No Policy is an Island: Mitigating COVID-19 in View of Interaction Effects

Jan-Philip Elm and Roee Sarel[†]

Why are COVID-19 mitigation strategies successful in reducing infections in some cases but not in others? Existing studies of individual policies tend to neglect the many interaction effects that arise when multiple policies are enacted simultaneously. Particularly, if a socially undesirable behavior has a close (and equally problematic) substitute, then a prohibition of that behavior will simply cause people to switch to the substitute, resulting in no effect on infections. However, joint policies that prohibit both the targeted behavior and the substitute will create a positive interaction effect, which closes the loophole. Respectively, behaviors that are complements (rather than substitutes) can be discouraged by prohibiting one behavior because this discourages complementary behaviors as well.

We provide a new argument for why COVID-19 policies can fail and why the evaluation of such policies may be incorrect: policies are effective only when they reduce infections as a general equilibrium, accounting not only for the targeted behavior but also for interaction effects.

We illustrate our arguments by applying insights from traditional and behavioral law and economics to several examples. Thereby, we highlight regulators' challenge when facing interaction effects and factors such as social norms and time preferences.

I. INTRODUCTION

The COVID-19 pandemic has profoundly changed how we, as human beings, live our lives.[1] As infection rates around the world continue to surge,[2] and worrisome

[1]*See generally* Amna A. Akbar et al., *Movement Law*, 73 Stan. L. Rev. 821 (2021); Katherine Florey, *Toward Tribal Regulatory Sovereignty in the Wake of the COVID-19 Pandemic*, 63 Ariz. L. Rev. 399 (2021); Eric E. Johnson & Theodore C. Bailey, *Legal Lessons from a Very Fast Problem: COVID-19*, 73 Stan. L. Rev. Online 89 (2020); Etienne C. Toussaint, *Of American Fragility: Public Rituals, Human Rights, and the End of Invisible Man*, 52 Colum. Hum. Rts. L. Rev. 826 (2021); Robyn M. Powell, *Applying the Health Justice Framework to Address Health and Health Care Inequities Experienced by People with Disabilities during and after COVID-19*, 96 Wash. L. Rev. 93 (2021); Divya Ramjee et al., *COVID-19 and Digital Contact Tracing: Regulating the Future of Public Health Surveillance*, 2021 Cardozo L. Rev. De-Novo 101 (2021).

[2]*See generally* Kelly J. Deere, *Governing by Executive Order during the COVID-19 Pandemic: Preliminary Observations Concerning the Proper Balance between Executive Orders and More Formal Rule Making*, 86 Mo. L. Rev. 722 (2021); James G. Hodge et al., *COVID'S Constitutional Conundrum: Assessing*

variants of the virus emerge,[3] policymakers struggle to adopt effective policies to curb the progress of the virus.[4] The measures taken around the world have been diverse, including lockdowns, curfews, travel restrictions, mask mandates, social distancing rules, shut-downs of non-essential businesses, movement tracing, and quarantines.[5] While some of these strategies seem to be working, at least in some areas,[6] many have failed,[7] resulting in major restrictions of freedom and interruptions of economic activities[8] but only minor benefits in slowing the virus' progression. Notwithstanding the scientific breakthroughs

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Individual Rights in Public Health Emergencies, Tenn. L. Rev (forthcoming) (providing details on the progress of the pandemic in the US and abroad). For data on current infection rates, *see* Worldometer, https://www.worldometers.info/coronavirus/ [https://perma.cc/J3LG-L3SA] (last visited Jan. 23, 2022, 12:03 PM).

[3] *See, e.g.*, James G. Hodge et al., *Legal Challenges Underlying COVID-19 Vaccinations*, 49 J. L., Med. & Ethics 495, 497 (2021); Catherine J.K. Sandoval et al., *Legal Education During the COVID-19 Pandemic: Put Health, Safety and Equity First*, 61 Santa Clara L. Rev. 367, 373 (2021). For a while, there were concerns that the "Delta Variant" may be vaccine-resistant. *See* Apoorva Mandavilli, *Why Vaccinated People Are Getting 'Breakthrough' Infections*, N.Y. Times (July 22, 2021), https://www.nytimes.com/ 2021/ 07/22/health/coronavirus-breakthrough-infections-delta.html [https://perma.cc/PG8G-XQP9]. More recently, the "Omicron" variant has been raising similar concerns. *See* Maggie Fox, *Studies Add to Evidence Omicron Sneaks Past Vaccines But May Cause Milder Disease*, CNN Health (Dec. 14, 2021, 10:26 PM), https://edition.cnn.com/2021/12/14/health/omicron-variant-south-africa-details/index.html [https://per ma.cc/7ZNS-EET4].

[4] *See generally* Ramjee et al., *supra* note 1; Mason Marks, *Drug Regulation for the COVID-19 Mental Health Crisis,* 72 Admin. L. Rev. 649 (2020); Eric M. Swalwell & R. Kyle Alagood, *Biological Threats Are National Security Risks: Why COVID-19 Should Be a Wake Up Call for Policy Makers*, 77 Wash. & Lee L. Rev. Online 217 (2021). As one example, Germany tried imposing a "Lockdown Light", keeping restaurants and bars open, in November 2020. After this policy insufficiently reduced infections, a "hard lockdown" was adopted in late December 2020. Thereafter, a "Mega Lockdown"—with tougher restrictions—was imposed in January 2021. S*ee, e.g.*, Vicky McKeever, *Why Germany's Coronavirus Strategy Doesn't Appear to be Working this Time Around,* CNBC (Nov. 6, 2020, 4:38 AM), https://www.cnbc.com/2020/11/06/why-germanys-coronavirus-strategy-doesnt-appear-to-be-working.html [https://perma.cc/ JB8Y-37X6] (discussing why the "lockdown light" failed); Reuters Staff, *Germany Heading Towards Extension of Hard Lockdown,* Reuters (Jan. 4, 2021, 5:44 AM), https://www.reuters.com/article/us-health-coronavirus-germany-idUSKBN299112 [https:// perma.cc/H6UB-ENWZ] (discussing the decision to extend the hard lockdown); Neil Murphy, *Merkel Plans Mega-lockdown as Germany Suffers Record Covid Deaths*, The National News (Jan. 14, 2021), https://www.thenationalnews.com/world/europe/merkel-plans-mega-lockdown-as-germany-suffers-record-covid-deaths-1.1146435 [https://perma.cc/6WKJ-FVWT] (discussing the mega-lockdown).

[5] *See generally* Cary Coglianese & Neysun A. Mahboubi, *Administrative Law in a Time of Crisis: Comparing National Responses to COVID-19,* 73 Admin. L. Rev. 1 (2021); Hodge, *supra* note 3; Craig Konnoth, *Narrowly Tailoring the COVID-19 Response,* 11 Calif. L. Rev. Online 193, 195-97 (2020); Palina Kolvan et al., Pandemic Backsliding: Democracy Nine Months into the COVID-19 Pandemic (V-Dem Institute, Policy Brief No. 26, 2020), http://v-dem.net/pb.html [https://perma.cc/64X9-3UJS].

[6] *See, e.g.*, Samer Kharroubi & Fatima Saleh, *Are Lockdown Measures Effective Against COVID-19?*, 8 Frontiers in Pub. Health 1, 1 (2020) (finding that a lockdown in Lebanon was effective); Moritz U.G Kraemer et al., *The Effect of Human Mobility and Control Measures on the COVID-19 Epidemic in China*, 368 Science 493, 493 (2020) (finding that a lockdown in Wuhan, China, was effective); Eyal Zamir & Doron Teichman, *Governmental Decision-Making Regarding the COVID-19 Pandemic—a Behavioral Perspective* 1 (Sep. 24, 2020) (unpublished manuscript), https://ssrn.com/abstract=3698682 [https://perma.cc/L6EU-87PR]. For an English-language overview of the regulatory efforts addressed in Zamir & Teichman's manuscript, *see* Ruth Levush, *Israel: Law Granting Government Special Authorities to Combat Novel Coronavirus Adopted*, Libr. of Cong. (July 29, 2020), https://www.loc.gov/item/global-legal-monitor/2020-07-29/israel-law-granting-government-special-authorities-to-combat-novel-coronavirus-adopted [https://perma.cc/GYA5-UQPN].

[7] *See, e.g.,* John Gibson*, Government Mandated Lockdowns Do Not Reduce COVID-19 Deaths: Implications for Evaluating the Stringent New Zealand Response,* N.Z. Econ. Papers, Nov. 2020, at 1, 6 (finding empirical evidence of ineffective lockdowns in the US); Joshua Nazareth et al., *Early Lessons from a Second COVID-19 Lockdown in Leicester, UK*, 396 The Lancet 10245, at e4 (2020) (finding that testing policy in Leicester was ineffective); Rahi Abouk & Babak Heydari, *The Immediate Effect of COVID-19 Policies on Social-Distancing Behavior in the United States,* 136 Pub. Health Reps. 245, 245 (2021) (finding no effect of four out of six policies analyzed).

[8] *See, e.g.*, Rosie Perper, *As the Coronavirus Spreads, One Study Predicts that Even the Best-Case Scenario is 15 Million Dead and a $2.4 Trillion Hit to Global GDP*, Bus. Insider (Mar. 5, 2020, 5:15 AM), https://www.businessinsider.com/coronavirus-death-toll-global-gdp-loss-australian-national-university-study-2020-3 [https://perma.cc/E5DY-MBCV]; Maria Polyakova et al., *Initial Economic Damage from the COVID-19 Pandemic*

of COVID-19 vaccines,[9] the (in)efficacy of some of the above mentioned strategies remains a focal point of public debate.[10]

Existing studies on COVID-19 mitigation strategies[11] mostly focus on figuring out which individual policies are effective in specific countries or specific spheres of everyday life. For instance, one study found that a lockdown policy was highly effective in China's city of Wuhan (the virus' "ground-zero"),[12] whereas another study found that voluntary social distancing in China was largely ineffective.[13] In the Netherlands, an "intelligent lockdown" (combining stay-at-home and social-distancing measures) was found to be effective, but only for some people (*e.g.*, those for whom it was feasible to follow the measures).[14] In Israel, self-quarantine policies were found to be effective, but the efficacy was much greater when individuals were compensated for loss of income during their quarantine.[15] Another study conducted in Ireland found that a policy calling for social distancing using posters is more likely to be effective when emphasizing how social distancing prevents harm to others.[16]

Such studies provide a glimpse into individual policies in isolation but are unlikely to reveal the full picture—compliance may well depend on more intricate factors than the details of a specific policy. For this reason, other studies have taken a different approach and instead examined how individual beliefs and demographics affect compliance with COVID-19 mitigation policies. For instance, compliance with mitigation policies in the United States was found to mainly depend on the capacity to obey the rules, the opportunity to break the rules, self-control, and intrinsic motivation.[17] Another

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in the United States is more Widespread Across Ages and Geographies than Initial Mortality Impacts, 117 Proc. Nat'l Acad. Scis., 27934, 27937 (2020).

[9]As of December 2021, the FDA has given a full approval only to a vaccine developed by Pfizer/ Biontech and an emergency-use approval for vaccines by Moderna and Johnson & Johnson. *See* Food & Drug Admin., COVID-19 Vaccines, https://www.fda.gov/emergency-preparedness-and-response/coronavirus-disease-2019-covid-19/covid-19-vaccines [https://perma.cc/T4TZ-N6K5] (last visited Dec. 27, 2021). For a discussion of the clinical trials, *see* Ana Santos Rutschman, *Vaccine Clinical Trials and Data Infrastructure*, 2021 Utah L. Rev. 771 (2021). In December 2021, a first treatment for COVID-19 was also given emergency-use approval by the FDA. *See* Food & Drug Admin, Coronavirus (COVID-19) Update: FDA Authorizes First Oral Antiviral for Treatment of COVID-19, https://www.fda.gov/news-events/press-announcements/coronavirus-covid-19-update-fda-authorizes-first-oral-antiviral-treatment-covid-19 [https://perma.cc/57RQ-VSAY] (last visited on Dec, 27, 2021).

[10]For recent evidence on public support of different COVID-19 mitigation strategies, *see generally* Jerg Gutmann, Roee Sarel & Stefan Voigt, *Measuring Constitutional Loyalty: Evidence from the COVID-19 Pandemic* (unpublished manuscript) (Feb. 4, 2022), https://ssrn.com/abstract=4026007.

[11]We use the term "mitigation strategies" (or "mitigation policies") to describe any type of measure taken to slow down the virus. Note that in some existing studies, the term is used to describe a specific type of policy that is aimed to manage but not eradicate the virus. *See, e.g.*, Stefan Baral et al., *Leveraging Epidemiological Principles to Evaluate Sweden's COVID-19 Response,* 54 Annals Epidemiology 21, 23 (2021) ("The mitigation-based approach in Sweden appeared to limit the breadth of health disruption facilitating the overall health and wellbeing of Swedes.").

[12]Kraemer et al., *supra* note 6, at 493.

[13]Alexander Chudik et al., *Mandated and Targeted Social Isolation Policies Flatten the COVID19 Curve and Can Help Mitigate the Associated Employment Losses,* VoxEU (May 2, 2020), https://voxeu.org/article/mandated-targeted-social-isolation-can-flatten-covid-19-curve-and-mitigate-employment-losses [https://perma.cc/YLY9-8GVK].

[14]Malouke Esra Kuiper et al*., The Intelligent Lockdown: Compliance with COVID-19 Mitigation Measures in the Netherlands* 2 (Amsterdam Law School Research Paper No. 2020-20, 2020).

[15]Moran Bodas & Kobi Peleg, *Self-Isolation Compliance in the COVID-19 Era Influenced by Compensation: Findings from a Recent Survey in Israel: Public Attitudes Toward the COVID-19 Outbreak and Self-isolation: A Cross Sectional Study of the Adult Population of Israel,* 39 Health Aff. 936, 939 (2020).

[16]Peter D. Lunn et al., *Motivating Social Distancing During the COVID-19 Pandemic: An Online Experiment,* 265 Soc. Sci. & Med. (Special Issue) 1, 1 (2020).

[17]Benjamin van Rooij et al., *Compliance with COVID-19 Mitigation Measures in the United States* 1 (Amsterdam Law School Research Paper No. 2020-21, 2020).

