Worth the Shot?:

A Quantitative Study of Lottery and Fixed COVID-19 Vaccine Incentives in the Midwest

By

Ashley Wu

Submitted in partial fulfillment of the requirements for the degree of

BACHELOR OF ARTS IN PUBLIC POLICY

at THE UNIVERSITY OF CHICAGO

Preceptor: Rachel Dec

April 18, 2022

ABSTRACT:

When the US expanded COVID-19 vaccine eligibility to all adults, many state governments developed cash incentive programs to motivate individuals to get vaccinated. Using a differences-in-differences method, I examine the effects of Illinois' lottery incentive (low odds/high payout) and Wisconsin's fixed incentive (high odds/low payout) on county first-dose vaccination rates in 2021. I find that (1) neither incentive produced a significant improvement from baseline vaccination trends on average, (2) the impact of each varied systematically along the lines of a county's partisan majority, ruralness, unemployment rate, and median household income, and (3) the incentives' disaggregated impacts were statistically significant but small relative to unvaccinated population that had to be mobilized at the time for meaningful progress toward herd immunity. I suggest that policy solutions addressing COVID-19 vaccine hesitancy must directly engage the complex and differentiated barriers to vaccine access, and that financial incentives cannot reliably improve vaccine intention at scale.

Table of Contents

I. Introduction

In the summer of 2021, the US was grappling with the height of the COVID-19 pandemic, and the country found itself with more doses of the COVID-19 vaccine than there were willing takers. Earlier that year, the government and its suppliers had raced to expand access to the vaccines against a backdrop of soaring mortality rates, overwhelmed healthcare systems, and an economy that had been on hold for over a year. If attained, widespread immunization promised to mitigate the tolls of the pandemic by making infections less deadly and less transmissible, while protecting the vulnerable minority that is unable to receive the vaccine due to health conditions. By late April, all American adults had become eligible for the free vaccine and supplies were ample and secure, however signs of a premature slowdown in vaccine uptake began to show across all states. With 35% of the country still unvaccinated in June, the Kaiser Family Foundation COVID Vaccine Monitor found that only 3% of US adults intended to get the vaccine as soon as they could, a number that had seen accelerating decline from 30% when full eligibility first expanded nationwide (Hamel et al., 2021). Furthermore, deep disparities in vaccine uptake and intention had existed between states, such that vaccination rates were considerably lower in many states of the Deep South and Mountain West, where the proportion of the adult population with at least one dose of a COVID-19 vaccine was 50% or less in each state, and in some parishes even less than 20% (Gamio and Walker, 2021).

In a push to contain the pandemic as quickly as possible, state governments across the country developed various incentive programs to raise vaccination rates in their jurisdictions. Their strategies were independent and unique, differing through dimensions such as the nature of prizes (cash vs. in-kind), the sizes of prizes, the odds of winning, and the eligibility requirements. It has become a high-profile national experimentation of innovative incentives to motivate participation in a crucial yet divisive public health measure, and understanding the outcomes of different designs can help policymakers estimate the effectiveness of similar programs in the future.

Implemented by over 20 states and municipalities during the pandemic, a particularly popular design is the **lottery incentive**. This type of program typically features six- to seven-figure prizes rewarded to a handful of lucky individuals, chosen periodically from a pool that anyone can enter given that they meet the defined vaccination requirement by certain deadlines. For instance, Illinois' 'All In For The Win' lottery budgeted a total of $10 million in prize money to be given in the form of cash prizes ranging from $100,000 to $1 million for adults and college savings plans worth $150,000 for minors. 10 weekly drawings took place between July 8th and August 26th of 2021, and any resident who had received a vaccine dose in Illinois by any day during the campaign was automatically entered into the drawing the week after, as well as all others that followed. This type of low-odds/high-payout model of rewards aims to exploit a pattern of human behavior observed in the research of prospect theory from the field of behavioral economics, which postulates that people tend to attribute excessive weight to events with low probabilities (Kahneman and Tversky, 1980). If unvaccinated residents consistently overestimate the expected value of their prize earnings through the lottery, proponents of the lottery incentive can argue that it has the advantage of an inflated benefit-cost ratio than other promotions at its scale.

On the contrary, much fewer states have implemented a high-odds/low-payout reward model in the form of a **fixed incentive**. This type of program typically features guaranteed cash prizes at $100 or less to those who meet a defined vaccination requirement during a particular time period. For example, the Wisconsin Department of Health Services launched a campaign from August 20th to September 19th, 2021, during which any Wisconsin resident who received a first dose of any COVID-19 vaccine was eligible for a $100 prize that they accepted in the mail. Theoretically, one advantage of the fixed incentive is that it avoids creating ambiguity and offers a straightforward exchange that some may find more compelling.

Although the positive effects of cash incentives used to motivate health behaviors in other contexts have been well-documented, there currently lacks generalizable consensus on whether various financial incentive programs have been successful in the specific context of the COVID-19 vaccine, how their payout structure impacts their effectiveness, and who their optimal recipients are. To meet this gap, this study investigates the effects of the Illinois and Wisconsin programs on county-level vaccination rates. It is the first to directly compare a lottery incentive to fixed one at the scale of a large, heterogeneous target population, as well as the first to parse apart their effects on different types of communities, asking the following questions: ***Which features of cash incentive programs have been the most effective at motivating unvaccinated Americans to get their first dose of a COVID-19 vaccine? More specifically, how have unvaccinated Americans responded to low-odds/high-payout lottery incentives as opposed to high-odds/low-payout fixed incentives?***

Using a differences-in-differences method, I found that the effectiveness of financial incentives did differentiate systematically along the lines of partisan majority, ruralness, unemployment, and (to a limited extent) median household income, and that fixed and lottery incentives produced different impacts for various types of counties. However, even though many of the disaggregated treatment effects were statistically distinct from the null, they were mostly small relative to the size of the unvaccinated population that still had to be mobilized at the time. Informed by broader literature on financial incentives, their capacity to modify health behavior, and today's vaccine-hesitancy trends, this study suggests that financial incentives are not a reliable policy tool for improving vaccine intention at scale and that future policy solutions to COVID-19 vaccine hesitancy must directly engage the complex and differentiated barriers to vaccine access.

II. Literature review

a. Theoretical Framework: Mechanisms of Financial Incentives

There exists a wealth of empirical evidence supporting the merits of financial incentives' capacity to motivate changes in health behaviors, provided by extensive research across topics such as smoking cessation, eating habits, health screenings, physical activity, weight loss, as well as adherence in the context of other vaccines. A 2014 systematic review and meta-analysis of 16 studies concluded that financial incentives were 1.5 to 2.5 times more effective for promoting healthy behaviors than no intervention or usual care (Giles et al., 2014). Additionally, a 2015 meta-analysis of 11 randomized controlled trials found that financial incentives with design considerations from behavioral economics were effective for promoting health-related behavior change (Haff et al., 2015). Most recently, a 2019 systematic review and meta-analysis of 11 controlled trials studied strategies for promoting adherence to Hepatitis B vaccination, finding that between modest financial incentives, accelerated dosing schedules, and case-management services, financial incentives were the most effective for producing a 7-fold increase in adherence (Tressler and Bhundari, 2019). Nonetheless, as this literature review will expose, evidence pointing to the general effectiveness of cash incentives in motivating inoculation against COVID-19 is currently limited, suggesting that a closer inspection of the role financial incentives play in modifying behavior and how generalizable it is to the specific US COVID-19 vaccine context is needed to evaluate the validity of existing approaches.

