accessed on 31 January 2023.
- Batabyal, A.A. and H. Beladi (2022) "Health interventions in a poor region in the presence of a pandemic." Forthcoming, *Applied Spatial Analysis and Policy*. https://mpra.ub.uni-muenchen.de/112159/1/MPRA_paper_112159.pdf. Accessed on 31 January 2023.
- Chaplin, S. (2020) "COVID-19: A brief history and treatments in development" *Prescriber*, 23-28 May.
- Coase, R.H. (1960) "The problem of social cost" *Journal of Law and Economics* **3**, 1-44.
- Gale, D. (1960) *The Theory of Linear Economic Models*. University of Chicago Press: Chicago, IL
- Gillespie, C. (2021) "Why do some people refuse to wear a face mask in public?" https://www.health.com/condition/infectious-diseases/coronavirus/face-mask-refuse-to-wear-one-but-why. Accessed on 8 December 2022.
- Kahane, L.H. (2021) "Politicizing the mask: Political, economic, and demographic factors affecting mask wearing behavior in the USA" *Eastern Economic Journal* **47**, 163-83.
- Karaivanov, A., Lu, S.E., Shigeoka, H., Chen, C. and S. Pamplona (2020) "Face masks, public policies, and slowing the spread of COVID-19: Evidence from Canada" *National Bureau of Economic Research Working Paper 27891*, NBER, Inc.: Cambridge, MA.
- McKelvey, T. (2020) "Coronavirus: Why are Americans so angry about masks?" https://www.bbc.com/news/world-us-canada-53477121. Accessed on 31 January 2023.