(cross-country) study found that the main determinants of compliance with (voluntary) requirements are the beliefs in the efficacy of policies and concerns for one's own health.[18] Yet, another study found that the only relevant individual factor affecting compliance was the person's subjective fear of contracting COVID-19.[19] A different study of young adults in Switzerland found that social-distancing measures yielded more compliance than hygienic requirements.[20]

These types of studies shed a bit more light on individual behavior but are still somewhat narrowly focused because they implicitly approach compliance as a static concept, where each policy is evaluated independently of others. In other words, many of the existing studies implicitly treat compliance as a result of what economists call a "partial equilibrium:"[21] an analysis that focuses on one limited set of variables to examine how a given market behaves in a vacuum, that is, without accounting for any interaction effects between markets.[22]

To illustrate, suppose that employers desperately need to hire new employees due to some economic shock.[23] The direct effect of this shock will be an increase in wages because employers will be willing to offer employees more money for their work. The adjusted wage and number of employed people will constitute a "partial equilibrium." However, consider what might happen next: as employers pay more money to their employees, the cost of production for goods that those employees produce would increase. Then, producers would ask for a higher price from consumers in the product market (to cover their uptick in costs). Consumers might not be willing to pay a higher price, so they would respond by buying less. Producers would see that consumers are not buying and cut back on production, thereby reducing the demand for workers, which would (at least partially) countervail the initial effect. The final outcome, which also takes into account the feedback loops due to the interaction between markets, is what is known as a "general equilibrium."[24]

Translating this into the context of COVID-19 requires viewing mitigation policies as the "shock" and the final outcome of changes in behavior as an "equilibrium."[25] Much like in the example, one might look at either a partial equilibrium—asking what is the direct consequence of a given policy—or a general equilibrium—asking what is the final outcome after taking into account spillovers between different "markets" (or, in the case of COVID-19, the result of different behaviors in response to different policies).[26]

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[18]Cory Clark et al., *Predictors of COVID-19 Voluntary Compliance Behaviors: An International Investigation*, 2 GLOB. TRANSITIONS 76, 76-77 (2020).

[19]Craig A. Harper et al., *Functional Fear Predicts Public Health Compliance in the COVID-19 Pandemic*, 19 INT'L J. MENTAL HEALTH & ADDICTION 1875, 1877 (2020).

[20]Amy Nivette et al*., Non-compliance with COVID-19-related Public Health Measures Among Young Adults in Switzerland: Insights from a Longitudinal Cohort Study,* SOC. SCI. & MED. (2021) 1, 7, 8.

[21]Joseph F. Francois & H. Keith Hall, *Partial Equilibrium Modeling*, in APPLIED METHODS FOR TRADE POLICY ANALYSIS: A HANDBOOK 6 (Joseph F. Francois & Kenneth A. Reinert eds., 1997).

[22]*See infra* Part II. A for a discussion of partial vs. general equilibria.

[23]This example is for illustration purposes only. We are, of course, well aware that COVID-19 generally leads to unemployment in most sectors.

[24]*See, e.g.*, ROBERT COOTER & THOMAS ULEN, LAW AND ECONOMICS 38 (6th ed., 2016) (defining a general equilibrium as "conditions under which the independent decisions of utility-maximizing consumers and profit-maximizing firms will lead to the inevitable, spontaneous establishment of equilibrium in all markets simultaneously").

[25]As one recent example that utilizes a similar view as the one we adopt in this paper, *see generally* Lukasz Rachel*, An Analytical Model of COVID-19 Lockdowns* (Dec. 4, 2020) (on file with author), https://sites.google.com/site/lukaszrachel/home [https://perma.cc/Q3GD-GVP4].

[26]*See, e.g.*, Marcus R. Keogh-Brown et al*, The Impact of COVID-19, Associated Behaviours and Policies on the UK Economy: A Computable General Equilibrium Model,* 12 SSM-POPULATION HEALTH 100666, 100666 (2020) (constructing a general equilibrium model to predict the economic impacts on COVID-19 on the UK economy).

Such spillovers may take two forms depending on whether the two behaviors are substitutes or complements.[27] Behaviors that are substitutes serve a similar need and can be mutually exclusive—for instance, going to the cinema and going to the theater are both entertainment activities, but a person seeking to be entertained can, at any given moment, choose only one of those activities.[28] An important characteristic of substitutes is the inverse relationship between the cost of one and the demand for the other. If a theater is relocated to a further location (*i.e.*, the cost of going to the theater increases), then people are more likely to switch to the cinema, leading to a higher demand for cinema tickets. Conversely, behaviors that are complements provide higher value when they are combined (simultaneously or sequentially). For instance, going to a restaurant and going to the cinema might allow for a "dinner-and-a-movie" combination, providing higher value when jointly consumed.[29] Complements, respectively, have a direct relationship between the cost of one and the demand for the other: if a restaurant raises its prices, people may opt-out of going out at all, leading to a lower demand for cinema tickets.

Similar to behavior, policies can also be classified as "strategic substitutes" and "strategic complements."[30] Policies are strategic substitutes if they offset one another but are strategic complements when they reinforce one another. In the context of COVID-19, the chief goal of mitigation policies is to slow down (or potentially halt) the progress of the virus. Hence, if the combination of two policies yields a synergistic effect,[31] then they are strategic complements, but if the two policies interfere with one another, then they are strategic substitutes.

In this context, it is important to differentiate between the relationship of two behaviors and the relationship of two COVID-19 mitigation strategies. For instance, hand washing with (i) soap and (ii) water are two complementary behaviors. Policies supplying free water and free soap to the public are then strategic complements, as they incentivize the two complementary behaviors. Conversely, going to (i) restaurants and (ii) cafés are two substitutable behaviors (as one can only go to a café or a restaurant at any given time), whereas two policies that eliminate both of these options (*e.g.*, through a shut-down) are still strategic complements. Eliminating both of these options has a synergistic effect, making it more likely that infections will not spread through indoor gathering.

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[27]In economics, two goods are considered substitutes if an increase in the price of one good leads to an increase in the demand for the other good. This happens when both goods serve a similar need (e.g. Pepsi and Coca Cola). Conversely, two goods are considered complements if the increase in the price of one good leads to a decrease in the demand for the other good. This happens when both goods provide more value when consumed together. *See, e.g.*, Neal Katyal, Kumar, *Deterrence's Difficulty*, 95 Mich. L. Rev. 2385, 2386 (1997); Cooter & Ulen, *supra* note 24, at 184.

[28]*See, e.g.*, Sangho Kim, *Cinema Demand in Korea,* 22 J. Media Econ. 36, 51 (2009) ("cinema is a substitute for trips to cultural facilities"). *But see*, Louis Lévy Garboua & Claude Montmarquette, *A Micro-econometric Study of Theatre Demand,* 20 J. Cultural Econ. 25, 40 (1996) (arguing that cinemas are a substitute only beyond a certain threshold of cinema-going).

[29]Of course, it is also possible that cinema is a substitute for restaurant if one has a limited budget that is sufficient for only one outdoor activity.

[30]*See generally* Jeremy I. Bulow et al., *Multimarket Oligopoly: Strategic Substitutes and Complements,* 93 J. Pol. Econ. 488 (1985) (originally coining the terms "strategic substitutes" and "strategic complements" in the context of production); Zhigang Cao et al., *Embedding Games with Strategic Complements into Games with Strategic Substitutes,* 78 J. Math. Econ. 45 (2018). For examples related to legal policies, *see, e.g.*, Nuno Garoupa, *A Note on Private Enforcement and Type-I Error*, 17 Int'l Rev. L. & Econ. 423, 425 (1997) ("Increasing accuracy is a way of increasing deterrence. Thus, expenditures on accuracy and on detection are strategic substitutes."); Matthew C. Stephenson, *The Strategic Substitution Effect: Textual Plausibility, Procedural Formality, and Judicial Review of Agency Statutory Interpretations*, 120 Harv. L. Rev. 528 (2006); Oren Bar-Gill & Omri Ben-Shahar, *The Uneasy Case for Comparative Negligence*, 5 Am. L. & Econ. Rev. 433, 447 (2003) ("Here, it is plausible that when one party reduces its care the marginal productivity of the other party's care increases, making the parties' care levels "strategic substitutes.").

[31]We use the terms complementarity and synergy synonymously.

With this framework in mind, the question we are interested in is which types of COVID-19-related behaviors and mitigation strategies are substitutes, which are complements, and which are simply unrelated.[32] The reason why this distinction is important is straightforward: any COVID-19 policy is an intervention that attempts to influence behavior, usually through incentives. Thus, to determine what happens if policymakers change the cost (or benefit) of a certain option by adopting a COVID-19 mitigation policy, one needs to have a good grasp of the relevant alternatives that individuals face. Yet, the set of relevant alternatives may well depend on which other concurrent policies are introduced, an aspect that might also differ from one country to another.[33] As a result, implementing individual policies without considering the connection between behaviors is often bound to fail.

In the following pages, we investigate how COVID-19 mitigation strategies might interact with one another and other (possibly country-specific) factors. This will allow us to explain why some strategies fail due to their neglect of final outcomes in a general equilibrium.

It is important to emphasize that COVID-19 mitigation strategies may also fail for a variety of reasons[34] other than the interaction effects we discuss. However, identifying the additional channels that we propose should help policymakers make better decisions, taking into account any and all possible effects that may hinder the effectiveness of a given mitigation strategy.

The rest of the Article is organized as follows: Part II discusses how a general equilibrium approach, mostly focusing on substitution effects, provides a better framework for creating and evaluating effective COVID-19 mitigation strategies. Part III provides several examples of interaction effects among COVID-19 mitigation strategies and other factors, such as social and environmental factors. We discuss our insights and offer some advice for policymaking in Part V. Thereafter, Part VI concludes.

II.   COVID-19 MITIGATION STRATEGIES: A GENERAL EQUI LIBRIUM APPROACH

A.   WHAT IS THE DIFFERENCE BETWEEN A PARTIAL AND A GENERAL EQUILIBRIUM?

To explain what one should look out for in the context of COVID-19 mitigation strategies, let us first explain in more detail what a general equilibrium is and how it differs from the effects that existing studies typically measure (*i.e.*, those of a partial equilibrium).

In neoclassical (micro-)economic theory, the price of goods is determined by an intersection of "demand"—reflecting consumers' willingness to pay for the good—and "supply"—reflecting the suppliers' willingness to (produce and) sell the good.[35] When

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[32]For concrete examples, *see infra* Part III.

[33]In addition, the economic effects of the pandemic might also differ from country to country. *See*, *e.g.*, Asger Lau Andersen et al., *Pandemic, Shutdown and Consumer Spending: Lessons from Scandinavian Policy Responses to COVID-19* (May 10, 2020) (unpublished manuscript), https://arxiv.org/abs/2005.04630 [https://perma.cc/3PV6-LPDV] (comparing Denmark and Sweden); Austan Goolsbee & Chad Syverson, *Fear, Lockdown, and Diversion: Comparing Drivers of Pandemic Economic Decline 2020,* 193 J. PUB. ECON., Jan. 2021, 1-2.; *see also* Doron Teichman & Kristen Underhill, *Infected by Bias: Behavioral Science and the Legal Response to COVID-19,* 47 AM. J. L. & MED. 205 (2021)).

[34]For instance, COVID-19 mitigation strategies may be difficult to implement due to coordination problems between countries or because of political constraints, such as the politician's need to raise public support for the policy. *See* Zamir & Teichman, *supra* note 6, at 207; Levush, *supra* note 6; *see generally* Eyal Benvenisti, *The WHO—Destined to Fail?: Political Cooperation and the COVID-19 Pandemic,* 114 AM. J. INT'L L. 588 (2020).

[35]*See generally* Richard Craswell, *Passing on the Costs of Legal Rules: Efficiency and Distribution in Buyer-seller Relationship,* 43 STAN. L. REV. 361, 361 (1991).

supply equals demand, the market reaches an *equilibrium*: a point where a certain quantity of the good sold for a certain price is acceptable by both consumers and suppliers.[36]

When the market suffers a shock (on either the demand or the supply side), the equilibrium price and quantity may change. There are many reasons why shocks occur, but for our purposes, we restrict attention to the introduction of a new legal policy as the shock of interest. For instance, suppose that consumers are willing to buy 10 widgets for the price of $1 per widget. Then, the government declares a shutdown of widget factories, causing a delay in production. As fewer widgets are being produced, they become scarcer, and supply decreases. If consumers still want to buy a widget, they would now need to pay more. This effect thus translates into a new "partial equilibrium" with a new price and a new quantity. The equilibrium is only "partial" because it is the result of a simple analysis that strictly focuses on the market for widgets, neglecting any and all side effects.

However, side effects are typically present in markets in the form of spillovers to (or from) other related markets. These may include, for example, people switching to a close substitute (*i.e.*, any other good satisfying a similar need as a widget), people reducing their purchases of a complementary product (*i.e.*, any other good that is consumed in combination with a widget), or people reducing their shopping of unrelated products because of income effects.[37] Additionally, if there are other (possibly unrelated) events or policies that occur *at the same time* and affect related markets, they might also indirectly shift the equilibrium price and quantity in the market for widgets. Hence, if one accounts for the universe of all possible effects, one can attain a better prediction—a "general equilibrium."

Scholars of law and economics have extended the idea of a general equilibrium into the analysis of non-market choices.[38] Namely, instead of considering what happens in the market for a particular good, one needs to assume that different behaviors are associated with a "price" and a "quantity." Subsequently, individuals conduct a cost-benefit analysis of the different choices in order to choose their profit-maximizing option.[39] For example, in the decision to drive a car, the "price" might be the cost of gas and the "quantity" might be the frequency of driving.[40] Intuitively, the choice of how much to

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[36]*See, e.g.*, COOTER & ULEN, *supra* note 24, at 28-33.

[37]For instance, if widget is a basic good, consumers will continue to buy it even if the price increases. However, they will then have less available income for other goods, leading to a reduction in demand for those goods.

[38]*See generally* John Fender, *A General Equilibrium Model of Crime and Punishment*, 39 J. ECON. BEHAV. & ORG. 437, *passim* (1999) (developing a model of criminal behavior); James B. Kau et al., *A General Equilibrium Model of Congressional Voting,* 97 Q. J. ECON. 271, *passim* (1982) (developing a model for congressional voting). However, it has been argued that also law and economics insufficiently accounts for general equilibrium effects. *See* Henry E. Smith, *Law and Economics: Realism or Democracy*, 32 HARV. J. L. & PUB. POL'Y 127, 133 (2009) ("Partial equilibrium and general equilibrium are two very different things. Law and economics rarely rests on a general equilibrium analysis. But partial analyses must be taken with a grain of salt; it is characteristic of complex systems that a subpart may not share properties with the whole.").

[39]*See, e.g.*, Jeffrey L Dunoff & Joel P. Trachtman, *The Law and Economics of Humanitarian Law Violations in Internal Conflict*, 93 AM. J. INT'L L. 394, 400 (1999) ("Price theory assumes that each individual engages in a rational cost-benefit analysis, and suggests that it is necessary to make the price of noncompliance high enough to exceed the perceived benefits from noncompliance."); Anja Weber & Erik Maier, *Reducing Competitive Research Shopping with Cross-channel Delivery,* 24 INT'L J. ELEC. COM. 78, 79 (2020) ("A cost-benefit analysis drives consumers' channel choice, in that consumers will choose the channel with the highest utility for their given purchase goal").