Neoclassical Model: Offsetting Costs and Barriers

The proposition of financial incentives as an effective vaccine intervention is rooted in the simple assumption that unvaccinated, rational individuals must be slow or hesitant to get their vaccines because they find it is more costly overall to do so than not; thus, assuming that all costs can be expressed through some dollar-measured equivalent, a sufficient financial incentive could modify their decision by reversing the cost-benefit calculus (Robertson et al., 2020). As this section explores, individuals' perceived costs of getting the COVID-19 vaccine stem from a wide range of considerations that can vary on an individual or systematic basis; while only some of those factors are directly tied to cash, an effort to measure and respond to all perceived costs in dollar terms suggests a more administratively simple intervention, which can prove particularly beneficial in the case of the COVID-19 vaccine rollout where broad, efficient coverage is key and there is little room for error in implementation.

One's personal costs of getting the vaccine can originate from two broad categories of barriers to access (Brewer et al., 2022): 1) the first is **structural barriers**, which create logistical difficulties for vaccine access that are costly to overcome; 2) the second is **attitude barriers**, which internally distance individuals from the urgency or legitimacy of vaccines, such that inoculation produces emotional costs due to its lack of alignment with personal beliefs. The following paragraphs elaborate upon each category of barriers as well as evidence from the literature on the effectiveness of financial incentives in remedying them.

Structural Barriers — Structural barriers can include the logistical costs of visiting a vaccine site or challenges of physical access relating to one's functional proximity to vaccines. In a randomized controlled study of women in rural Nigeria, researchers found that respondents were 3.4 times more likely to get the one-time tetanus vaccine when they received a $2 cash incentive as opposed to the control treatment of no incentive, and that the effect of the incentive was stronger if they faced transportation costs that were less than the cash incentive offered (Sato and Fintan, 2020). The study also found that women were more likely to opt for more expensive modes of transport when they were offered a larger cash incentive, which further suggests that they associated incentives with compensation for the logistical costs of vaccination even when those costs were no longer constraining. Together, this study provides evidence for financial incentives' real and perceived role in offsetting salient logistical costs where the former is at least as large as the latter, although the narrowly defined context limits the study's generalizability to other populations and vaccine characteristics.

In the US, the geographic accessibility of the COVID-19 vaccine and its impact on vaccine uptake has been empirically measured. A study found that mass closures of vaccination sites in California in 2021 significantly increased travel distance to a site by 10% on average, and as a result, nearly 4 fewer individuals were vaccinated every week in every zip code in the state (Bravo, Hu, and Long, 2022). During the pandemic, physical accessibility of vaccination sites was also highly variable and often inadequate: in smaller towns and rural areas of the US, only 53% and 36% of residents experience medium to high accessibility, respectively, which are small relative to the 87% statistic for metropolitan areas (Rader et al., 2020); furthermore, as much as 14% of the US population, representing over 67 million individuals, reside in vaccine deserts existing in pockets across both urban and rural areas, facing little to no local accessibility to vaccines (Rader et al., 2020). These findings reveal that for a substantial group of Americans, transportation logistics may be a primary factor informing their decision on vaccination, which suggests a promising outlook for financial incentives that can directly offset the potentially prohibitive costs of overcoming geographic barriers.

Structural barriers can also take the form of limited flexibility in workplace or domestic duties to accommodate for the time needed to seek out the vaccine or recover from its side effects. In April 2021, the Kaiser Family Foundation's COVID-19 Vaccine Monitor survey found that among unvaccinated Americans who said they wanted the vaccine as soon as possible, the top two most common reason why they had not sought out an appointment yet concerned daytime commitments: the number one reason was "Busy/didn't have time/schedule conflict", followed by "Can't take time off work/conflicts with work hours" (Hamel et al., 2021). This result indicates that the most movable group of unvaccinated individuals at the time were mostly constrained by a circumstantial tradeoff with their daytime commitments that they could not afford to make. The same survey found that 48% of all unvaccinated adults at the time expressed concerns with missing work because of side effects, and that these concerns were twice as prevalent as the concern with missing work only to get the vaccine (Hamel et al., 2021). It is reasonable that side effects present a much greater barrier for their potentially prolonged impact, which can incapacitate individuals for the few days following inoculation; although side effects of the vaccine are rarely serious, about 1 in 8 people reported inability to work or do normal activities after the first dose of a Pfizer or Moderna vaccine, and up to 1 in 3 people made similar reports after the second dose, a study of 298 million doses in the US found (Rosenblum et al., 2022). According to the Bureau of Labor Statistics, about a quarter of Americans in the private industry did not have paid sick leave as of March 2021, which implies that getting the vaccine may mean risking days' worth of wages for this group. Even for workers who have sick leave, expecting to miss up to two days of work due to vaccine side effects can also be a deterrent, as half of all American workers with paid sick leave have an allowance of just six days or fewer each year (Bureau of Labor Statistics). Legislation to reform paid sick leave policy in the US is possible, but it faces significant inertia. A prudently structured financial incentive may present the opportunity for a simpler and cheaper intervention to offset the perceived risk of lost wages.

Attitude Barriers — Attitude barriers can include low perceived risks of contracting COVID-19, lack of trust in vaccines, and misinformation or disinformation about vaccines. A survey experiment investigating the impacts of vaccine attributes on public attitudes toward COVID-19 vaccination found that strong beliefs in the general safety of vaccines, past histories of frequent influenza vaccination, and favorable attitudes toward the pharmaceutical industry all constituted traits positively associated with willingness to accept a COVID-19 vaccine (Kreps et al., 2021), indicating that long-term attitudes play a considerable role in individuals' vaccination decisions. Furthermore, the study found that a vaccine released on the Food and Drug Administration's (FDA) Emergency Use Authorization (EUA) reduced willingness to vaccinate by 7%, relative to the baseline case where the same vaccine received full authorization, which translates to a difference of 23 million Americans. This pattern surfaces in spite of the FDA's rigorous standards for vaccine safety, quality, and effectiveness in approving EUAs (Food and Drug Administration), suggesting that many Americans still teeter on the verge of skepticism when it comes to buying in to the vaccine.

The aforementioned Kaiser Family Foundation survey from April 2021 also found that for the respondents reporting that they would wait and see or get vaccinated only if required, the top two reasons for not trying to get an appointment include “Concerned about safety and/or side effects” and “Don’t want it/need it” (Hamel et al., 2021). This reveals that while the most movable group of unvaccinated individuals was primarily constrained by structural barriers, the remaining less enthusiastic group was heavily influenced by attitude barriers, reporting disbelief in the dangers of an infection or in the safety of the vaccine. As a later section on measuring individuals’ WTA will show, research has found limited capacity for publicly feasible financial incentives to fundamentally reverse belief-driven vaccine intention.

Behavioral Model: Additional Dimensions of Influence

The model of financial incentives illustrated so far assumes that unvaccinated individuals have perfectly rational preferences and are always utility-maximizing, however the field of behavioral economics predicts that this is seldom true. Empirical findings from the field predict that humans are generally present-biased, risk- and loss-averse, and loyal to defaults, especially in cases where probabilities are ambiguous; together, these traits make the average person more likely to underweight delayed, abstract, and uncertain gains and overweight immediate losses that are tied to a behavioral change (Haff et al., 2015), such as getting the COVID-19 vaccine. For many, the vaccine promised immunity against a potential future infection which may or may not come while creating short-term costs, such as health side effects or needing to miss work; meanwhile, its efficacy and safety were also subject to skepticism despite the government’s efforts to reassure otherwise, due mostly to the vaccine’s accelerated release under the EUA. This expected bias in the direction of hesitancy also calls for an incentive program that creates vaccine-associated gains with more certainty and immediate tangibility, such as a cash prize.