[40]Driving may, of course, entail other costs (e.g. the risk of causing an accident) and its benefit depends also on substitutes and complements. As one example, a recent study finds that an increase in the price of children car seats (which is a complement to cars) is an implicit cost of buying a car. *See generally* Jordan Nickerson & David H. Solomon, Car Seats as Contraception (Sept. 22, 2020) (unpublished manuscript), https://ssrn.com/abstract=3665046 [https://perma.cc/Y4SX-GDD5].

drive is also subject to possible demand shocks (*e.g.*, when the government imposes a tax on gas) and supply shocks (*e.g.*, if the government closes a main road). Also in this context, one can seek out the partial equilibrium or the general equilibrium; for example, a tax on gas leads to less driving in a partial equilibrium (as driving becomes more costly, the demand for driving decreases), but if the tax on gas also affects the production of some other activities associated with driving (*e.g.*, car-parts manufacturing) there are additional side effects.[41] Following a similar line of thought, we proceed to analyze COVID-19 mitigation strategies.

B.   WHAT IS THE JUSTIFICATION FOR A LEGAL INTERVENTION IN A GENERAL EQUILIBRIUM?

From an economic perspective, a general equilibrium can be a desirable phenomenon, as the market forces can bring about an outcome that is not only stable but also *efficient.*[42] Namely, if markets are competitive and frictionless,[43] then the (general) equilibrium outcome *is* efficient[44] so there is no clear economic need for legal intervention.[45] This result reflects Adam Smith's "invisible hand"—even though people (rationally) maximize their own self-interest, the result is socially beneficial.[46]

Under this prism, COVID-19 mitigation strategies make (economic) sense insofar as the general equilibrium is *inefficient*, which only happens if some frictions are present. Yet, it is fairly clear that frictions, in the form of negative externalities,[47] are a strong driver of behavior during a pandemic because (insufficient) precautions to avoid infections have a strong influence on others.[48] As an example, the quantity of facial masks[49]

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[41] As one example, the cost of a children's car seat might not only affects driving, but also the ex-ante decision of how many children to have. *Id.*

[42] This result, that a competitive equilibrium is efficient, is known as the "first fundamental theorem of welfare economics." *See, e.g., id.;* Matthew Dimick, *The Law and Economics of Redistribution,* 15 ANN. REV. L. & SOC. SCI. 559, 582 (2019)).

[43] Market frictions here refer to two types of problems: asymmetric information (e.g. where sellers or buyers do not have full information about the value of a product) and externalities (where a product sold has a positive or negative effect on others who are neither the sellers nor the buyers). *See, e.g.,* Joseph T. Mahoney & Lihong Qian, *Market Frictions as Building Blocks of an Organizational Economics Approach to Strategic Management,* 34 STRATEGIC MGMT. J. 1019, 1021 (2013) (listing frictions, including externalities); Hiba Hafiz, *Structural Labor Rights,* 119 MICH. L. REV. 651, 693 (2021) (mentioning information asymmetry as a market frictions).

[44] Dimick, *supra* note 42.

[45] Note that economists mostly focus on social welfare in the form of Kaldor-Hicks efficiency—which assumes that the goal is to maximize the sum of utilities of individuals, irrespective of the distribution. *See* COOTER & ULEN, *supra* note 24, at 42. Thus, legal interventions that aim to promote fairness or justice considerations would only be relevant if one adopts a non-efficiency perspective.

[46] *See, e.g.,* Allan Gibbard, *Social Choice Theory and the Imperfectability of a Legal Order,* 10 HOFSTRA L. REV. 401, 402 (1982); Adrian Vermeule, *The Invisible Hand in Legal and Political Theory,* 96 VA. L. REV. 1417, 1418-19 (2010).

[47] Externalities occur when benefits or costs of certain actions have an effect on third parties. For instance, a seller and a buyer may achieve a mutually agreeable transaction surrounding the sale of a polluting product, but such purchases also have negative effects (negative externalities) on others who are not part of the negotiations. *See, e.g.,* COOTER & ULEN, *supra* note 24, at 39-40.

[48] *See, e.g.,* Nicholas W. Papageorge et al., *Socio-demographic Factors Associated with Self-protecting Behavior During the Covid-19 Pandemic,* 34 J. POPULATION ECON. 691 (2021) ("The spread of illness is largely influenced by human behavior. In the presence of strong externalities, a concern is that individual behavior may not align with socially optimal outcomes"); Teichman & Underhill, *supra* note 33, at 207 ("when peoples' choices generate massive negative externalities—as is the case with a highly contagious and deadly virus").

[49] *See generally*: Ricky V. Tso & Benjamin J. Cowling, *Importance of Face Masks for COVID-19: A Call for Effective Public Education,* 71 CLINICAL INFECTIOUS DISEASES 2195 (2020); Christiane Matuschek et al., *Face Masks: Benefits and Risks during the COVID-19 Crisis,* 25 EUR. J. MED. RES. 1 (2020).

sold in equilibrium may be inefficiently low because either sellers selfishly charge an overly high price from consumers (while disregarding the social cost)[50] or consumers selfishly underutilize (and therefore demand too few) masks. Note that the problem arises through two channels: (i) masks prevent their wearer from infecting others, and (ii) masks reduce the chance that their wearer gets infected and hence impose costs on others (either by infecting them or by taking up scarce medical resources).[51] Such behavior leads to a "market failure"—people behave rationally and the outcome is, nonetheless, inefficient.[52] Framed differently, individuals may refuse to bear a personal cost to enhance health by reducing the spread of COVID-19, given that health is a "public good"[53]—a good that everyone can enjoy at the same time ("non-rivalrous") and that no one can easily exclude others from consuming ("non-excludable").[54] Public goods typically suffer from undersupply because people who produce (or consume) them have an incentive to free ride on other people's effort—here, by not incurring the inconvenience of wearing a facial mask.[55] Such a market failure[56] serves as the economic justification for governmental intervention in the form of mitigation strategies.

C. How can COVID-19 Mitigation Strategies Change the Equilibrium?

In the context of COVID-19, policymakers can attempt to influence human behavior using public policies that create shocks to targeted behaviors. Consider a COVID-19 mitigation policy stating that "no person shall be allowed to stay at another person's private residence."[57] The apparent logic of such a policy is that the prohibition will decrease the frequency of face-to-face meetings using a threat of sanctions, mostly in the form of a monetary fine. Whether such a policy will indeed lead to the desired switch can be conveniently captured by standard models of crime deterrence in the spirit of the canonical model of Nobel Prize Laureate Gary Becker.[58] In such models, rational individuals make choices based on their anticipation of the costs and benefits associated with each option. Thus, they calculate whether the net benefit from some action "A" is higher than the net benefit from the alternative action "B." Whichever option is expected to yield

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[50]*See, e.g.*, Reuters Staff, *Beijing Drug Store Fined $434,530 for Hiking Price of Masks*, Reuters (Jan. 29, 2020), https://www.reuters.com/article/china-health-masks-idUSL4N29Y09B [https://perma.cc/H4P3-UJGD] (reporting on an incident in Beijing where a store starkly raised the price of masks in the early days of COVID-19).

[51]For a general discussion on the rational use of facial masks, *see generally* Shou Feng et al., *Rational Use of Face Masks in the COVID-19 Pandemic,* 8 Lancet Respiratory Med. 434 (2020); Steve G. Parsons, I*s a Requirement to Wear a Mask Economically Valid During COVID-19?*, 6 U. Bologna L. Rev. 76 (2021).

[52]Cooter & Ulen*, supra* note 24, at 38-42.

[53]*See, e.g.,* Shawn HE Harmon & Aisling McMahon, *Banking (on) the Brain: From Consent to Authorisation and the Transformative Potential of Solidarity*, 22 Med. l. Rev. 572, 576 (2014) ("health is a global public good"); *see also* Ohan A. Oldekop et al.*, COVID-19 and the Case for Global Development,* World Dev., June 2020, at 1-2.

[54]For a definition of a public good, *see* Cooter & Ulen*, supra* note 24, at 40.

[55]From a game-theoretical perspective, the problem is one of dominant strategies, where people think that "if everyone else wears a mask, there is no need for me to where a mask" whereas if no one wears a mask then "it will anyway not matter if I am the only one who wears a mask". Hence, it is a dominant strategy not to wear a mask. *See, e.g.*, Cooter & Ulen, *supra* note 24, at 35 (discussing dominant strategies).

[56]Cooter & Ulen*, supra* note 24, at 40.

[57]For instance, such a policy was implemented in Israel. TOI Staff, *Rules of Israel's Third Lockdown: What You Need to Know,* Times of Israel (Dec. 25, 2020), https://www.timesofisrael.com/israels-third-lockdown-what-you-need-to-know [https://perma.cc/8L8M-MY8G]. Formally, the rule does not prohibit the stay per se, but prohibits going out of ones' home for the purpose of staying at another person's home. *Id.*

[58]Gary S. Becker, *Crime and Punishment: An Economic Approach,* 76 J. Pol. Econ. 169 (1968). For a recent discussion of Becker's framework in the context of pandemics, *see* Roee Sarel, *Crime and Punishment in Times of Pandemics*, Eur. J. L. & Econ., Dec. 2021, at 3.

higher utility is then chosen. In the simplest case, where sitting idly (action "A") yields a zero utility and violating the law (action "B") yields a benefit,[59] individuals violate (*i.e.*, commit a crime) if and only if

$$b - p * f > 0,$$

where b is the benefit from crime (from action "B"), p is the probability of being caught and punished, and f is the size of the penalty (*e.g.*, a monetary fine).[60]

As a more general case, individuals will prefer action B to action A if

$$E(b_B) - E(c_B) > E(b_A) - E(c_A),$$

where b_i is the benefit from action $i \in \{A, B\}$, c_i is the cost of action i, and $E(\cdot)$ denotes an "expected" cost or benefit (there is usually some uncertainty about whether the benefit will be attained or the cost will be incurred).[61]

Relating this inequality to the example above, suppose that action "A" is violating a rule (*e.g.*, by visiting a friend at his private residence), whereas action "B" is staying alone at home. A person considering what to do will need to calculate the costs and benefits of each option: the benefit of visiting a friend, the chance of being caught, the severity of the penalty, the level of boredom from remaining home, the chances of being infected at home as compared to at a friend's house, and so on. Then, if the net benefit of visiting a friend is higher (lower), the individual will (not) violate the rule.

The key question, then, is what determines the net costs and benefits of each option. One straightforward component is the expected penalty:[62] individuals should care about the probability of being caught when visiting their friend and the magnitude of the fine that they might incur. For simplicity, we assume that individuals are risk-neutral, *i.e.*, they only maximize their expected utility.[63] The expected penalty depends also on how the policy is enforced, such as whether the police often enter private homes and whether fines are indeed issued by police officers.[64] Thus, it is tempting to restrict attention to the expected penalty, which policymakers can easily influence,[65] and assume that if the cost of a certain action is high enough, it will simply not be chosen.

Yet, this is precisely the problem of over-focusing on a partial equilibrium: the expected penalty affects the *absolute net benefit* of the targeted action but does not reveal what happens to the *relative net benefit.* In particular, the implicit assumption here is that

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[59]For simplicity, we assume here that individuals are also risk-neutral.

[60]The zero on the right-hand side of the inequality is the utility from sitting idly in this example.

[61]In economics, an expected payoff means the product of the probability times the size of the payoff.

[62]We use the terms "expected penalty" and "expected sanction" synonymously to describe the product of (1) the probability of apprehension and conviction and (2) the size of the sanction. COOTER & ULEN, *supra* note 24, at 465. Note that some articles consider uncertain sanction sizes, in which case the term is sometimes used separately from the probability of apprehension. *See, e.g.,* Marisa Nack, *The Next Step: The Future of New York State's Human Trafficking Law,* 18 J. L. & POL'Y 817, 851 (2010) *("… perpetrators will only engage in trafficking if the benefits of committing the crime outweigh the costs (the probability of detection and the expected sanction").*

[63]*See* COOTER & ULEN, *supra* note 24, at 45-46.

[64]A full consideration of a general equilibrium may also require to account for how different agents, such as law enforcement, victims, and judges. For economic models that incorporate such agents, *see generally* William J. Furlong, *A General Equilibrium Model Of Crime Commission and Prevention,* 34. J. PUB. ECON. 87 (1987); Bruce L. Benson et al, *Estimating Deterrence Effects: A Public Choice Perspective on the Economics of Crime Literature,* 61 S. ECON. J 161 (1994) (developing a model where deterrence depends on police effort)). For example, the effort of police officers may be lower if they sympathize with the victim's difficulty to avoid social distancing. However, we restrict attention to substitution and complementarity effects.

[65]Policymakers can influence the expected sanction by either changing the probability of apprehension (e.g. by hiring more police officers) or by changing the penalty (e.g. increasing the monetary fine).

action B is benign, that is, it entails no (or a negligible) social harm. Concretely, the policy implicitly assumes that a person who abstains from visiting a friend will instead choose to stay home, but whether this is true depends on (i) whether the policy also indirectly changes the benefit from staying at home and (ii) whether feasible alternatives to staying at home that are less benign exist.[66]

If policymakers were only interested in finding out whether the policy reduces the frequency of visiting friends, these two issues would not matter. However, as the goal of the policy is reducing COVID-19 infections (and not reducing visits *per se*), what policy-makers should care about is the general equilibrium—what happens to the number of infections and deaths. With this in mind, we proceed to consider which types of interaction effects come into play.

III.   INTERACTION EFFECTS: SUBSTITUTION AND COMPLEMENTARITY

In this Part, we consider the role of "interaction effects:" effects that cause heterogeneity in behavior (and hence in the efficacy of a policy) depending on some varying factors.[67] In the context at hand, we consider two kinds of interaction effects: *substitution effects* and *complementarity effects.* As mentioned above,[68] two goods are substitutes if they serve a similar need and are complements if they generate a higher benefit when they are jointly consumed. Similarly, two behaviors may also be either substitutes or complements.

This distinction, which lies at the heart of this Article, determines what happens when a COVID-19 mitigation policy is adopted. If the policy increases the cost of a certain activity, then people will *switch from* complements *to* substitutes.[69] To illustrate the importance of this point, we consider two concrete examples in the next Sections.

A.   COVID-19 MITIGATION STRATEGIES: SUBSTITUTION EFFECTS

Let us return to the example of a policy prohibiting staying at other people's private residences. Suppose that while visiting a friend's *residence* is prohibited, visiting a friend's *office* is allowed. In this case, it seems plausible that a meeting will still take place, but the meeting's location will simply switch from the private residence to the office, rendering the policy largely ineffective.[70] This is a straightforward example of a substitution

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[66]In economic terms, the problem can also be framed in terms of "opportunity cost"—the cost of foregoing other opportunities. *See, e.g.*, COOTER & ULEN, *supra* note 24, at 30.

[67]The term "interaction effect" is often used in econometrics to describe a situation where the joint occurrence of two events causes an effect above and beyond the effect of each event individually. Hence, when there is an interaction effect between "X1" and "X2," then the effect of X1 on some outcome Y depends on X2. For instance, in the equation $Y = x_1 + x_2 + x_1 * x_2$ the effect of increasing x_1 by 1 unit depends on how high x_2 is, due to the last term which is a product of x_1 and x_2. *See, e.g.*, JAMES H. STOCK & MARK W. WATSON, INTRODUCTION TO ECONOMETRICS 277-278 (2015).

[68]*See* Katyal, *supra* note 27, at 2386.

[69]These effects are typically known in economics as cross-price elasticities, reflecting what happens to the quantity demanded of product A when the price of product B changes. *See, e.g.,* Terry M. Schlade, *Proposed Objective Relevant Product Market Criteria Under Section 2 of the Sherman Act and Section 7 of the Clayton Act,* 35 U. CIN. L. REV. 376, 381 (1966). Substitutes have a positive cross-price elasticity because if the price of a substitute product B becomes more expensive then consumers will demand *more* of A. Similarly, complements have a negative cross-price elasticity.

[70]Of course, it is also possible that the meeting's location will switch to an open-air location, where the risk of infection is lower. However, this is less likely to occur if public gatherings are prohibited as well (whereas business meetings are still allowed and the risk of being detected when conducting private meetings at the office is low).

effect among behaviors—a policy discouraging one harmful behavior might just lead people to switch to another (possibly no less) harmful behavior.[71]

The possibility of substitution effects reflects a common criticism of the Becker model, known as the "marginal deterrence argument:"[72] changes in the penalty of one crime can cause people to switch to another, possibly worse, crime (or to a higher degree of the same type of crime).[73] A similar insight also arises in criminology's "crime displacement theory,"[74] which suggests that police enforcement efforts in one area may simply cause offenders to switch the location of their criminal activity to a nearby location with less enforcement.[75]

Conversely, suppose instead that it is also prohibited to meet people at the office (and that this is strictly enforced). This would eliminate the substitution effect and may also have a complementary effect, as a prohibition to go to the office can reduce the use of public transportation and incentivize people to stay at home as the viable alternative.

To further illustrate, consider the following numerical example: an individual values the net benefit from staying at home at "2" and the net benefit from visiting a friend at "5." This individual would clearly choose to visit a friend (which is a costly activity to society in times of COVID-19) unless there is some threat of a fine. Then, suppose the government decides that visiting a friend at home is subject to an expected monetary fine of "4," anticipating that the individual would prefer staying at home. With these numbers, as summarized in Table 1 below, the policy would work—but this is only because we are looking at the policy in isolation (*i.e.*, at the partial equilibrium).

Next, suppose that the individual has the alternative option to visit the friend at the office, yielding a net benefit of "3" (*i.e.*, it is a close substitute for visiting a friend at home). We would then instead get Table 2, showing that, with an intervention, the individual would simply choose to visit the office (rather than stay at home).

Table 1. Illustration of a simple choice between two options

	Staying at home	Visiting a friend at home
Without intervention	2	**5**
With intervention (fine = 4)	**2**	1

Note: This table presents an illustration of payoffs with and without legal intervention (a monetary fine). The numbers represent the utility of an individual, who then chooses the column yielding the highest utility in the row that applies (depending on whether there is intervention). The utility-maximizing option in each row is marked using bold text.

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[71]For a discussion of substitution effects and harmful (criminal) behaviors, *see generally* Tracey L. Meares et al., *Updating the Study of Punishment*, 56 STAN. L. REV. 1171, 1173-74 (2003); Joel Van der Weele, *Beyond the State of Nature: Introducing Social Interactions in the Economic Model of Crime*, 8 REV. L & ECON. 401, 413 (2012). The substitution effects are closely related to the concept of "marginal deterrence." *See, e.g.*, George J. Stigler, *The Optimum Enforcement of Laws*, 78 J. POL. ECON. 526, 527 (1970)).

[72]*See* Richard A. Posner, *An Economic Theory of the Criminal Law*, 85 COLUM. L. REV. 1193, 1207 (1985); C.Y. Cyrus Chu & Neville Jiang, *Are Fines More Efficient Than Imprisonment?*, 51 J. PUB. ECON. 391, 392, 392 n.3 (1993); *see also* Steven Shavell, *A Note on Optimal Deterrence when Individuals Choose among Harmful Acts* 1 (Nat'l Bureau of Econ. Research., Working Paper 3061, 1989).

[73]For instance, a change in the penalty on drug consumption might lead offenders to either increase their consumption of the same drug, as this becomes less costly on the margins, or switch to another, worse, drug. *See* Katyal, supra note 27, at 2391, 2400.

[74]John E. Eck, *The Threat of Crime Displacement,* 25 CRIM. J. ABSTRACTS 527, 527 (1993).

[75]However, the empirical evidence seems to suggest that displacement is not inevitable and that enforcement may lead to diffusion benefits instead in many cases. *See generally* Shane D. Johnson et al*., Crime Displacement: What We Know, What We Don't Know, and What It Means for Crime Reduction,* 10 J. EXPERIMENTAL CRIMINOLOGY 549 (2014); Rob T. Guerette & Kate J. Bowers, *Assessing the Extent of Crime Displacement and Diffusion of Benefits: A Review of Situational Crime Prevention Evaluations,* 47 CRIMINOLOGY 1331 (2009).

Table 2. Illustration of choice between three options

	Staying at home	Visiting a friend at home	Visiting a friend at the office
Without intervention	2	**5**	3
With intervention (fine = 4)	2	1	**3**

Note: This table extends Table 1 by adding a third column capturing the possibility of visiting a friend at the office. The utility-maximizing option in each row is again marked using bold text.

Table 3. Illustration of choice: complementary policies

	Staying at home	Visiting a friend at home	Visiting a friend at the office
Without intervention	2	**5**	3
With intervention (fine for visiting a friend at home = 4; fine for visiting the office = 2)	**2**	1	1

Note: This table describes the payoffs of the same choice detailed in Table 2 but under the assumption that there is also a fine for visiting a friend at the office. The utility-maximizing option in each row is again marked using bold text.

To avoid the adverse consequences of this substitution effect, the government must adopt a complementary policy of punishing visits to the office. For instance, if a visit to the office entails a punishment of "2," then we get Table 3, showing the individual chooses the desired, benign behavior.

Note that the two policies—prohibiting visits to a residence and prohibiting visits to an office—are indeed strategic complements: their interaction creates a synergy that achieves the desired outcome. In fact, in this example, neither policy is effective on its own—if one would only prohibit office visits, this would have no effect (as the meetings at a residence would continue as usual).

B.   COVID-19 MITIGATION STRATEGIES: COMPLEMENTARITY EFFECTS

As a counter-example, consider the policy of alcohol bans, which was adopted in various forms and in multiple countries during the COVID-19 pandemic.[76] At first glance, the logical connection between alcohol and COVID-19 is unclear because these policies do not directly reduce infections. A first rationale might be that such a ban reduces the likelihood that some intoxicated individuals would carelessly get too close to others and thereby hinder the ability to maintain social distancing. However, a second explanation might be related to complementarity effects: if people consume alcohol mainly in conjunction with social gatherings, then the ban would also indirectly induce people to stay at home.

Using a numerical example as before, suppose that an individual gets a utility of "5" when he can drink alcohol with his friends, "3" when he meets his friends but does not

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[76]*See generally* Richard Matzopoulos et al*., South Africa's COVID-19 Alcohol Sales Ban: The Potential for Better Policy-Making,* 9 INT'L J. HEALTH POL'Y & MGMT. 486, 486-87 (2020) (discussing a ban in South Africa); Swarndeep Singh et al., *The Impact of Nationwide Alcohol Ban during the COVID-19 Lockdown on Alcohol use-related Internet Searches and Behaviour in India: An Infodemiology Study,* 40 DRUG & ALCOHOL REV. 196, 196-97 (2021) (discussing a ban in India); City of Hamburg, Corona Rules and Regulations in Hamburg, §4D (Dec. 23, 2020), https://www.hamburg.com/residents/settle/health/13921528/rules-and-regulations/ [https://perma.cc/FWJ8-AF9F] (enacting a ban on public consumption of alcohol in Hamburg, Germany.)

drink, and "4" when he stays at home. A policy that punishes alcohol consumption with a fine of "2" then yields Table 4:

Table 4. Illustration of complementarity effect

	Staying at home	Meet friends without drinking alcohol	Meet friends & drink alcohol
Without intervention	4	3	**5**
With intervention (fine for consuming alcohol = 2)	**4**	3	3

Note: This table presents an illustration of payoffs with and without legal intervention (a monetary fine), for the example of bans on alcohol consumption. As in all previous tables, the numbers represent the utility of an individual, who then chooses the column yielding the highest utility in the row that applies (depending on whether there is intervention). The utility-maximizing option in each row is marked using bold text.

In this example, a fine for consuming alcohol, by itself, is sufficient for causing individuals to switch to the benign activity of staying at home. However, with a slight adjustment, this may not work, either because meeting friends without alcohol would bring a high benefit[77] or because people would substitute alcohol for another product. For instance, some individuals might simply consume drugs (*e.g.*, marijuana) while gathering with friends instead of drinking alcohol,[78] rendering the policy ineffective due to a substitution effect.

Notably, the two policies of banning alcohol and prohibiting gatherings are not necessarily strategic complements. For instance, suppose we add another column of "consuming alcohol outdoors alone," referring to an activity that is still costly from a social perspective (*e.g.*, because intoxication may cause the person to get close to strangers) but not as costly as drinking with friends. Then, slightly changing the numbers from the previous example, Table 5 below illustrates a scenario that combines complementarity and substitution effects.

In this scenario, the government can impose a fine for gatherings, a fine for consuming alcohol, or both. The worst possible outcome is meeting friends and drinking alcohol—yielding a social cost of "20," followed by the (somewhat) less problematic activity of drinking alone (social cost of "17"), gatherings without alcohol (social cost of "13"), and staying at home as a benign activity. As before, the individual chooses the option with the highest private benefit. Here, if the government adopts only an alcohol ban, the individual still meets friends (without drinking). Conversely, if the government prohibits only gatherings, then the individual prefers drinking alone outside. This means that both policies have some positive impact—and in that sense, if the goal is simply to eliminate the most dangerous activity, then the policies are strategic substitutes. Yet, as the last row of the table demonstrates, when the policies are combined, the individual chooses the optimal action (staying at home). Thus, if the goal is to reduce the social cost as much as possible, the policies are *strategic complements*.

As another brief example, consider the mitigation strategy of international travel bans, adopted in many countries at different times throughout the pandemic.[79] If one was

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[77] For example, if meeting friends without drinking yields a utility of "4.5," then the alcohol ban would simply cause people to meet without drinking alcohol, as this would still be larger than the utility of staying home (of "4").

[78] *See, e.g.*, Frank J. Chaloupka & Adit Laixuthai, *Do Youths Substitute Alcohol and Marijuana? Some Econometric Evidence,* 23 E. Econ. J. 253, 253 (1997) (finding evidence that prohibition of drugs leads youth to switch to alcohol).

[79] *See, e.g.,* Sharmila Devi, *Travel Restrictions Hampering COVID-19 Response,* 395 Lancet 1331, 1331 (2020); Kevin Linka et al., *Is it Safe to Lift COVID-19 Travel Bans? The Newfoundland Story,* 66 Computational Mech. 1081, 1081-82 (2020).

Table 5. Illustration of effects with costs vs. benefits

	Staying at home	Meet friends without drinking alcohol	Drink alone Outdoors	Meet friends & drink alcohol
Social cost	0	13	17	20
Private Benefit without intervention	1	3	4	**5**
Private benefit with an alcohol ban only (=fine of 4 for consuming alcohol)	1	**3**	0	1
Private benefit when only prohibiting gatherings (fine =4)	1	-1	**4**	1
Private benefit when both policies are adopted (fine=4 for both)	**1**	-1	0	-3

Note: This table presents an illustration of payoffs with and without legal intervention (a monetary fine), given four mutually exclusive choices. The first row specifies the social cost. The other rows specify, as in all previous tables, the utility of an individual. The individual again chooses the column yielding the highest utility in the row that applies (depending on whether there is intervention). The utility-maximizing option in each row is marked using bold text.

exclusively interested in the effect of this policy on the spread of COVID-19 during flights (a partial equilibrium), there might be ways to alleviate this concern through rigid testing and proper ventilation. However, travel bans seem more justifiable from a general equilibrium perspective because of activities that are complements to flights (*e.g.*, dining in different restaurants while on holiday abroad) and may bear a high risk of infection. Thus, by banning flights, one also gets the indirect benefit of reducing the frequency of complementary activities.[80] At the same time, when unable to travel internationally, individuals may respond by turning to the closest substitute—a domestic vacation (with domestic dining), partially countervailing the benefit.

These examples highlight the challenge that policymakers face: they must account for multiple substitution and complementarity effects.[81] To evaluate policy options, Neal Katyal has proposed that policymakers conceptually differentiate between substitution and complementarity effects in crime deterrence that yield either increases or decreases in the demand for both the punishable activity and other activities.[82] This model can be mapped onto most of the effects identified above[83] but includes some additional measurements. For instance, a prohibition of an activity might generally affect preferences, (*e.g.*, cause people to dislike the prohibited activity). For COVID-19 mitigation strategies, however, this seems less relevant—the prohibitions do not generally have a declaratory moral aspect; rather, the goal is usually instrumental (to temporarily reduce the frequency of the activity to prevent infections).

There are additional challenges that arise because the various effects may be heterogeneous, that is, in some areas, the effects will be strong while in others they will be

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[80]There might be other motivations to restrict flights that are not purely efficiency-driven, such as exploiting the pandemic to prevent the entry of foreigners.

[81]A similar problem arises in the field of marketing, where advertisements for one good may impact the demand for many other goods, leading to a multitude of effects. *See* Allan D. Shocker, *Product Complements and Substitutes in the Real World: The Relevance of "Other Products"*, 68 J. MKTG. 28, 28 (2004).

[82]Katyal, *supra* note 27, at 2470.

[83]For instance, Katyal (*id,* at 2491*)* uses the term "Y-optimality" to describe how reductions in other activities can sometimes help prevent other crimes. *Id.* at 2419. This is similar to our argument of complementarity effects between the prohibition of alcohol consumption in public and the reduction of social gatherings.

weak (or non-existent). To account for this, one must consider how COVID-19 mitigation policies interact with additional factors. As the range of relevant factors may be vast, we consider only a few examples in the next Part (without claiming to be exhaustive in any way). These examples will help illustrate the type of interactions that policymakers may want to consider.

IV.   FURTHER APPLICATIONS

The prohibition of staying at another person's residence and the ban on selling alcohol[84] provide straightforward case studies of interactions in terms of either substitution or complementarity effects. However, given that interaction effects are a function of the elusive, immediate environment, they are likely to be multidimensional. In this Part, we broaden the discussion by focusing on three salient examples, some of which are also supported by existing empirical evidence.[85] In so doing, we shed light on how policymakers can fine-tune effective COVID-19 mitigation strategies in a cost-efficient manner, namely by taking into account important phenomena such as social norms[86] and environmental factors.