Financial incentives used in modifying health behavior also imply other behavioral influences that may either add to or detract from their effectiveness, depending on details of their construction. A 2019 systematic review of 47 studies from the last decade identifies five main themes of financial incentives that affect their public acceptability, of which two are most relevant to the context of first-dose vaccination and highlighted here: **messaging** and **liberty** (Hoskins et al., 2019).

Messaging — Financial incentives express messaging on the behaviors they aim to motivate, which individuals use to interpret the programs' underlying policy intentions and political attitudes. Reviewing a diverse set of incentives and target behaviors, Hoskins et al. found that financial incentives could communicate a complex range of meanings, including both those that improve public appeal and others that hinder it. Specifically, the authors highlight a tension between two prominent effects. On one hand, financial incentives can help signal the positive value of target behaviors and reward the individual efforts invested toward them. This can promote visibility and normalization for the behaviors where they may conflict with social norms (Johnson et al., 2018; Whelan et al., 2014), producing not just behavior change but also attitude change. Yet on the other hand, financial incentives can also crowd out intrinsic motivation and undermine the sense of individual responsibility in mastering behavior change (Thomson et al., 2014). They can perpetuate assumptions that behavior change must be externally motivated and fail to produce lasting change in behavior or attitude beyond the campaign period.

To a limited extent, the COVID-19 vaccine incentives studied in this paper stood to benefit from the first messaging effect without suffering from the second. Though it is not likely that the element of reward messaging can assuage the attitude barriers faced by the most vaccine-hesitant, who are not receptive to the fundamental propositions of the vaccine, it may see greater success in motivating more urgent action and enthusiasm among those who are receptive but have been slow to seek out the vaccine. Furthermore, the baseline measure of program success for COVID-19 vaccine incentives which I measure in this study is their ability to achieve the explicit purpose of mobilizing first-dose vaccination. Unlike other health behaviors examined by Hoskins et al., such as smoking cessation or breastfeeding, first-dose vaccination is a mostly standalone action that does not hinge on long-term habit-building and is thus not vulnerable to the negative effects of the paternalistic messaging. Although completion of the vaccination sequence is ideal for full protection against the virus, the incentive programs' relationship to this outcome lies beyond the scope of this study and will not serve to explain its findings. Nonetheless, an inquiry into whether financial incentives negatively impacted second-dose and booster shots due to paternalistic messaging can yield valuable policy insights and should be pursued in a future study.

Liberty — By exploiting the universal appeal of cash, financial incentives produce implications for the material autonomy of individuals, which can affect their attitudes toward vaccination. Hoskins et al. identify a common tension between financial incentives' effect of creating opportunities for choice and their effect of producing pressure or perceptions of alienation. In situations where individuals are deterred from health-conscious choices as a result of peer influence or social norms, financial incentives can sometimes promote their autonomy by providing a rationalizing justification they can use to defend their choices to their peers (Gorin and Schmidt, 2015; Wolff, 2015), i.e. claim that they are "only doing it for the money". These incentive programs form a context for decision-making that normalizes the desired health choice by tying it to financial motivations, which are less stigmatized and may allow individuals to act in accordance with their values more freely. Among those who are not sufficiently invested in making the behavior change, however, financial incentives may have the opposite effect and create feelings of pressure that diminish buy-in (Priebe et al., 2016; Noordraven et al., 2017). For those who are more resource-constrained, the pressure to undertake a controversial measure in exchange for money can even be perceived as an encroachment upon their rights to choose what they do with their bodies (Furman, 2017), even if the incentive offer is not inherently coercive (Wertheimer and Miller, 2008).

For a COVID-19 vaccine incentive, the liberating effect on perceived liberty is relevant but likely small in practice. A survey by the American Enterprise Institute in May 2021 found that Republicans were roughly half as likely to have friends who have been vaccinated or to have received encouragement from friends or family members to get vaccinated, compared to Democrats, for whom vaccination was overall the norm among peers; moreover, as many as one in three Republican respondents reported that friends or family had advised them to not get the vaccine or that they had received mixed messages about the importance of getting one (Cox, 2021). In July, one Missouri doctor also shared anecdotal evidence that she had seen a "[small] number" of people getting vaccinated in secret to avoid "the peer pressure or the outbursts from other people about them" (Elamroussi, 2021). These findings suggest that dominant attitudes in one's social circle may exert significant influences on individual vaccine decision-making, and per the liberating effect of financial incentives, a compelling program may be able to empower a subgroup of vaccine-believers in vaccine-hesitant circles to seek out inoculation by mitigating the expected backlash. Notably, both anecdotal and survey evidence provided thus far suggest that this subgroup may represent a small margin of unvaccinated individuals, and that the social pressure against inoculation may not be easily quelled by a financial incentive; thus, this specific mechanism may likely account for only a small increase in COVID-19 vaccination rates.

On the contrary, the latter effect of alienating those who perceive the financial incentive as coercive is a highly pertinent point for consideration, particularly in the economic context of COVID-19. A survey report by the Pew Research Center found that in April 2021 (the beginning of the general vaccine rollout), up to 43% of American adults claimed that they or someone in their household had experienced job loss or a pay cut because of the pandemic, and 32% responded that they were not going to be able to pay some bills that month, representing a larger share of respondents than those who said this was the case in a typical month (24%) (Parker et al., 2020). These statistics suggest that many Americans were suffering greater economic hardship during the pandemic, which may have produced an increase in the material demand for cash gifts from the government without necessarily improving their appeal or acceptability. In an opinion piece for the American Medical Association, medical ethics and health policy experts wrote that “offering payment as an incentive for COVID-19 vaccination may be seen as unfairly taking advantage of those US residents who have lost jobs, experienced food and housing insecurity, or slipped into poverty during the pandemic” and fare poorly among those who were not satisfied with the government’s delivery of general economic relief (Largent and Miller, 2021). This line of reasoning corroborates the general pattern of responses to financial incentives as identified by Hoskins et al., wherein individuals may lose intrinsic motivation to modify their behavior if they find the offer of incentives to feel coercive. Nonetheless, it is unclear whether this effect systematically results in resistance or reluctant acceptance of the incentives, and thus there is not enough evidence to indicate the direction of its effect on vaccination rates.

b. Existing Literature: Sufficient Size of Financial Incentive

An extremely narrow body of literature has attempted to measure the size of financial incentives that would sufficiently motivate COVID-19 vaccination among the unvaccinated, but their findings lack consensus and generalizability. There are two prominent studies that set out to rigorously estimate individuals' willingness to accept (WTA) money in exchange for inoculation, both using survey methods.

The first study by Carpio et al. surveyed 2000 US adults in around August 2021, using a convenience sample provided by Amazon's MTurk. The researchers used a series of contingent valuation questions to determine whether respondents would immediately pay or be paid to get vaccinated, as well as an estimate of the maximum amount they would pay (WTP) or the minimum amount they must be paid (WTA) in each respective condition. The values of WTP and WTA were approximated through a multi-round choice structure containing an initial round of multiple-choice options, ranging between $50 and $150, and follow-up rounds of offers that went up to $1100. The study found that while 12% of the US population would not accept vaccination under any terms, another 14% were willing to take the vaccine only if paid to do so. Within that group, the mean WTA value was $716.17 (Carpio et al., 2021), which is over 7 times the fixed incentive amount used in the Wisconsin program I investigated in this paper. Given the upper limit of incentive options, the true mean WTA may be an even higher value.

The second study by Robertson et al. in December 2020 found a smaller margin of individuals who were willing to get the vaccine for a payment, with only 8% of respondents claiming that they would be willing to get the vaccine for any of the hypothetical incentives offered to them ($1000, $1500, or $2000) (Robertson et al., 2021). Notably, the researchers set the lower bound of the incentive options higher than the mean WTA found by Carpio et al. and the upper bound higher than the highest option offered by Carpio et al., suggesting that if the two methods were equally accurate and objective, the Robertson et al. study would be expected to measure a larger share of respondents who are receptive to payment, however this was not the case. The Robertson et al. study also differed in that it used a randomized sample of 1000 US adults, suggesting less biased but also less statistically significant results. The study made the additional finding that the size of the incentive offered did not dramatically affect vaccine uptake rate, which implies that respondents were either willing to get the vaccine for no payment, willing to get it for a cash incentive, or unwilling to get the vaccine unconditionally; a cash difference of up to $1000 did not tend to influence the category they identified in. If true, this undermines the theoretical model of WTA used by the Carpio et al. study, which assumed that individuals were capable of incrementally identifying the exact cutoff at which the vaccine starts to become acceptable.

These studies do not reconcile neatly, due to the differences between their survey designs. Considered together, they are overall more indicative that neoclassical models are not strong or consistent predictors of Americans' willingness to receive the vaccine, and that financial incentives have a more complex relationship to vaccine uptake that go beyond offsetting costs, as suggested by mechanisms proposed in the behavioral model.

Furthermore, both studies identified relatively small margins of individuals whose vaccination intentions were actually affectable by a fixed payment under $2000. Seeing as this range of payments already far exceeds the $100 reward used in most states with a fixed incentive program, the average increases of 8% and 14% in expected uptake may be overestimations of what real programs could achieve; yet still, this scale of impact can be insufficient for the race to herd immunity, especially in areas experiencing the greatest vaccine hesitancy. The outlook of feasible financial incentives becomes even less optimistic when considering that modest payments in the range of $10 to $100 were not found to significantly improve individuals' probabilities of vaccination from baseline, according to another survey study (Kreps et al., 2021).

c. Existing Literature: Effectiveness of Current Interventions

As cash incentive programs for the COVID-19 vaccine grew increasingly commonplace across the US, several quantitative studies set out to empirically measure the impact that they have had on first-dose vaccination rates. Due to their popularity, lottery programs have inspired a more extensive literature on their effectiveness, while there has been no direct studies of the impacts of fixed incentive programs thus far.

David et al. conducted a differences-in-differences study of all 19 states that announced lottery programs before July 1, 2021, using daily state-level COVID-19 vaccination data from the period between April 28 and July 1, 2021, when vaccine appointments became broadly available. In their analysis, the authors compared the daily reported vaccination rate in states before and after they announced lotteries with states that never made the announcement, while controlling for covariates. They found that the association between announcements and state vaccination rates was statistically indistinguishable from zero (Dave et al., 2021), which demonstrates that vaccination trends observed in the treatment states were attributable to factors other than the announcement of the lottery incentive. This study is potentially limited by the fact that the states that announced lotteries before July 1, 2021 were perhaps systematically differentiated from the states that did not, in ways that correlate with vaccination behavior but were not captured by the authors' model. For instance, party affiliation is strongly associated with vaccine attitudes, suggesting that state governments whose constituents show the greatest enthusiasm for a vaccine intervention were more likely to launch such an intervention earlier, and those constituents were more likely to respond favorably to such interventions. However, factors that contribute to selection bias would have positively and systematically biased the study's findings, and yet the reported results were neither positive nor statistically significant, which suggests that accounting for potential selection bias may not have yielded more informative results.

Using the interrupted time series method, Walkey et al. studied the Ohio vaccine lottery's impacts on daily vaccination rates by comparing linear state vaccination trends across the periods before and after the lottery's announcement (April 15 to May 12, 2021 and May 13 to June 9, 2021, respectively). Although an initial analysis shows a small jump in Ohio's vaccinations after the lottery's announcement, taking the difference between Ohio's vaccination data and that of the whole country causes the jump to disappear (Walkey et al., 2021), which implies that the observed local increase was likely not attributable to the lottery's announcement but rather symptomatic of influences shared across all of the US. These results led the authors to conclude that they did not find evidence for a positive association between Ohio's incentive and rates of vaccinations in the state. The applicability of this claim is limited, however, by the fact that the authors did not account for the potential impacts of lottery vaccine incentives that were announced in other parts of the country at around the same time, such as in New York, Maryland, and Oregon (Siese, 2021), when they employed national data as a baseline. Since these concurrent lotteries may have contributed to the jump that was also observed across the country, the authors' findings cannot conclusively negate the effectiveness of either Ohio's lottery incentive or those occurring in other states.

The last major study of lottery incentives is authored by Gandhi et al., who conducted a randomized experiment to test the role of winning odds in affecting the impact of Philadelphia's vaccine regret lottery. In the study, the regret lottery was designed to enter all Philadelphia residents to the vaccine lottery and advertise that among individuals whose names get drawn in the lottery, only those who had received their first dose before the previous midnight were eligible to claim the prize. This structure aimed to exploit the behavioral economics concept of loss aversion, in which humans experience a greater desire to avoid loss than to seek an equivalent gain (Kahneman and Tversky, 1980), however the authors found mixed estimates as to whether this design was beneficial to Philadelphia's overall vaccination rate. The study also randomly assigned zip codes to the treatment of artificially enlarged odds of winning the lottery, which were boosted to 59 to 98 times those of their neighbors. Using a differences-in-differences method, the authors reported that they did not detect statistically significant benefits of the treatment, even in zip codes where the odds of winning were raised (Gandhi et al., 2021). Informed by the rest of the literature on vaccine intentions, possible explanations for this unique finding may include the following: 1) individuals in the study were not efficient or consistent in how they factored odds into their perceptions of expected values, so they were not sensitive to variations in the odds treatment; 2) as Robertson et al. and Carpio et al. predicted, individuals in the study had discontinuous preferences, and the hypothetical margin of people who would be compelled to get vaccinated only if their expected value was higher than the baseline did not exist or was insignificant; or 3) individuals in the study did not overwhelmingly believe that their odds were different from their neighbors in other zip codes, either due to mistrust or lack of program publicity.

Despite their potential individual limitations, the three studies on lottery incentives across the US overwhelmingly found that this mode of intervention has not significantly or substantially improved vaccination rates at the state and municipal levels. Even though the lotteries and regret lotteries were designed to intentionally exploit individuals' behavioral traits by inflating the perceived sizes of payouts or threatening the risk of losing a once-in-a-lifetime prize, these studies find through empirical analysis that this incentive structure has not achieved particularly strong results.

d. Gaps in the Literature and Proposed Contribution

Comparing the effects of lottery and fixed vaccine incentives — Empirical efforts to strictly measure individuals' willingness to get vaccinated as a payment in dollars have testified to the complexity and contingency of financial motivators. Gandhi et al. began to probe at the role of incentive structuring in mediating the effectiveness of financial incentives; they focused specifically on loss-aversion and perceptions of expected utility but found that neither aspect made a significant contribution to affecting vaccination rates in Philadelphia (Gandhi et al., 2021). The literature on incentive designs across other health contexts suggests that many more considerations can influence their success, and a popular tension in the structuring of payments for vaccination against COVID-19 that has not yet been interrogated empirically is the balancing of payout size and winning odds, given a limited budget. There exists limited comparative evidence on small, homogenous contexts, which have found in other health contexts that fixed incentives can be up to 10 times more effective than lottery ones at motivating behavior change (Niza et al., 2013; Giles et al., 2016; Marti et al., 2017), but these results lack external validity and cannot be extrapolated to the context of large epidemics or polarized health attitudes.