A.   Restricting Freedom of Movement in Light of Social Norms: Family Ties

Traditional microeconomic theory assumes that individuals behave as "*homo oeconomicus*"—homogenous economic units that act selfishly and only strive to maximize their own utility.[87] This is precisely why the aforementioned public-goods problem emerges: people do not care about infecting others. However, the validity of the *homo oeconomicus* assumption has been challenged by a long line of experimental findings suggesting that people have "social preferences,"[88] that is, they also care about what happens to others.[89] If social preferences were the dominant factor driving behavior, we might not need much intervention at all (as people would take precautions to avoid infecting strangers). However, there may be specific types of social preferences in play that affect behavior but not with respect to strangers. For instance, a well-known theory in social sciences distinguishes between several values, one of which is "benevolence," or the preservation and enhancement of people with whom one is in frequent contact (*e.g.*, family members).[90] This differs from "altruism" or "pro-sociality" in that the individual cares about a specific subset of in-group people,

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[84]*See supra* Part III.

[85]Our first and third example include the effects of social norms and the weather respectively. A recent study found that high social capital and bad weather both reduce movement during COVID-19. Francesca Borgonovi & Elodie Andrieu, *Bowling Together by Bowling Alone: Social Capital and Covid-19,* Soc. Sci. & Med., Nov. 2020, at 2.

[86]For a discussion of how social norms may matter during the COVID-19 pandemic in another context (of risk perception), *see* Teichman & Underhill, *supra* note 33, at 239-43.

[87]*See, e.g.*, Christine Jolls et al*., A Behavioral Approach to Law and Economics,* 50 Stan. L. Rev. 1471, 1476 (1998).

[88]Gary Charness & Matthew Rabin, *Understanding Social Preferences with Simple Tests,* 117 Q. J. Econ. 817, 817 (2002).

[89]*See, e.g.*, Jana Bellová*, Behavioural Economics and its Implications on Regulatory Law*, 15 Int'l & Comp. L. Rev. 89, 92 (2015); Colin Camerer et al., *Regulation for Conservatives: Behavioral Economics and the Case for "Asymmetric Paternalism"*, 151 U. Pa. L. Rev. 1211, 1216 (2003).

[90]Lilach Sagiv & Shalom H. Schwartz, *Value Priorities and Readiness for Out-group Social Contact,* 69 J. Personality & Soc. Psychol. 437, 438 (1995).

rather than human beings in general.[91] However, the degree to which social preferences translate into behavioral changes may depend on social norms,[92] which can be defined as informal rules of everyday life that reflect a shared view of what is considered appropriate behavior.[93] For instance, whether one is expected to visit one's family is often a social norm that differs starkly across countries. An implication of this social norm is that policymakers should be more concerned about violations of social distancing among the family members in some countries but less so in others, and COVID-19 mitigation strategies should be tailored accordingly. However, social norms need not be detrimental to mitigation efforts. Policymakers could try to leverage social norms and tailor their COVID-19 mitigation strategies to create better incentives.

Consider the said norm of visiting (or, more generally, taking care of) one's family.[94] Social support within the family, such as by paying weekly visits to one's parents, becomes even more significant in times of social isolation due to COVID-19. On the one hand, this may then just lead to the obvious effect—people would be more likely to visit their family, even in violation of social-distancing rules. On the other hand, the opposite may hold: younger generations may have an inherent incentive to protect older generations, such as parents and grandparents (so-called "groups at risk"), from contracting the virus, which then provides a strong incentive to avoid visiting close family members.[95] A third, more interesting option, however, is a mix of the two: the young may continue to visit their family, but instead take extra care when meeting *others*, thereby mitigating the risk that they themselves get infected prior to the visit. If this practice occurs, then the possibility of visiting one's family enhances the incentive to comply with social-distancing measures in everyday life.

Given this, what would then be the effect of a policy that restricts family visits? If properly enforced, the outcome of this policy should be fewer family visits, which can reduce the transmissions within the family. At the same time, such a restriction would *crowd out the intrinsic motivation* to socially-distance:[96] if young people cannot meet their family at all, they no longer have to worry about infecting family members.[97] Such reasoning would likely apply to restrictions of freedom of movement that prevent a person from going out of one's residence beyond a small perimeter (*e.g.*, 1,000 meters);[98] if not all

[91] Shalom H. Schwartz, *Universals in the Content and Structure of Values: Theoretical Advances and Empirical Tests in Twenty Countries,* 25 ADVANCES EXPERIMENTAL SOC. PSYCHOL. 1, 11 (1992).

[92] The social norm we consider here can also be described as "social capital." *See generally* Borgonovi & Andrieu*, supra* note 85.

[93] *See* Andriy Boytsun*, Social Norms, Social Cohesion, and Corporate Governance,* 19 CORP. GOVERNANCE: INT'L REV. 41, 41 (2011).

[94] Such norms are particularly strong in Mediterranean countries. *See*, *e.g.*, Howard Litwin, *Social Networks and Well-being: A Comparison of Older People in Mediterranean and non-Mediterranean Countries,* 65 J. GERONTOLOGY SERIES B: PSYCHOL. SCI. & SOC. SCI. 599, 599 (2010) (finding differences in family networks of the elderly between Mediterranean and non-Mediterranean countries).

[95] Such an effect has been observed in Israel, where the desire to protect family members seems to have been a strong motivation for complying with lockdowns. *See* Arielle Kaim et al., *Factors that Enhance or Impede Compliance of the Public with Governmental Regulation of Lockdown during COVID-19 in Israel,* INT'L J. DISASTER RISK REDUCTION, Sept. 2021, at 5.

[96] The concept of "crowding-out of intrinsic motivation" is originally attributed to a study of fines imposed for being late to day cares in Israel. *See* Uri Gneezy & Aldo Rustichini, *A Fine is a Price,* 29 J. LEGAL STUD. 1, 16 (2000) (finding the effect can be explained by the fact that people view the fine as a price). In our example, that might also happen, but we are considering a more explicit change by eliminating the incentive to act pro-socially due to the prohibition to meet one's family.

[97] This effect would then be the mirror image of the empirical finding that close communities are more careful not to infect one another. Borgonovi & Andrieu, *supra* note 85, at 22.

[98] *See* Regulation of Special Authorities to Handle the New Coronavirus (Emergency Regulation) (tightening of restrictions) (2020), [in Hebrew], https://www.nevo.co.il/law_word/law01/502_363.doc [https://perma.cc/FXM4-VPZZ] (stating that "no person shall leave their place of residence or location of permanent stay …to the public sphere unless it is for one of the following actions or goals […] (16) leaving to a distance of up to

Table 6. Illustration of choices in light of strong family ties

	Staying at home	Visiting a friend within 1 km	Visiting family further away than 1km
Without intervention	1	2	**6**
With intervention (fine for violating the 1,000m perimeter = 2)	1	**5**	4

Note: This table presents an illustration of payoffs with and without legal intervention (a monetary fine) for the example with a social norm. The individual chooses the column yielding the highest utility in the row that applies (depending on whether there is intervention). The utility-maximizing option in each row is marked using bold text.

family members live less than 1,000 meters apart from each other, the restriction may crowd out a young person's incentive to comply with social-distancing measures because the person cannot visit—and therefore does not need to protect—their family from contracting COVID-19. That person's *friends* (or neighbors), on the other hand, might live nearby, especially in dense cities. Looking at the numerical example specified in Table 6, one can see that visiting one's family (thereby violating the 1,000 meters restriction) provides higher levels of utility as compared to visiting a friend who lives less than 1,000 meters away. Namely, in this example, we assume that individuals have an intrinsic utility of "3" from keeping their family safe. What happens, then, is that an intervention imposing a monetary fine for violating the 1,000 meters perimeter (to visit one's family) has two *simultaneous* effects: (i) it reduces the benefit from visiting the family (via the threat of a fine) *and* (ii) it increases the benefit from visiting one's friend by "3" (the intrinsic motivation). The result reflects the same kind of substitution effects that we discussed in detail above—switching from family visits to friend visits—but due to the simultaneous effects, the result is not a switch to the benign activity but to another harmful activity.

As a result, not only is the policy possibly ineffective, but also harmful—it has other side effects: by restricting family visits, the elderly may suffer psychological hardship due to social isolation without a clear reduction in infections. Of course, this does protect the elderly because those infected would be friends and not family members. However, this may prolong the time needed to fight the pandemic, thereby increasing the suffering of everyone.

It should be noted that the relationship between social norms and COVID-19 strategies is a special case of a more general discussion on whether social norms and sanctions are substitutes or complements.[99] In the example we considered, the social norm of visiting one's family is a substitute for any policy that tries to reduce COVID-19 infections, but one might also think of a more explicit substitute for COVID-19 mitigation policies, such as an informal rule of social distancing. Additionally, the degree to which such an informal rule influences behavior may also be heterogeneous and may (or may not) be correlated with the social norm of visiting the parents. For example, countries that emphasize family life may also have a strong tendency of physical vicinity to others as a social norm, making social-distancing measures in light of COVID-19 even more necessary.

Another example can be found in the distinction between "loose" and "tight" societies:[100] loose societies are informal, individualistic, and expressive, whereas tight

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1,000 meters from the place of residence, given that the departure is not in order to stay at another person's home"); *see also* Levush, *supra* note 6 (English overview of the regulations). This regulation is formally temporary but has been extended repeatedly (as of December 2021, it is still in force).

[99] *See generally* Yoshinobu Zasu, *Sanctions by Social Norms and the Law: Substitutes or Complements?*, 36 J. Legal Stud. 379, 379 (2007).

[100] This distinction is typically made by anthropologists. *See* Pertii J. Pelto, *The Differences Between "Tight" and "Loose" Societies*, 5 Trans-action 37, 37 (1968).

societies are formal, orderly,[101] and characterized by "strong norms and low tolerance for deviant behavior."[102] This distinction may help predict the strength of the interaction effects, but interacting societal values may yield countervailing results. For instance, tight countries in which the social norm (*e.g.*, visiting the elderly) is strong will demonstrate a stronger interaction effect but may also tend towards strong compliance to formal rules, such as those imposed by COVID-19 mitigation strategies. Recent empirical evidence from late 2020 suggests that tight countries outperformed loose countries in mitigating COVID-19,[103] an effect attributed by the researchers to the superior ability to enforce rules.[104] At the same time, some argue that the pandemic itself may "tighten" some countries,[105] which would then lead to further heterogeneity. To make things more complicated, some have pointed out an interaction between the degree of looseness and the degree of centralization, suggesting that a "one-size-fits-all" strategy for combating COVID-19 is doomed to fail.[106] Thus, a full consideration requires observing not only which social norms are in play, but also whether these norms interact with other factors.

B.   TAKING INTO ACCOUNT ENVIRONMENTAL FACTORS: THE WEATHER

Next, we consider an environmental factor that policymakers need to take into account in introducing effective COVID-19 mitigation strategies: the weather. Evidence on the connection between COVID-19 and climate conditions is generally mixed[107] and seems to have received insufficient attention in the early days of the pandemic. While the weather may matter for several reasons, we focus here on how it may affect the level and type of social interactions in which people would like to engage.

People typically draw a higher benefit from staying at home in times of bad weather (*e.g.*, in winter) as compared to times of good weather (*e.g.*, in summer). In other words, staying at home is relatively more attractive in times of bad weather because the opportunity cost associated with leaving one's home is high, whereas staying at home in times of good weather is relatively less attractive because the opportunity cost associated with leaving one's home is low.[108] Similar to the underlying reasoning of complements, one may conceptualize staying at home as complementary to bad weather and leaving one's home as complementary to good weather. Policymakers should anticipate this line of thought when introducing COVID-19 mitigation strategies to render the strategy more cost-efficient. If we consider the numerical example below in Table 7, it becomes evident that, given the higher benefit derived from staying home in winter, one can achieve the same level of deterrence in winter by introducing a lower fine.

While this example applies to countries with varying seasons (*i.e.*, in moderate climate zones), the same reasoning holds in a one-sided way for countries where the

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[101]*Id.*

[102]Michele J. Gelfand et al., *Differences Between Tight and Loose Cultures: A 33-nation Study*, 332 SCIENCE 1100, 1100 (2011).

[103]Michele J. Gelfand et al., *The Relationship between Cultural Tightness–looseness and COVID-19 Cases and Deaths: A Global Analysis*, 5 LANCET PLANETARY HEALTH e135, e142 (2021).

[104]*Id.*

[105]Jay J. van Bavel et al., *Using Social and Behavioural Science to Support COVID-19 Pandemic Response*, 4 NATURE HUM. BEHAV. 460, 463 (2020).

[106]Bo Yan et al., *Why do Countries Respond Differently to COVID-19? A Comparative Study of Sweden, China, France, and Japan*, 50 AM. REV. PUB. ADMIN. 762, 762 (2020).

[107]*See generally* Dimitrios Paraskevis et al., *A Review of the Impact of Weather and Climate Variables to COVID-19: In the Absence of Public Health Measures High Temperatures Cannot Probably Mitigate Outbreaks*, SCI. TOTAL ENV'T, Dec. 2020, at 1-2.

[108]*See, e.g.*, Borgonovi & Andrieu, *supra* note 85, at 2 ("when weather conditions are poor, leaving home becomes less enjoyable and thus the opportunity cost of staying home decreases").

Table 7. Illustration of Choices in Summer vs. Winter

	Staying at Home	Visiting a friend
Summer (good weather)		
Without intervention	2	**4**
With intervention (fine=3)	**2**	1
Winter (bad weather)		
Without intervention	3	**4**
With intervention (fine=2)	**3**	2

Note: This table presents an illustration of payoffs with and without legal intervention (a monetary fine), in summer vs. winter time. The individual chooses the column yielding the highest utility in the row that applies (depending on the weather and presence of intervention). The utility-maximizing option in each row is marked using bold text.

changes between seasons are less pronounced. For instance, the fines in countries located around the equator may have to be higher throughout the year due to consistently better weather conditions (and vice versa for countries in the high north or south). However, even in these one-sided cases, people in countries with similar weather conditions throughout the year might display higher levels of sensitivity to small changes in the weather.

Weather may also have other effects that influence the rate of COVID-19 infections independent of compliance with restrictions. For example, one study found a positive correlation between the average temperature and the rate of infections in Jakarta, Indonesia,[109] whereas another study found a negative correlation in Turkey.[110] Note that a negative correlation would reinforce the example (the private benefit from going outside increases in summer and the cost of going outside decreases due to more infections), whereas a positive correlation is a countervailing effect (*i.e.,* the private benefit from going out in summer is higher and the social cost is then higher as well due to more infections). Moreover, the relevance of the weather may also differ across population segments due to differences in living arrangements. For instance, the inability to go outside should matter more for those who reside in buildings without a garden than for those who live in rural areas.[111]

One could also speculate that bad weather may sometimes drive people to meet others indoors whereas good weather may yield meetings outdoors (which is beneficial, as COVID-19 tends to spread more indoors).[112] But, outdoor meetings may possibly occur with a larger group of people because being outside entails less space constraints. Hence, the exact interaction effect depends on the circumstances, but is, in any case, relevant.[113]

C.   TIMING OF COVID-19 MITIGATION STRATEGIES: BACK-TO-BACK LOCKDOWNS

As a final example, one might consider whether the value of the payoffs for (non)compliance with mitigation policies changes as a result of (non)compliance over time. Consider the case of back-to-back lockdowns; some governments declared a

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[109]Ramadhan Tosepu et al., *Correlation between Weather and Covid-19 Pandemic in Jakarta, Indonesia,* Sci. Total Env't (2020) 1, 2.