To meet this gap, the following study is the first to directly compare the motivational impacts of lottery and fixed incentives launched at the state level, targeting large heterogeneous populations. Using a much larger data sample with greater natural variation, this study has also generated findings on fixed incentives with much higher significance than the preceding literature. Lastly, this study is also the first to compare fixed and lottery incentives in the specific context of COVID-19, which represent a historic policy push that is not comparable to most other health contexts studied in the past but still produces highly revealing insights for future and preventative policy decisions.

Disentangling treatment effects by demographic characteristics — The empirical knowledge on COVID-19 vaccine lottery programs have overwhelmingly demonstrated limited effects on overall vaccine intention at the state level, however the broader literature makes many consistent references to the fact that incentives can fare very differently with different demographics. Conclusive evidence on financial incentives tends to come from studies focused on narrow demographics characterized by shared traits such as age, sex, and socioeconomic status (Niza et al., 2013; Sato and Fintan, 2020; Mantzari et al., 2015), often with mechanisms that work in opposing directions (Hoskins et al., 2019). The literature has also identified systematic associations between these traits and responsiveness to financial incentives (Hoskins et al., 2019). For instance, the meta-analysis by Hoskins et al. found that being lower middle-class or employed increased the likelihood of being in favor of financial incentives, and that adults with higher levels of deprivation were in some cases more accepting of financial incentives. Furthermore, Robertson et al. found that Republican respondents were less responsive to financial incentives than the general population, while Democrats were more responsive

(Robertson et al., 2021). Lastly, Rader et al. identified stark inequities in access to vaccination sites between urban and rural regions of the US (Rader et al., 2021), which could also give rise to systematic disparities in responsiveness to financial incentives. Based on this body of research, it appears plausible that the limited aggregate effect measured by current studies of the COVID-19 vaccine incentives may be a composite of differentiated impacts acting in different directions, and there is currently no comprehensive study asking if the incentives have been more effective in some settings than others.

Inspired by this gap, the following study makes the first attempt at measuring the impacts of COVID-19 vaccine incentives in disaggregated terms, differentiating by locations' demographic traits, such as voting history, median household income, and ruralness. Using data on the county rather than state level, it is able to account for the wide heterogeneities within each state with more granular specificity. This study is also distinct from studies of unique, narrow settings (e.g. a study of a specific city) by identifying systematic patterns across large groups of similar settings, which allows it to yield more generalizable findings.

III. Methodology

a. Empirical Model

This study uses a differences-in-differences (DID) framework to separately analyze the impact of (1) Illinois' lottery incentive program and (2) Wisconsin's fixed incentive program on each state's vaccination rates at the county-level. The DID method is a quasi-experimental approach that facilitates causal inference regarding an intervention where individuals' random assignment to treatment or control groups is not possible. As the name suggests, it does so by taking a difference of differences in outcomes: First, it sorts individuals into either the treatment or control group, based on whether or not it has experienced the intervention, and for each group measures the average difference in outcomes before and after the intervention has been introduced; by comparing each group to itself, this first difference accounts for each group's time-invariant characteristics, which may give rise to inherently different baselines. Second, this framework takes a difference of each group's average before-to-after change in outcomes; this second difference accounts for time-varying factors that apply uniformly to both groups and are unrelated to the intervention. The DID framework relies on an assumption of parallel trends, i.e., in the absence of treatment, the two groups demonstrate the same changes in outcomes over time, relative to each group's own baseline.

The DID method is well-suited for this study, as vaccine incentive programs were uniquely enacted at the state level, and thus assignment to treatment was clearly not randomized at the individual county level. To preserve the parallel trends assumption as much as possible, I chose to focus on three demographically and geographically similar states in the Midwest, each representing a group of counties with a different treatment status: (1) Illinois, which only enacted a statewide lottery incentive; (2) Wisconsin, which only enacted a statewide fixed incentive; and (3) Iowa, which had not enacted any statewide cash incentive before or during the other states' incentive programs. The impact of each incentive program is measured by applying a DID analysis to a set of county-level data from both the program state in question and Iowa, such that a binary relationship between treatment and no treatment is established for each treatment type. This design attempts to satisfy the parallel trends assumption by identifying Iowa as a state experiencing comparable environmental and sociopolitical pressures on vaccination rates that are unrelated to the incentive programs, such that Iowan counties' vaccination developments over time may be a strong representation of those that would also otherwise manifest among Illinois and Wisconsin counties had their states not enacted their programs.

Among the Midwestern states that did not launch a statewide cash incentive program in this period, I chose Iowa to serve as the control group for this study because it demonstrates the greatest political similarity to Illinois and Wisconsin in terms of recent voting history. I found that in the Midwest, a state's political identity is strongly associated with whether it enacts a COVID-19 vaccine incentive; specifically, states with a higher percentage of Republican-voting counties were less likely to have enacted a COVID-19 vaccine incentive by the summer of 2021. Across the country, Republican states are also more likely to vaccinate against COVID-19 at slower rates overall (Hamel et al., 2021). Altogether, these observations suggest that political identity tends to be similarly tied to both the intensity of state interventions and the predisposition of residents to get vaccinated regardless of state intervention, and thus choosing a control state that is as politically similar to the treatment states as possible is important for meeting the parallel trends assumption. As a robustness check, I also found that Iowa demonstrated comparable vaccination trends from April until the start of the Illinois and Wisconsin programs, which further suggests its suitability for representing non-intervention trends also experienced by the treatment states.

Based on the above considerations, the base empirical model for each program's DID analysis is specified as follows:

EQUATION (1)

$$Y_{cst} = \alpha_c + \beta I_{st} + \lambda_t + \varepsilon_{cst}$$

In this specification, the dependent or outcome variable (Y_{cst}) is the vaccination rate Y in county c, in state s, and on date t. The main explanatory variable I_{st} is a dummy indicating whether the incentive is underway in state s, at time t. The coefficient on I_{st} (β) estimates the treatment effect and represents the average change in counties that were exposed to the incentive relative to the average change in counties that were not exposed to the incentive. The constant α_c represents time-invariant county fixed effects of county c and the constant λ_t represents the date fixed effects of date t. Lastly, ε_{cst} is the error or residual term, accounting for each observation's deviation from the fitted value predicted by the regression model.

Due to the nature of the vaccine incentive program, this model considers each incentive on an underway/not underway basis, rather than the before/after basis described earlier in this section. Like most others across the country, the vaccine interventions in Illinois and Wisconsin were campaigns that each spanned a limited window of time and aimed to motivate a temporary acceleration in vaccination rates only during that window. Theoretically, unvaccinated individuals are not any more motivated by the campaign to get their first dose after it has already ended; this contrasts with interventions like a children's tutoring program, which may have lasting effects on participants' educational outcomes even after its end. Thus, I_{st} is constructed as an interaction between the state dummy (i.e. whether the treatment is applied) and a dummy indicating whether date t falls within the program period.

An extended empirical specification considers the potential for differential impacts of the incentive on counties with different demographic characteristics, such as income level, voting history, and urban status. To parse apart these disaggregated impacts, I interact the control variables from equation (1) with a given characteristic variable, such as dummies indicating the county's median household income decile.

EQUATION (2)

$$Y_{xcst} = \alpha_{xc} + \beta_x I_{st} + \lambda_{xt} + \varepsilon_{xcst}$$

This allows me to estimate different β_x coefficients to reflect the average impact of the incentive on outcomes in counties with each specific characteristic of interest. The identification assumption here becomes that outcomes for treatment counties with a given characteristic of interest would have changed similarly to outcomes for control counties with the same characteristic.

b. Data Construction

Past studies on vaccine incentives that did find significant treatment effects tend to have studied small, narrow demographics while those that did not tend to have studied large, heterogeneous populations, with literature on the COVID-19 vaccine generally falling into the latter category. I hypothesized that disaggregating the treatment effect by homogenous demographic groups may help to reconcile inconsistent findings on this research topic. To do so, I analyzed county-level vaccination data from Illinois, Wisconsin, and Iowa, grouped counties in the dataset by shared demographic characteristics, and derived a treatment effect for each group.

For simplicity and due to the limited availability of data, the demographic attributes of interest were assumed to be time-invariant constants and expressed in terms of county generalizations, median measurements, or majority traits, depending on the individual attribute. These descriptors are identified by studies conducted as contemporaneously to the incentive programs as possible (within 10 years) to support the time-invariance assumption that they accurately reflect county conditions throughout the range of dates included in this dataset. Although county-level descriptors cannot directly identify how responsive each demographic segment is—as each county contains a mix of demographically distinct individuals and households—they are fitting for drawing generalizations about the larger communities they populate, which tend to be the scale at which public vaccine incentives are implemented.

An additional consideration for evaluating county-level vaccination data is that it allows the model to approximately capture influences of external vaccine interventions introduced at county or municipal levels by absorbing county fixed effects.

TABLE 1: REGRESSION TERMS AND ASSOCIATED DATA SOURCES

	Regression term	**Description**	**Data Source**
Outcome variable	percent_dose1	Percentage of county age 12+ population with at least one dose of vaccine	Centers for Disease Control and Prevention (CDC)[1]
Explanatory variables	illinois	Dummy variable for the state of Illinois	CDC
	lotteryactive	Dummy variable for lottery incentive's active period	State of Illinois Coronavirus Response site[2]
	il_lottery	Interaction term between state of Illinois and lottery incentive's active period	-
	wisconsin	Dummy variable for the state of Wisconsin	CDC
	fixedactive	Dummy variable for the fixed incentive's active period	Wisconsin Department of Health Services site[3]
	wi_fixed	Interaction term between state of Wisconsin and fixed incentive's active period	-
	date	Time variable at the daily level	Associated with multiple datasets

1 https://covid.cdc.gov/covid-data-tracker/#county-view?list_select_state=all_states&list_select_county=all_counties&data-type=Vaccinations&metric=Administered_Dose1_Pop_Pct&null=Vaccinations
2 https://coronavirus.illinois.gov/all-in-illinois.html
3 https://www.dhs.wisconsin.gov/covid-19/100.htm

Control variables	month	Time variable at the monthly level	Associated with multiple datasets
	fips	Federal Information Processing System (FIPS) code, which are unique IDs for counties	Associated with multiple datasets
County characteristics	rucc	Rural Urban Continuum Code (2013)	US Department of Agriculture, Economic Research Service (USDA ERS)[4]
	uic	Urban Influence Code (2013)	USDA ERS[5]
	mhi	Median household income (2019)	Census Bureau, Small Area Income and Poverty Estimates (SAIPE) Program[6]
	unemp	Unemployment rate (2020)	Bureau of Labor Statistics, Local Area Unemployment Statistics (LAUS) data[7]
	democrat	Dummy variable for whether the Democratic candidate won the most votes in the county in 2020, proxy for current majority politics; the winning candidate in each county of this dataset is either Democratic or Republican	Massachusetts Institute of Technology (MIT)[8]

Outcome variable: vaccination rate — The outcome variable of interest in this study is the county vaccination rate, measured by the percentage of the county above-12 population with at least one dose of a COVID-19 vaccine. Since both the Illinois and Wisconsin programs aimed to motivate unvaccinated individuals to get their first dose and offered rewards on only that basis, the programs' effects in each county can be reasonably measured in terms of the first-dose vaccination rate.

---

[4] https://www.ers.usda.gov/data-products/rural-urban-continuum-codes.aspx
[5] https://www.ers.usda.gov/data-products/urban-influence-codes/
[6] https://www.census.gov/programs-surveys/saipe.html
[7] https://www.bls.gov/lau/#data
[8] https://dataverse.harvard.edu/dataset.xhtml?persistentId=doi:10.7910/DVN/VOQCHQ

While completion of the full vaccination series (for those that require multiple administrations) is an important indication of a population's protection against the virus, this study's DID design is not suited for measuring the program's impact in this dimension. Specifically, the empirical model measures the treatment effect in terms of changes in outcomes during the campaign periods, rather than before or after, based on the theory of change hypothesized above. The Pfizer and Moderna vaccines require at least 3- and 4-week intervals, respectively, between the first and second doses of each series in order to provide effective protection. The lengths of these intervals are substantial relative the Illinois and Wisconsin campaign periods, and unvaccinated individuals are not particularly incentivized to plan for completing their full sequences within the campaign periods. Together, these facts of implementation suggest that even if the programs had an indirect effect on motivating individuals' decisions to also get their second dose, there is no reasonable expectation that they would choose or be able to get their second dose during the period that my empirical measures, and thus it cannot provide an informative measurement in this dimension. The specification of ages above 12 reflects the earliest eligibility guidelines when vaccines became initially available to the general public; though age guidelines have evolved, I also chose to exclude data on children below 12 because they often lack the autonomy to make decisions regarding their own vaccination status and are less likely to unilaterally seek out vaccination resources.

Provided by the Centers for Disease Control and Prevention (CDC) COVID Data Tracker, the vaccination data used in this study comprise of individual timeseries for each county in the sample states, with a distinct observation for each day in each county.

Explanatory variable: state and program period interaction — For the analysis of each program, the main explanatory variable is an interaction term indicating whether the observation is taken in a treatment county while the program is underway. To illustrate how this interaction term was generated for each analysis, I will start by explaining my process in the lottery incentive analysis. In this case, I first generated two dummy variables: one indicating whether the observation is from an Illinois county, and another indicating whether the observation is made between July 8th and August 26th of 2021, per the program details collected from the State of Illinois Coronavirus Response site. Next, I generated another dummy variable that is defined as the product of the two first dummy variables, such that it indicates whether the observation satisfies both the state and date criteria, or in other words, whether it represents a treatment county while the treatment was underway. This then becomes the interaction term. The same process is replicated for the fixed incentive analysis using different treatment details.

TABLE 2: COUNTY TREATMENT GROUPS

Intervention	**State**	**Program Period**
Lottery Incentive	Illinois	7/8/2021 - 8/26/2021
Fixed Incentive	Wisconsin	8/20/2021 - 9/19/2021
Control (No Intervention)	Iowa	-

County characteristic: majority politics — To investigate potential heterogeneities of treatment effects across counties with different majority politics, I drew upon vote history data from the Massachusetts Institute of Technology Election Data and Science Lab (MEDSL). Because voter participation in the US is historically higher in general elections than midterm elections, I used the county majority vote in the most recent general election for the 2020 presidency as a proxy for the county's overall political leaning. To accomplish this, I coded the counties in my dataset by the party identification of the 2020 presidential candidate that received the most votes from that county. Because the winning candidate across the counties in my dataset was always from either the Republican party or the Democratic party, I generated a dummy variable to reflect the binary nature of this trait.