[110]Mehmet şahin, *Impact of Weather on COVID-19 Pandemic in Turkey,* Sci. Total Env't (2020) 1, 5.

[111]Note that the type of population who lives in buildings without a garden may be the poorer population in some regions (as the poor cannot afford to live in a house with a garden) but the richer population in other regions (whenever the rich prefer living in luxury towers).

[112]*See, e.g.,* Turki M. Habeebullah et al., *Impact of Outdoor and Indoor Meteorological Conditions on the COVID-19 Transmission in the Western Region of Saudi Arabia,* 288 J. Env't Mgmt (2021) 1, 1.

[113]Note that the tendency of COVID-19 to spread indoors may also depend on the weather. *Id.*

lockdown for a given period of time but then extended the lockdown further, with or without tightening the restrictions.[114] When this happens, the benefit from the activities prohibited during the lockdown may change over time. For instance, suppose that a lockdown restricts the ability to meet other people (family or friends), leading to a feeling of loneliness and isolation. This feeling can intensify over time if one remains isolated during a lockdown.[115] Hence, the longer one avoids meeting one's family—the higher the benefit of a family visit.[116]

In other words, a family visit today and a family visit tomorrow are *not* perfect substitutes, and hence the dilemma of whether to breach the lockdown for visits differs in back-to-back lockdowns. To illustrate, Figure 1 presents a decision tree capturing the choices and payoffs of an individual who needs to decide whether to stay at home (*i.e.*, comply with the lockdown) or visit family.[117] In the example we use, the individual gains "4" from visiting friends if he is not lonely. However, if the individual did not visit friends during the first lockdown, he becomes lonely so the benefit of visiting a friend during the second lockdown increases by some factor to "4x" (where $x > 1$). For simplicity, the probability of apprehension is the same in both lockdowns and represented by p. The penalty, however, can vary—so that f_1 and f_2 are the penalties for visiting in the first and second lockdown, respectively.

Let us assume the individual did visit a friend in time 1 (during the first lockdown), so he is not lonely. The benefit from visiting in time 2 is then still "4" and so the individual visits if (and only if) $4 > pf_2$.[118] This is the same calculation that the individual does in time 1—he visits if $4 > pf_1$. Therefore, if loneliness is not an issue, then policymakers could just set $f_1 = f_2 \geq \frac{4}{p}$, *i.e.*, keep the fine constant over time. However, what happens if we examine the scenario where the individual complied with the first lockdown and did not visit (and is therefore lonely)? Then, during the second lockdown, the individual visits if $4x > pf_2$. This means that policymakers must increase the fine in time 2.

To see this, suppose that $p=0.5$ and the fine in both time 1 and time 2 is $f_1 = f_2 = 12$. Then, in time 1, there is no visit, as $4 < 0.5*12 = 6$. But to deter visits in time

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[114]For instance, Israel imposed three lockdowns. *See* TOI Staff, *Virus Czar: With COVID-19 Mutations, Third Lockdown may not be Israel's Last,* Times Isr. (Jan. 25, 2021, 5:20PM), https://www. timesofisrael.com/virus-czar-with-covid-19-mutations-third-lockdown-may-not-be-israels-last/ [https://perma. cc/Q7JU-3EJP]; Jason Gewirtz, *Israel to Enter Third National Lockdown Despite Successful Covid Vaccination Campaign,* CNBC (Jan. 5, 2021, 3:46PM), https://www.cnbc.com/2021/01/05/israel-to-enter-third-national-lockdown-despite-successful-covid-vaccination-campaign.html [https://perma.cc/H2YW-8LNC]; *see also* Teichman & Zamir, *supra* note 6, at 4. Germany declared a lockdown in November 2020 and extended it several times. *See* McKeever, *supra* note 4; Reuters Staff, *supra* note 4; Murphy, *supra* note 4.
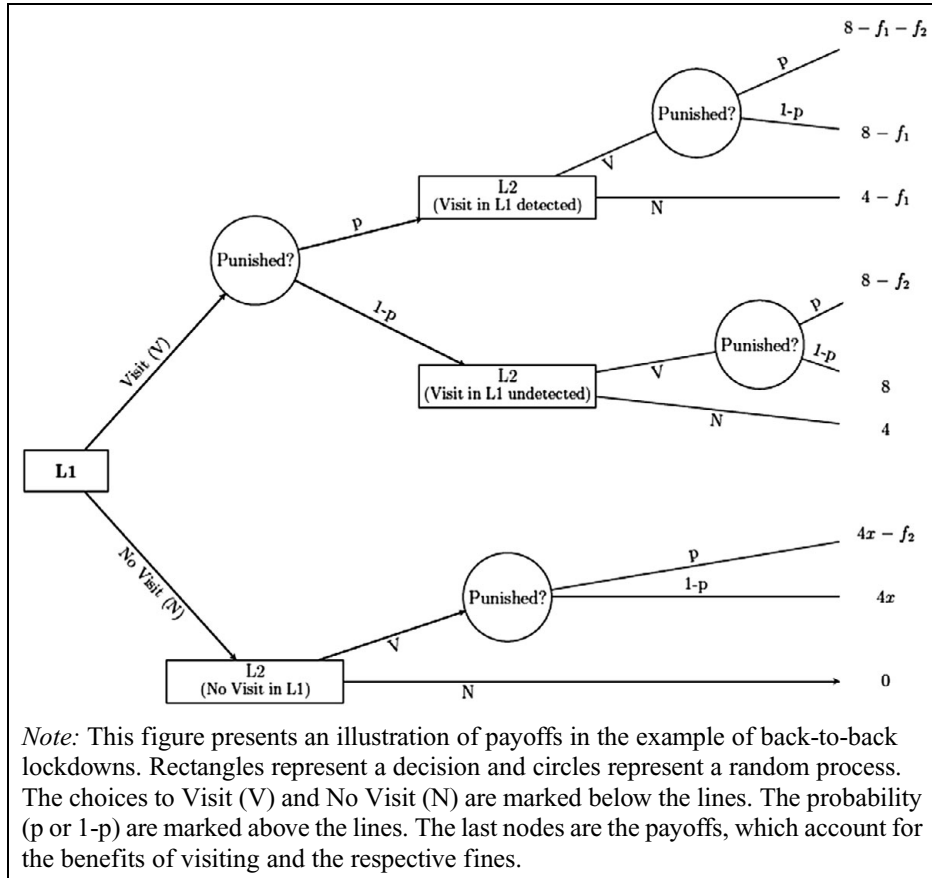
[115]The empirical evidence on whether lockdowns lead to more loneliness is, however, mixed. Some studies find that loneliness is unaffected by the lockdown, whereas others do find an effect—as well as a negative impact of the lockdown on mental health. *See, e.g.*, Martina Luchetti et al, *The Trajectory of Loneliness in Response to COVID-19*, 75 Am. Psychol. 897, 897 (2020); *see generally* Maria Elizabeth Loades et al*, Rapid Systematic Review: The Impact of Social Isolation and Loneliness on the Mental Health of Children and Adolescents in the Context of COVID-19*, 59 J. Am. Acad. Child & Adolescent Psychiatry 1218, 1218 (2020).

[116]For simplicity, we neglect here the possibly countervailing behavioral effect known as "moral identity," where compliance strengthens one's self-esteem and belief that one is "the good guy," making it more likely to comply again in the future. *See generally* Ernesto Dal Bó & Marko Terviö, *Self-esteem, Moral Capital, and Wrongdoing,* 11 J. Eur. Econ. Ass'n 599, 599 (2013).

[117]In game-theory, dynamic games (with more than one time period) are solved using "backward induction"—solving from end to start. *See, e.g.*, Jack Knight & Lee Epstein, *On the Struggle for Judicial Supremacy,* 30 L. & Soc. Rev. 87, 107 (1996). However, in our simple example, there is no need for complex calculations, as the punishments for violations in the second lockdown have no effect on the decision in the first lockdown.

[118]This is simply an implementation of the formula $b > pf$ that was mentioned in Part II.B. *supra.*

Figure 1 Illustration of Back-to-Back Lockdowns

Note: This figure presents an illustration of payoffs in the example of back-to-back lockdowns. Rectangles represent a decision and circles represent a random process. The choices to Visit (V) and No Visit (N) are marked below the lines. The probability (p or 1-p) are marked above the lines. The last nodes are the payoffs, which account for the benefits of visiting and the respective fines.

2, it is required that $4x < 6$, *i.e.*, this only works if $x < 1.5$. Thus, if loneliness is strong enough ($x > 1.5$) the same policy that worked during the first lockdown will not work in the second lockdown.

       Note that the calculation in our example was simple because there was no effect on the choice in time 2 of being punished in time 1. That is, the choice of whether to visit in time 1 is basically independent of the choice in time 2. If we were to complicate the analysis by introducing different fines for repeat offenders (*e.g.*, by having a different f_2 depending on whether the individual was caught and penalized in time 1), we would get even more intricate results. An increased fine would decrease the payoff from a repeat offense in time 2, and the anticipation of the fine in time 2 could also affect visits in time 1. This result mirrors the debate in law and economics on whether escalating fines are needed for repeat offenders.[119] In an even more complicated setting, individuals could also have

[119] *See generally* David A. Dana, *Rethinking the Puzzle of Escalating Penalties for Repeat Offenders,* 110 Yale L.J. 733, 733 (2001); Winand Emons, *Escalating Penalties for Repeat Offenders,* 27 Int'l Rev. L. & Econ. 170, 170 (2007); Thomas J. Miceli, *Escalating Penalties for Repeat Offenders: Why are they so Hard to Explain?*, 169 J. Inst. & Theoretical Econ. 587 (2013); Shmuel Leshem & Avraham D. Tabbach, *The Option*

heterogeneous benefits from committing a crime, so the policymakers' choices depend on the distribution of benefits.

Accounting for these different complications is beyond the scope of this Article, but the bottom line is that COVID-19 mitigation strategies raise, in essence, a similar question as other types of legal sanctions—and are therefore subject to a large variety of interaction effects. Still, our example illustrates that even in a fairly simple setting, policymakers should not only carefully assess the sequencing of COVID-19 mitigation strategies but also consider how to set the sanctions associated with prolonged COVID-19 measures. In the next Part, we also consider some complications in the form of behavioral effects.

V. DISCUSSION

A. GENERAL

Our analysis shines a spotlight on what policymakers ought to do to best leverage substitution and complementarity effects in fighting COVID-19. Simply put, a general equilibrium approach prompts policymakers to target strategic complements and—insofar as possible—avoid policies that are strategic substitutes,[120] not only to slow down the progression of the virus, but also to deploy COVID-19 mitigation strategies in a cost-efficient manner.

With respect to strategic complements, the foregoing remarks show that a ban on alcohol, for example—without directly targeting the progress of the virus *per se*—naturally reduces a person's incentive to participate in social gatherings, which in turn greatly contributes to slowing down the spread of COVID-19. Policymakers should also be aware that, while complements may be found in all spheres of everyday life, they may well vary from one country to another. That is, policymakers should also take into account environmental factors such as social norms and climate conditions. Bad weather, for example, naturally raises the cost associated with visiting a friend, which means that policymakers may reduce enforcement efforts in connection with social-distancing measures without jeopardizing the effectiveness of the measure. Social norms such as weekly visits of one's parents also serve as a strong natural incentive to comply with social-distancing measures and should not be lowered through restrictions of freedom of movement. That is to say, preventing a person from paying weekly visits to their family forces policymakers to bear additional enforcement costs in light of the person's higher incentive not to comply with social-distancing measures within the permitted perimeter.

In contrast, adopting COVID-19 mitigation strategies that are strategic substitutes compromises the efforts to slow down the progression of the virus and are wasteful in terms of resources (as the policies undermine one another). As the foregoing examples show, a person may be inclined to spend more time with their colleagues at the office (such as by working overtime) rather than staying at home. Similarly, in the case of back-to-back lockdowns, as visiting one's family and friends either today or tomorrow are not perfect substitutes, a person might prefer to violate the rule of staying home during the first lockdown in anticipation of the second, subsequent lockdown. Alternatively, that person

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Value of Record-Based Sanctions (Jan. 27, 2020) (unpublished manuscript), https://ssrn.com/abstract=3514094 [https://perma.cc/8E39-RDL4].
[120]For other examples of how general equilibrium effects relate to complements and substitutes in public policymaking, *see generally* Dirk Krueger & Alexander Ludwig, *On the Optimal Provision of Social Insurance: Progressive Taxation versus Education Subsidies in General Equilibrium*, 77 J. Monetary Econ. 72 (2016); Don Fullerton & Garth Heutel, *The General Equilibrium Incidence of Environmental Taxes,* 91 J. Pub. Econ. 571 (2007).

may also become more likely to violate the rule during the second lockdown in light of the higher benefit from visiting one's family due to, for example, acute feelings of loneliness. When considering the extension of a lockdown, policymakers should therefore be aware that enforcement costs are likely to increase.

B.   A BRIEF DISCUSSION OF BEHAVIORAL LAW AND ECONOMICS

Our analysis has thus far implicitly assumed that people are rational in the sense that they maximize their utility based on an optimally gathered amount of information.[121] By looking at how people "really" behave (*e.g.*, by using experimental research methods), behavioral law and economics[122] challenge the assumptions underlying traditional law and economics—relaxing the aforementioned assumption of *homo oeconomicus*.[123]

Instead, behavioralists assume that people may systematically diverge from rational decision-making by, for example, following heuristics (instead of conducting a full-fledged cost-benefit analysis) or falling prey to various cognitive biases.[124] Several existing papers have already identified the potential effects of these divergences on compliance with COVID-19 mitigation policies.[125] Fully considering these effects is beyond the scope of this Article, but it is nonetheless interesting to briefly consider how these effects relate to what one might expect in a general equilibrium.

A first, rather obvious, insight is that if people miscalculate the benefits or the costs of their choices, some behaviors may stop serving as a substitute (complement) due to that miscalculation. A second, more interesting insight concerns the behavioral tool known as "nudges."[126] Nudges are an intervention that create a choice architecture that change people's behavior in a "predictable way without forbidding any options or significantly changing their economic incentives."[127] For instance, in the context of COVID-19, one mitigation strategy is placing markings on the floor to help people comply with social-distancing measures in a crowded area.[128] These markings do not reveal any new information or affect the payoffs but serve as a reminder that makes the rule more salient. A recent example is the use of nudges to encourage COVID-19 vaccinations; experimental evidence suggests that sending simple text messages reminding people of their vaccination appointment increases the rate of vaccinations[129]—particularly when the message makes recipients feel like the owner of a specific vaccine dose.[130]

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[121] GARY S. BECKER, THE ECONOMIC APPROACH TO HUMAN BEHAVIOR 111 (1976).