County characteristic: urban/rural status — To examine the relationship between how urban or rural a county is and treatment effectiveness, I used two county-level classification systems developed by the United States Department of Agriculture Economic Research Service (USDA ERS) to associate counties with delineated tiers of ruralness (Appendix 1 and 2). First, I referred to the 2013 Rural-Urban Continuum Codes, which scores counties on a scale from 1 to 9, where a larger value represents a more rural county by population-related criteria. I also used the 2013 Urban Influence Codes, which scores counties on a scale from 1 to 12, where a larger value similarly represents a more rural county but by criteria of proximity to urban centers.

County characteristic: unemployment rate — This study considers the influence of county unemployment rates on treatment effects with the use of 2020 unemployment data from the USDA ERS. To accomplish this, I sorted all counties in the dataset (recall that for each analysis, the full dataset is respectively restricted to the treatment state and Iowa) into 9 deciles of unemployment rates relative to values in the dataset. This allowed me to generate a dummy variable associated with each decile, interact that dummy with the terms of my regression model, and derive a separate treatment effect for each decile of unemployment rates.

County characteristic: median household income — County median household income is factored into my analysis through the same strategy I used to consider unemployment rates, as I describe above. Data on counties' median household incomes is provided by a 2019 study hosted by the USDA ERS, and observations are transformed into deciles relative to values in the dataset.

The median household income data used in this study is provided by a 2019 study, which precedes the timeline of closures due to the pandemic in the US. The pandemic closures impacted income across different job sectors inconsistently, with certain professions experiencing a larger temporary hit than others—for instance, service industries, retail stores, restaurants and bars, and the leisure, hospitality and entertainment industry were disproportionately impacted by closures, while professional services and manufacturing were the least impacted (Bartik et al., 2020). This suggests that the pandemic may have modified the distribution of counties by median household income if certain job sectors are overrepresented in certain counties, and 2019 estimates may not be the most precise representation of present county conditions when the incentive programs were launched after the worst economic consequences of the pandemic had already set in. On the other hand, 2019 estimates may be a more accurate approximation of long-term financial vulnerability, regardless of the pandemic's short-term effects on annual income. This assumption is supported by the fact that low-income families in the US have disproportionately experienced any income loss, income losses of a greater degree, missing loan or rent payments, and the need to make an early withdrawal from retirement savings during the pandemic (Bertrand et al., 2020); in other words, long-term financial vulnerability has a demonstrated link to financial hardships during the pandemic, suggesting that 2019 median household income estimates can be a strong predictor of overall financial adversity in a county though not an exact representation of its annual incomes in 2021.

IV. Findings

a. Average Impact on Vaccination and Role of County Characteristics

In Table 3, columns 1, 2, 4, and 5, I present estimated average impacts of Illinois' and Wisconsin's incentive programs on first-dose vaccination rates overall, with and without absorption of county fixed effects. Absorbing county fixed effects means that the model adjusts for all time-invariant, county-specific factors that influence observed outcomes but are not captured by terms in the regression; doing so can reduce the risk of bias and noise arising from omitted variables and improve the accuracy of estimates that are accounted for in the model. Across the effects of both incentives, accounting for county-specific characteristics increase the R^2 statistics (i.e. improve model fit) greatly, suggesting that these factors altogether play a substantial role in explaining the relationship between the program's administration and vaccination outcomes on the county level, which provides evidence for this study's main motivation. Furthermore, absorbing county fixed effects reduce the magnitudes of estimated treatment effects such that they become closer to 0, with the lottery incentive reducing the county vaccination rate by 0.478% and the fixed incentive increasing it by 0.901% on average. This observation suggests that omitted county characteristics falsely inflated the measured treatment effects when they were not controlled for, and that those counties predisposed to perform better on first-dose vaccination tend slightly to coincide with assignment to the fixed treatment (i.e. be located in Wisconsin), with the opposite being the case for assignment to the Illinois lottery treatment. Altogether, I find that county characteristics cannot be overlooked when attempting to evaluate and draw generalizations about the effectiveness of COVID-19 incentive programs, at least in the context of the three states I sampled.

TABLE 3: EFFECT OF INCENTIVE PROGRAMS ON FIRST-DOSE VACCINATION, BY INCENTIVE TYPE AND COUNTY MAJORITY POLITICS

	Illinois lottery incentive			Wisconsin fixed incentive		
	All counties, no county FE (1)	All counties, county FE (2)	By majority politics, county FE (3)	All counties, no county FE (4)	All counties, county FE (5)	By majority politics, county FE (6)
Incentive	-1.255***	-0.478***		1.753***	0.901***	
	(.150)	(.0669)		(.227)	(.096)	
Incentive x Democrat			1.287***			0.660*
			(.157)			(.295)
Incentive x Republican			-1.210***			0.307***
			(.0619)			(.077)
R^2 statistic	.888	.961	.972	.906	.965	.953
Observations	69,357	69,357	69,357	59,010	59,010	59,010

Notably, the less biased, less noisy model absorbing county fixed effects measures the overall lottery treatment effect to be nearly neutral, which matches the current consensus in the literature that state lottery incentives have not significantly motivated higher rates of first-dose vaccination. I find a largely similar picture for the less researched fixed incentive; it had seemingly only boosted first-dose vaccination rates by less than 1% on average at a time when about 45.7% of Wisconsin's population was still completely unvaccinated (WBay News). When applied to all counties indiscriminately, both the lottery and fixed incentive programs find limited success overall.

b. Impacts by Majority Politics

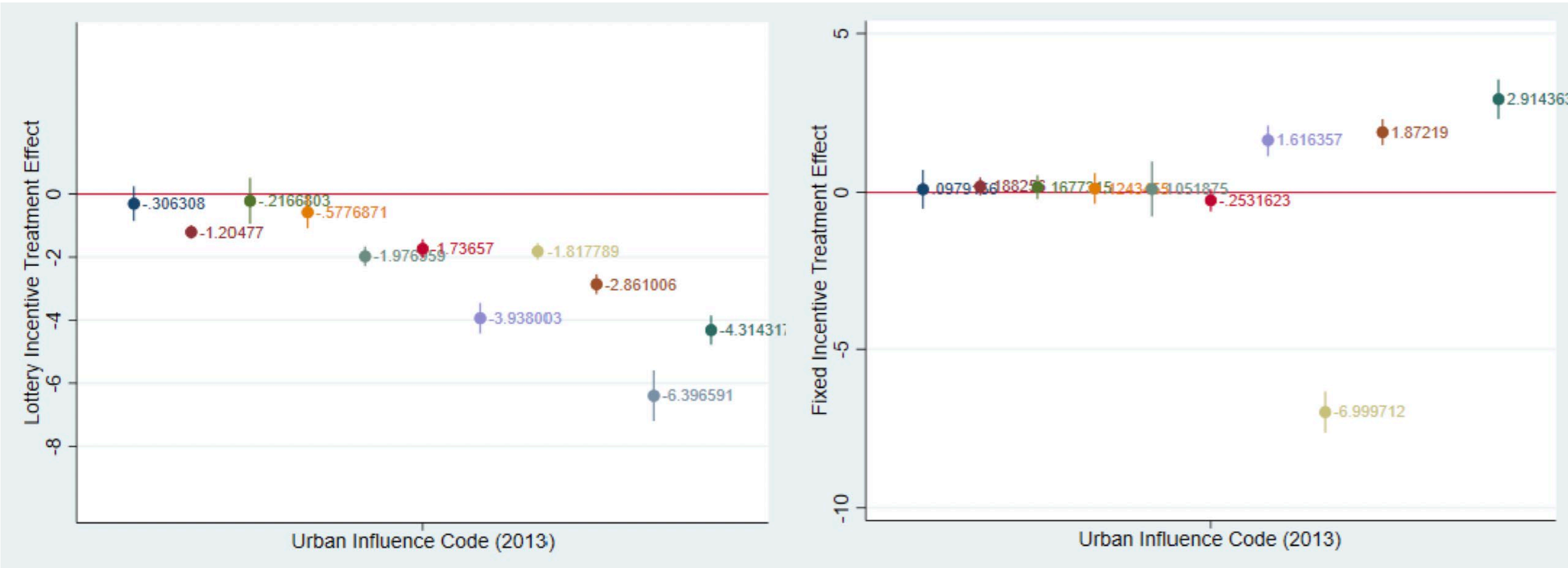
In Table 3, columns 3 and 6, I report estimated impacts of Illinois' and Wisconsin's incentive programs on first-dose vaccination rates among Democrat-majority and Republican-majority counties. While the fixed incentive does not demonstrate significantly differentiated impacts, the lottery incentive appears to have worked in directly opposite directions for Democrat-majority and Republican-majority counties: it improved vaccination rates among Democrat-majority counties by around 1.2% with statistical significance, and reduced vaccination rates among Republican-majority counties by around the same amount, also with statistical significance.