[122] For a discussion of behavioral law and economics in the context of COVID-19, s*ee generally* Teichman & Underhill, *supra* note 33. For a general overview of behavioral law and economics, *see*, *e.g.*, DORON TEICHMAN & EYAL ZAMIR, BEHAVIORAL LAW AND ECONOMICS 19 (2018).

[123] *See*, *e.g.*, Sabine Frerichs*, False Promises? A Sociological Critique of the Behavioural Turn in Law and Economics*, 34 J. CONSUMER POL'Y 289, 289 (2011) ("with the behavioural turn in law and economics, homo oeconomicus seems to be transformed into Homer Economicus, and consumer law prone to be Simpsonized.").

[124] *See* Teichman & Underhill, *supra* note 33, at 212; *see generally* Amos Tversky & Daniel Kahneman, *Judgment under Uncertainty: Heuristics and Biases,* 185 SCIENCE 1124 (1974).

[125] For example, it has been argued that individuals might miscalculate the probabilities of being infected (or of infecting), which might translate into misguided choices. *See* Zamir & Teichman*, supra* note 6, at 7; *see also* Teichman & Underhill, *supra* note 33, at 212-13 (mentioning examples such as omission bias).

[126] *See* RICHARD H. THALER & CASS R. SUNSTEIN, NUDGE: IMPROVING DECISIONS ABOUT HEALTH, WEALTH, AND HAPPINESS (rev. ed. 2009); Cass R. Sunstein, *Nudges.Gov: Behaviorally Informed Regulation*, in THE OXFORD HANDBOOK OF BEHAVIORAL ECONOMICS AND THE LAW (Eyal Zamir & Doron Teichman eds., 2014).

[127] *See*, *e.g.*, Catherine Doherty & Karen Dooley, *Responsibilising Parents: The Nudge Towards Shadow Tutoring,* 39 BRIT. J. SOC. EDUC. 551, 556-7 (2017); THALER & SUNSTEIN*, supra* note 126 at 6.

[128] *See* Teichman & Underhill, *supra* note 33, at 244.

[129] Hengchen Dai et al., *Behavioural Nudges Increase COVID-19 Vaccinations*, 597 NATURE 404, 404 (2021).

[130] *Id.*

The interesting question for this Article is then how such nudges affect the general equilibrium. A recent study argues that nudges serve as either substitutes or complements to COVID-19 mitigation strategies;[131] whenever mandates are impractical (*e.g.*, due to constitutional or political constraints), nudges can be adopted as a substitute.[132] Respectively, nudges may become complements when mandates are ineffective[133] (*e.g.*, by inducing compliance with the (mandated) rule where enforcement would otherwise be difficult).[134]

Notably, the relationship between mandates and nudges seem independent of the target behavior. That is, two policies that are strategic substitutes (or complements), as we defined them above, may each take the form of either a mandate or a nudge. Thus, the added value of nudges is interesting only insofar as they open new channels to restrict substitution effects among *behaviors.*

One area where nudges may be relevant is in the avoidance of undesirable substitution effects (*e.g.*, people visiting friends at the office instead of their residence). The mandates which we considered above simply change the payoffs of different choices without any side effects that push people specifically toward the benign activity. However, several studies have shown that nudges could be leveraged to emphasize the moral aspect of decisions by highlighting what would be "the right thing to do."[135] For example, placing a message at workplaces that highlights the importance of staying at home may drive people toward the benign choice. Another advantage of this nudge, compared to a mandate, is its relatively lower cost (as posting signs is much cheaper than, *e.g.*, deploying police officers).[136] However, nudges might not only interact with explicit prohibitions but also with each other—or with other country-specific factors[137]—which renders the analysis far more complex, if not overly cumbersome.

An additional layer of complexity arises when one considers the time-dimension, such as in the example of back-to-back lockdowns analyzed above. As part of the behavioral movement, several studies argue that intertemporal preferences (*i.e.*, how people evaluate the costs and the benefits arriving at different points in time)[138] are more complex than what standard economic theory would predict. In particular, a phenomenon known as "hyperbolic discounting"[139] supposes that people heavily and disproportionately discount future payoffs.[140] Relating to the lockdowns example, this may

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[131]Teichman & Underhill, *supra* note 33, at 234.

[132]*Id.*

[133]*Id.* at 235.

[134]*Id.* at 236 (proposing the example of hand washing, where a mandate would be difficult to enforce (as monitoring would be very costly) but nudges can be used to facilitate compliance). While such nudges may be effective even without a mandate, some forms of nudging do require a mandate in the background (e.g., when the nudges is to remind people of their obligation) and hence can be properly classified as a complement.). *Id.*

[135]*See generally* Valerio Capraro et al., *Increasing Altruistic and Cooperative Behaviour with Simple Moral Nudges,* 9 Sci. Rep. 1, 7 (2019).

[136]*See, e.g.*, Nissim Cohen & Hadar Yoana Jabotinsky, *Nudge Regulation and Innovation Policy*, at 14 (Mar. 5, 2020) (unpublished manuscript), https://ssrn.com/abstract=3523910 [https://perma.cc/NKB5-B8MV].

[137]For instance, it has been argued that nudges during the COVID-19 pandemic worked well in Sweden because of the high degree of trust in the government, and that this is unlikely to carry over to areas with low trust. Jon Pierre, *Nudges Against Pandemics: Sweden's COVID-19 Containment Strategy in Perspective*, 39 Pol'y & Soc'y 478, 480 (2020).

[138]*See, e.g.,* Shane Frederick, George Loewenstein & Ted O'Donoghue, *Time Discounting and Time Preference: A Critical Review*, 40 J. Econ. Literature 351, 351 (2002).

[139]*See, e.g.*, David Laibson, *Golden Eggs and Hyperbolic Discounting*, 112 Q.J. Econ. 443, 445-446 (1997); Gal Zauberman et al., *Discounting Time and Time Discounting: Subjective Time Perception and Intertemporal Preferences*, 46 J. Mktg. Rsch. 543, 544 (2009).

[140]For discussions of hyperbolic discounting in deterrence models, which most closely resemble what we consider in our example, *see generally* Thomas A. Loughran, Ray Paternoster & Douglas Weiss, *Hyperbolic Time Discounting, Offender Time Preferences and Deterrence,* 28 J. Quantitative Criminology 607, 613-14 (2012).

mean that either the penalty or the degree of loneliness may be heavily discounted, thereby completely changing the calculation. Hyperbolic discounting is also closely related to the issue of self-control.[141] Namely, as loneliness accumulates, people may find it increasingly difficult to control themselves,[142] thus opting to visit a family member in contrast to the predictions of standard models. A similar outcome can result due to yet another effect—like "behavioral fatigue" or, more broadly, "ego-depletion."[143] In the context at hand, behavioral fatigue causes people to become less sensitive to new mitigation policies, given they feel depleted from complying with earlier policies. While the effect of behavioral fatigue is controversial, even in the context of COVID-19,[144] it can affect how policies interact with one another. For example, two substitutes that are deployed at different times may have weaker spillovers because the later policy is met with fatigue.

Such arguments can, of course, be applied to many other behavioral effects.[145] For instance, the phenomenon of "loss aversion"[146] can affect people's incentives to comply with the law during COVID-19[147] differently depending on which action is perceived as a "loss" and which one as a "gain." For instance, one might perceive the family visit as a recovery from a loss (rather than as a gain) and therefore be more likely to visit even when there is a risk of being punished[148] because losses are perceived to be worse than equally-sized gains.[149] However, what is perceived as a loss might change over time if a

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[141]ZAMIR & TEICHMAN, *supra* note 122, at 89.

[142]*See, e.g.* Jiayu Li et al., *Loneliness and Problematic Mobile Phone use Among Adolescents During the COVID-19 Pandemic: The Roles of Escape Motivation and Self-control,* 118 ADDICTIVE BEHAV. 106857 (2021) (providing evidence on low self-control among teenagers during COVID-19).

[143]*See* Malte Friese et al., *Is Ego Depletion Real? An Analysis of Arguments*, 23 PERS. & SOC. PSYCHOL. REV. 107, 107-31 (2019); Nigel Harvey, *Behavioral Fatigue: Real Phenomenon, Naïve Construct, or Policy Contrivance?*, 11 FRONTIERS IN PSYCHOL. 1, 4 (2020) (discussing behavioral fatigue as a possible consequence of ego-depletion); Mogens Jin Pedersen & Nathan Favero, *Social Distancing during the COVID-19 Pandemic: Who Are the Present and Future Noncompliers?*, 80 PUB. ADMIN. REV. 805, 806 (2020) ("much research supports the concept of "behavioral fatigue" for pandemic prevention measures"); Ritwik Banerjee et al*., Exponential-Growth Prediction Bias and Compliance with Safety Measures Related to COVID-19,* SOC. SCI. & MED., Oct. 2020, at 8. ("Do we see evidence of such behavioral fatigue? While we do not have a direct measure of behavioral fatigue, we have a proxy relating to awareness: information bias…"); *see, e.g.*, Richard Thaler, *Some Empirical Evidence on Dynamic Inconsistency*, 8 ECON. LETT. 201, 205 (1981). *But see* Derek Ireland*, The Behavioral Ethics Challenges of Covid-19 Crisis to Recovery,* 3 J. MKTG MGMT. & CONSUMER BEHAV. 1, 32-33; 32 n.49 (2021) (discussing the scholarly controversy surrounding behavioral fatigue in the UK during the early days of the pandemic).

[144]*See supra* note 143.

[145]For a discussion of behavioral biases and heuristics in the context of the COVID-19 pandemic, *see generally* Teichman & Underhill*, supra* note 33.

[146]*See generally* Cass R. Sunstein, *Behavioral Analysis of Law,* 64 U. CHI. L. REV. 1175, 1179-81 (1997).

[147]*See generally* Sarel, *supra* note 58, at §4.2.

[148]A higher willingness to take risks to avoid losses is consistent with the common theory in behavioral economics, known as "prospect theory." *See generally* Daniel Kahneman & Amos Tversky, *Prospect Theory: An Analysis of Decision Under Risk,* 47 ECONOMETRICA 263 (1979); Amos Tversky, & Daniel Kahneman, *Advances in Prospect Theory: Cumulative Representation of Uncertainty,* 5 J. RISK & UNCERTAINTY 297 (1992). For an overview of how the theory has been applied in economics, *see* Nicholas C. Barberis, *Thirty Years of Prospect Theory in Economics: A Review and Assessment,* 27 J. ECON. PERSP. 173 (2013)). For an application of the theory in the context of COVID-19, *see* Sarel, *supra* note 58. For the impact of loss aversion in a crime-deterrence model, *see* Eberhard Feess & Roee Sarel, *Optimal Fine Reductions for Self-Reporting: The Impact of Loss Aversion,* INT'L REV. L. & ECON. (forthcoming).

[149]Recent estimations (based on a meta-analysis) suggest that people that gains must be 1.8 to 2.1 times larger in order to be perceived as equal to a loss. Alexander L. Brown et al., *Meta-analysis of Empirical Estimates of Loss-aversion* 1 (CESifo Working Papers, Paper No. 8848, 2021).

pandic persists and people get used to a "new normal."[150] Moreover, loss aversion can affect discounting,[151] adding further complications.

While such complications certainly introduce complex challenges to policy-makers, their potential presence only supports our main claim: narrow attempts to focus on individual policies are unlikely to be sufficient, and policies relying on such analyses are doomed to fail. However, whether or not behavioral effects are meaningful depends on the magnitude of these effects. If effects are negligible, one can simply neglect them and treat them as random errors[152] (but still focus on regular substitution and complementarity effects). Insofar that effects are consistent—they are also predictable.[153] Thus, one would simply add these to the analysis, but the applicable logic of searching for a general equilibrium would not change.

C.   FINAL NOTES

Our analysis mainly builds on traditional deterrence theory—that is, cost-benefit analysis in light of expected sanctions. Some recent studies seem to cast doubts as to whether deterrence plays a central role in compliance with COVID-19 mitigation strategies with some studies finding a weak role for deterrence[154] and others suggesting that deterrence cannot work as the sole lever of influence.[155] Nonetheless, there are at least two reasons why our analyses should be robust. First, some of the studies rely on survey evidence,[156] which can be less appropriate for estimating actual deterrence. In particular, scholars of law and economics are skeptical toward measurements that do not constitute "revealed preferences" (*i.e.*, people's actual behavior); hypothetical answers in a survey may thus be less reliable than observed behavior.[157] This is particularly relevant when measuring compliance because people may be reluctant to be truthful by saying they will break the law. Second, and more importantly, these studies are precisely those whose research question is based on a partial equilibrium—as opposed to general equilibrium—analysis, which does not account for whether deterrence translates into more or less infections.

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[150]*See* Sarel, *supra* note 58.

[151]*See, e.g.*, Thaler, *supra* note 143.

[152]Richard H. Thaler, *From Cashews to Nudges: The Evolution of Behavioral Economics,* 108 Am. Econ. Rev. 1265, 1267 (2018).

[153]*Id.*

[154]*See* van Rooij et al., *supra* note 17; Kuiper et al*., supra* note 14; Emmeke Barbara Kooistra et al., *Mitigating Covid-19 in a Nationally Representative UK Sample: Personal Abilities and Obligation to Obey the Law Shape Compliance with Mitigation Measures* 25 (Amsterdam L. Sch. Legal Studies Research. Paper No. 2020-19, 2020).

[155]George W. Burruss et al., *Modeling Individual Defiance of COVID-19 Pandemic Mitigation Strategies: Insights from the Expanded Model of Deterrence and Protection Motivation Theory*, 53 Crim. Just. & Behav. 1317, 1320 (2021).

[156]van Rooij et al, *supra* note 17, at 1 ("The present study assesses what factors influence Americans to comply with the stay at home and social distancing measures. It analyzes data from an online survey…"); Kuiper et al, *supra* note 14, at 1 ("We analyzed data from an online survey.."); Kooistra et al, *supra* note 155, at 1 ("The present study assesses what factors influenced inhabitants of the United Kingdom to comply with lockdown and social distancing measures. It analyses data from an online survey..").

[157]*See, e.g.*, Ananish Chaudhuri*, Is the Price Right?: Fair Play and Economics,* 19 U. Auckland Bus. Rev. 16, 24 (2016) ("One problem with survey evidence is that people's survey responses and their real-life actions do not always match up."). Partly for this reason, the field of "experimental criminal law" has emerged in recent years, emphasizing the validity of the results when people's choices are actually measured. *See generally* Christoph Engel, *Experimental Criminal Law: A Survey of Contributions from Law, Economics, and Criminology, in* Empirical Legal Research in Action 57-108 (Willem H. van Boom et al. eds., 2018).

A final thought experiment might provide further insight. Consider what happens if humanity were to adopt a full global lockdown. That is, shut down the entire world for a period of, say, four weeks. Such an idea may be politically infeasible, but one can make the logical argument that if everything was to shut down at once, then all substitutes would disappear and everyone would switch to benign behaviors like staying at home. Some existing models have tried to analyze such an option, yielding mixed conclusions; one study found that local lockdowns would outperform a global lockdown,[158] whereas another found precisely the opposite.[159] Our analysis can provide some insight into why this question is difficult to answer: a complete shutdown not only entails substitution effects, but also complementarity effects. Hence, when a lockdown restricts a complement of a desirable behavior (as in the example of social norms, where discouraging family visits decreases the incentive to take precaution), the result may be an overall negative—depending on which of the effects of the lockdown dominate. This too requires diving into the details and potential heterogeneity across countries. Thus, analyses must be more robust to provide more accurate calculations.

VI.   CONCLUSION

As COVID-19 continues to wreak havoc around the globe, designing mitigation strategies that work is more important than ever. However, this is easier said than done. Any attempt to deter socially harmful behavior inevitably sets off a chain of events that entails potential substitution and complementarity effects. While some effects may be difficult to predict, an abstract analysis that ignores complications by focusing solely on partial effects is bound to fail. In other words, when designing mitigation strategies, as the saying goes: *the devil is in the details*. Interaction effects are thus one of many important details policymakers ought to consider. Using various examples, we illustrated why some policies may be ineffective (or even counterproductive) because they shift behavior to other harmful behaviors (substitution effects) while others can "kill two birds with one stone"—discouraging one bad behavior and indirectly reducing another related behavior (complementarity effects). The examples further demonstrate that the strategies need to account for the heterogeneity of factors, such as social norms, the weather, and the timing of lockdowns.

From a practical perspective, one may ask whether policymakers can truly know which interaction effects are relevant. In other words, how should one estimate the size of the interaction effects? Answering this question requires empirical data. Yet, accurate empirical data is seldom available because governments are often reluctant to conduct public policy experiments. One could imagine that the best way to figure out whether a lockdown works in a certain country would be to implement some kind of a field experiment, where area A is under lockdown whereas area B continues as normal. This would, of course, be imperfect if people could substitute activity in area A for activity in area B (resulting in the same substitution effects we detail in this Article), but the main problem is a political one: people in area A would be outraged that they are serving as "Guinea pigs" in a discriminatory way. However, one could make the argument that this is again the same "public-goods problem"[160] that COVID-19 mitigation strategies aim to overcome in the first place—that is, the refusal to participate because people do not

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[158] *See generally* Vadim A. Karatayev et al*., Local Lockdowns Outperform Global Lockdown on the Far Side of the COVID-19 Epidemic Curve,* 117 Proc. Nat'l Acad. Sci. 24575 (2020).

[159] *See generally* Bhupendra Kumar Verma et al, *Global Lockdown: An Effective Safeguard in Responding to the Threat of COVID-19,* 26 J. Evaluation Clinical Prac. 1592 (2020).

[160] *See* Cooter & Ulen, *supra* note 24, at 40-41, 102-03.

internalize the benefit to society, even though clearer results may spare others' suffering (by developing more effective lockdowns).

As the pandemic progressed, some scholars did engage in more elaborate research designs by contrasting sets of policies in specific areas[161] or contexts.[162] Moreover, some scholars designed ad-hoc field experiments, mostly to test whether COVID-19 is more or less transmissible under different hygiene conditions.[163] Furthermore, in some cases, variation in policies across different jurisdictions might meet the requirements of a "natural experiment," so that causal inferences are feasible.[164] In any case, in the face of scarce experimental data, policymakers would still be better off expanding the analyses of individual policies into a broader perspective that considers what happens in a general equilibrium.

Another challenge from a policymaking perspective is the multitude of authorities that might be involved in setting the policies. For instance, responses such as travel bans might require coordination between transportation and health authorities, possibly with some overlap in responsibility. This may intuitively lead to either over-regulation, if authorities perceive the situation as an implicit competition, where each wants to be conspicuous in policymaking, or under-regulation, if authorities try to free ride on each other's efforts.[165] Whether the former or the latter occurs is, again, a question of whether policies under each authority are substitutes (in which case, there is an incentive to free ride, because the policy of one authority partially solves the same problem that its counterpart is trying to solve) or complements (where there is a stronger incentive to cooperate in order to achieve synergy). A special case of this problem can arise when nearby geographical areas serve as potential substitutes due to differences in regulation, leading some people to engage in the same activity that is prohibited in one place by traveling across the border to another area that does not prohibit the activity.[166]

A different challenge arises if regulators can determine which actions are substitutes. For instance, consider the rules governing so-called COVID-19 certificates ("green passes").[167] These certificates grant certain liberties (*e.g.*, access to public events) only to vaccinated individuals or unvaccinated individuals that meet narrow exceptions. The economic logic of such certificates seems to be two-fold: (i) they incentivize people to

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[161] *See* Adam J. Kucharski et al., *Effectiveness of Isolation, Testing, Contact Tracing, and Physical Distancing on Reducing Transmission of SARS-CoV-2 in Different Settings: A Mathematical Modelling Study,* 20 LANCET INFECTIOUS DISEASES 1151, 1154-56 (2020) (comparing combinations of policies in the UK).

[162] Ryan Seamus McGee et al., *Model-driven Mitigation Measures for Reopening Schools During the COVID-19 Pandemic*, 118 PROC. NAT'L ACAD. SCI. 1, 5 (Sept. 2021) (comparing proactive testing vs. vaccination of school teachers).

[163] *See, e.g.,* Stefan Moritz et al., *The Risk of Indoor Sports and Culture Events for the Transmission of COVID-19*, 12 NAT. COMMUN. 1, 2 (Aug. 2021).

[164] *See, e.g.,* Wei Lyu & George L. Wehby, *Community Use of Face Masks and COVID-19: Evidence from a Natural Experiment of State Mandates in the US: Study Examines Impact on COVID-19 Growth Rates Associated with State Government Mandates Requiring Face Mask Use in Public,* 39 HEALTH AFF. 1419, 1420-21 (2020) (treating variance in adoption of mask mandates across the US as a natural experiment).

[165] For a brief overview of the literature on competition between regulators, *see* Giovanni Dell'Ariccia & Robert Marquez, *Competition Among Regulators and Credit Market Integration,* 79 J. FIN. ECON. 401, 404-06 (2006).

[166] Note that this bears resemblance to both the crime-displacement problem as well as the well-known concept of 'regulatory arbitrage.' *See, e.g.*, Victor Fleischer, *Regulatory Arbitrage,* 89 TEX. L. REV. 227, 247 (2010).

[167] *See generally* Shelly Kamin-Friedman & Maya Peled Raz, *Lessons from Israel's COVID-19 Green Pass Program*, 10 ISRAEL J. HEALTH POL'Y RES. 1, 1 (2021); Luca Roncati & Monica Roncati, *COVID-19 "Green Pass": A Lesson on the Proportionality Principle from Galicia*, 1 EUR. J. HEALTH L. 525, 526 (2021); Ruth Waitzberg et al., *The Israeli Experience with the "Green Pass" Policy Highlights Issues to Be Considered by Policymakers in Other Countries,* 18 INT'L J. ENVTL. RES. & PUB. HEALTH 1, 2 (2021).

get vaccinated, as doing so yields more liberties, and (ii) they minimize the restriction of liberties of the vaccinated, who are generally at lower risk of transmitting the virus. Given the latter rationale, some governments subsequently exempted vaccinated people from the need to get tested,[168] thereby determining that tests and vaccines are substitutes from the individuals' perspective. When the relationship between actions (substitutes or complements) is endogenous (*i.e.*, under the regulator's control), governments face the additional complication of how to optimize the menu of actions available to individuals. A suboptimal menu can easily lead to the same problems discussed above. For instance, as vaccinated individuals are not entirely risk-free, tests and vaccines might be preferably set as complements rather than substitutes. It may be preferable to grant rights only to those who are both vaccinated *and* tested. Deciding whether this is indeed preferable requires a delicate balancing of costs and benefits (and indeed there is some debate on whether COVID-19 certificates are proportional)[169] but is a necessary part of accounting for interaction effects.

Finally, investing effort in locating the general equilibrium is only efficient if the costs of calculation are not too high compared to the benefit. That is, even if there are spillover effects of some policies due to interactions with other policies, they need to be of sufficiently large importance to justify the cost of investing resources to calculate the different payoffs.[170] In this context, one should also consider the difficulty of choosing the right measure, as the spread of COVID-19 can be estimated using many different variables (*e.g.*, number of cases, number of deaths, or number of hospitalized patients), which further raises estimation challenges.[171]

A social planner seeking to balance costs and benefits in terms of COVID-19 mitigation strategies must therefore construct a target function and engage in solving an optimization problem.[172] This is no simple task and one must account not only for the multitude of effects but also uncertainty, which requires some adjustments.[173] Moreover, even with reliable experimental data on which policies work, scaling up might be difficult.[174] While mitigation strategies may be less susceptible to funding constraints (which

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[168]For instance, Germany initially adoped a so-called "3G" rule, which grants equal liberties to the vaccinated (*"Geimpft"),* the recovered *("Genesen"),* and the tested *("Getestet"). See, e.g.,* Zachary Desson et al., *Finding the Way Forward: COVID-19 Vaccination Progress in Germany, Austria and Switzerland*, Health Pol'y & Tech. 1, 9 (2021). Later on, a "2G" policy (i.e. only vaccinated and recovered) was also made available. *See, e.g.,* Ned Stafford, *Covid-19: Germany's Doctors Call for Clear Rules to "Break Chains of Infection" as Cases Soar,* BMJ (Nov. 12, 2021), https://www.bmj.com/content/375/bmj.n2783.full [https://perma.cc/EB8F-RR8Y].

[169]For a discussion of the rationales behind COVID-19 certificates and whether such certificates are proportional, *see* Roncati & Roncati, *supra* note 24, at 525-32; Evelyn Paris, *Applying the Proportionality Principle to COVID-19 Certificates*, 12 Eur. J. Risk. Reg. 287, 289 (2021); Iris Goldner Lang, *EU COVID-19 Certificates: A Critical Analysis*, 12 Eur. J. Risk. Reg 298, 300 (2021).

[170]This is analogous, for instance, to the issue of whether courts should follow precedents or invest effort into investigating the specific valuations that people assign to assets in a legal case. Efficiency requires that courts search for information only if the search costs are not too high. *See* Cooter & Ulen, *supra* note 24, at 88.

[171]*See generally* Dionissi Aliprantis & Kristen Tauber, *Measuring Deaths from COVID-19,* 2020-18 Econ. Comment. 1 (2020); Thomas Beaney et al., *Excess Mortality: The Gold Standard in Measuring the Impact of COVID-19 Worldwide?,* 113 J. Royal Soc. Med. 329 (2020).

[172]*See generally* Charles F. Manski, V*accination Planning Under Uncertainty, with Application to Covid-19* (Nat'l Bureau of Econ. Research., Working Paper No. 28446, 2021).

[173]*Id.*, John Mullahy et al.*, Embracing Uncertainty: The Value of Partial Identification in Public Health and Clinical Research,* 61 Am. J. Preventive Med. e103 (2021).

[174]*See generally* Snigdha Gupta et al., *Failed to Scale: Embracing the Challenge of Scaling in Early Childhood*, *in* The Scale-Up Effect in Early Childhood and Public Policy 1 (John List et al. eds., 2021); Glenn W. Harrison, *Field Experiments and Public Policy: Festina Lente,* 5 Behav. Pub. Pol. 117 (2021). In the context of COVID-19 in particular, *see also* Rosanna W. Peeling et al., *Scaling up COVID-19 Rapid Antigen Tests: Promises and Challenges,* 21 Lancet Infectious Diseases e290 (2021).

are one typical inhibitor of scaling),[175] they are still often fragmented and based only on partial data[176] unless some form of effective global data-sharing cooperation emerges. Encouragingly, the COVID-19 pandemic has indeed spurred some initiatives for keeping track of infections and comparing policies.[177] Combining such initiatives with a general equilibrium approach may therefore be a positive step in the right direction. This combination need not restrict attention to standard preferences and can (or even should) combine behavioral aspects (*e.g.*, by adopting a stepwise model along the lines of so-called "Behavioral Interventions to Advance Self-Sufficiency" ("BIAS") model).[178] This model is a stepwise process: it begins with identifying where public policies perform suboptimally and proceeds by analyzing which behavioral explanations can potentially explain the policy's failure using feedbacks from stakeholders in the field. Thereafter, randomized control trials are used to contrast potential interventions, including nudges,[179] to develop an evidence-based solution. While behaviorally-informed policies (and nudges in particular) may also face scaling challenges,[180] we would view such an approach that focuses on a general equilibrium and accounts for behavioral effects as a success.

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[175]Gupta et al., *supra* note 174, at 5.

[176]Fragmentation and lack of universal data are also inhibitors of scaling. *See id.*

[177]*See, e.g.*, Liesbet M. Peeters et al., *COVID-19 in People with Multiple Sclerosis: A Global Data Sharing Initiative,* 26 MULTIPLE SCLEROSIS J. 1157 (2020); Sarah Engler et al., *Democracy in Times of the Pandemic Explaining the Variation of COVID-19 Policies Across European Democracies*, 44 WEST EUR. POL. 1077 (2021); Global Initiative On Sharing All Influenza Data, https://www.gisaid.org [https://perma.cc/2ZBP-NDRU] (last visited Dec. 27, 2021). For an overview, *see also* Anna Bernasconi et al*., A Review on Viral Data Sources and Search Systems for Perspective Mitigation of COVID-19,* 22 BRIEFINGS BIOINFORMATICS 664 (2021).

[178]John A. List et al., *Combining Behavioral Economics and Field Experiments to Reimagine Early Childhood Education,* 2 BEHAV. PUB. POL'Y 1, 14-15 (2018).

[179]*Id.* at 12-13.

[180]The evidence on scaling of nudges seems to be mixed. For instance, Stefano DellaVigna and Elizabeth Linos find that nudges adopted by two US "Nudge Units" yielded significant effects but smaller in size than those appearing in academic studies. *See* Stefano DellaVigna & Elizabeth Linos, *RCTs to Scale: Comprehensive Evidence from Two Nudge Units* (Nat'l Bureau of Econ. Research., Working Paper No. 27594, 2020). Conversely, Kelli A. Bird et al. find no effect of a large-scale nudge related to educational loans. Kelli A. Bird et al., *Nudging at Scale: Experimental Evidence from FAFSA Completion Campaigns,* 183 J. ECON. & BEHAV. ORG. 105, 113 (2021). Furthermore, Justin E. Holz et al find that tax-related nudges worked on some types of firms but not others. *See* Justin E. Holz et al., *The $100 Million Nudge: Increasing Tax Compliance of Businesses and the Self-employed Using a Natural Field Experiment* (Nat'l Bureau of Econ. Research, Working Paper No. 27666, 2020).