The general political divide in responsiveness to the vaccine incentive is not surprising, as Robertson et al. had also found in their survey experiment that Republican-identifying respondents were less likely to accept any fixed payment in the range of $1000 to $2000 in exchange for getting vaccinated, when compared to the general population, and Democrat-identifying respondents exhibited above average responsiveness to the payment offer (Robertson et al., 2021). However, my results disagrees slightly because they find the effects of lotteries to be polarized but not the effects of fixed incentives. This seeming contradiction may be attributable to several factors however, including the fact that the Robertson et al. study was limited by its low statistical power and self-reporting basis, as well as the different payment sizes that were offered. In behavioral economics, the use of larger payments to encourage participation in voluntary procedures has been found to signal undesirability in those procedures as well as raise participants' risk perception (Volpp et al., 2020; Cryder et al., 2010). Surveys have found that vaccine misinformation is more common among Republicans than Democrats (Hamel et al., 2021), which makes it reasonable that the large payment offered in the Robertson et al. study produced a more negative reaction among Republicans, but the $100 incentive in Wisconsin's program may not have evoked a similar partisan divide in impacts on attitude.

c. Impacts by Urban/Rural Status

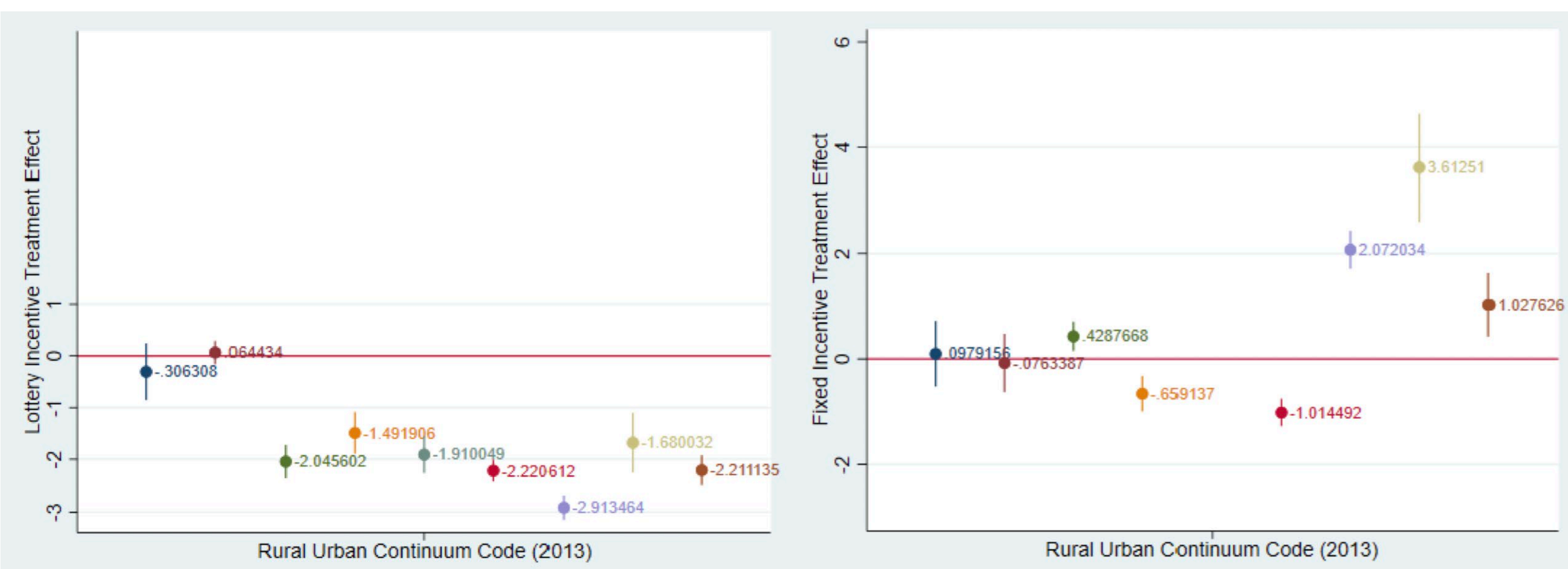
In Figures 1 and 2, I visualize the heterogeneity of treatment effects across different levels of ruralness, as classified by urban influence code and rural-urban continuum code (Appendix 1 and 2). The two systems of measuring ruralness reveal similar insights. The lottery incentive develops an increasingly negative impact on first-dose vaccination rates as counties become more rural, with one of the most rural groups of counties (by the urban influence code classification) experiencing as high as a 6.4% reduction to their baseline vaccine trends on average, as a result of the lottery program. Rural areas have been found to have constrained access to vaccination resources (Rader et al., 2021), which explains their low baseline vaccination trends even while controlling for partisanship, age, and sex (Hamel et al., 2021); however, this observation alone does not provide strong explanation for why the lottery effectively hurt vaccination rates in such areas.

FIGURE 1: HETEROGENEITY OF LOTTERY AND FIXED INCENTIVE TREATMENT EFFECTS, BY URBAN INFLUENCE CODE



Summary: As a county's urban influence code increases (i.e. the county becomes more rural), the lottery incentive has an increasing negative impact on first-dose vaccination rates. For urban influence codes 1 to 6, urban status has a neutral relationship to the incentive's treatment effect, which is null in this range. For codes larger than 6, urban influence code has an overall positive relationship to the treatment effect of the fixed incentive, with one outlier to the trend.

FIGURE 2: HETEROGENEITY OF LOTTERY AND FIXED INCENTIVE TREATMENT EFFECTS, BY RURAL-URBAN CONTINUUM CODE



Summary: As a county's rural-urban continuum code increases (i.e. the county becomes more rural), the lottery incentive has a slightly increasing negative impact on first-dose vaccination rates. Rural-urban continuum code has an inconclusive relationship to the treatment effect of the fixed incentive.

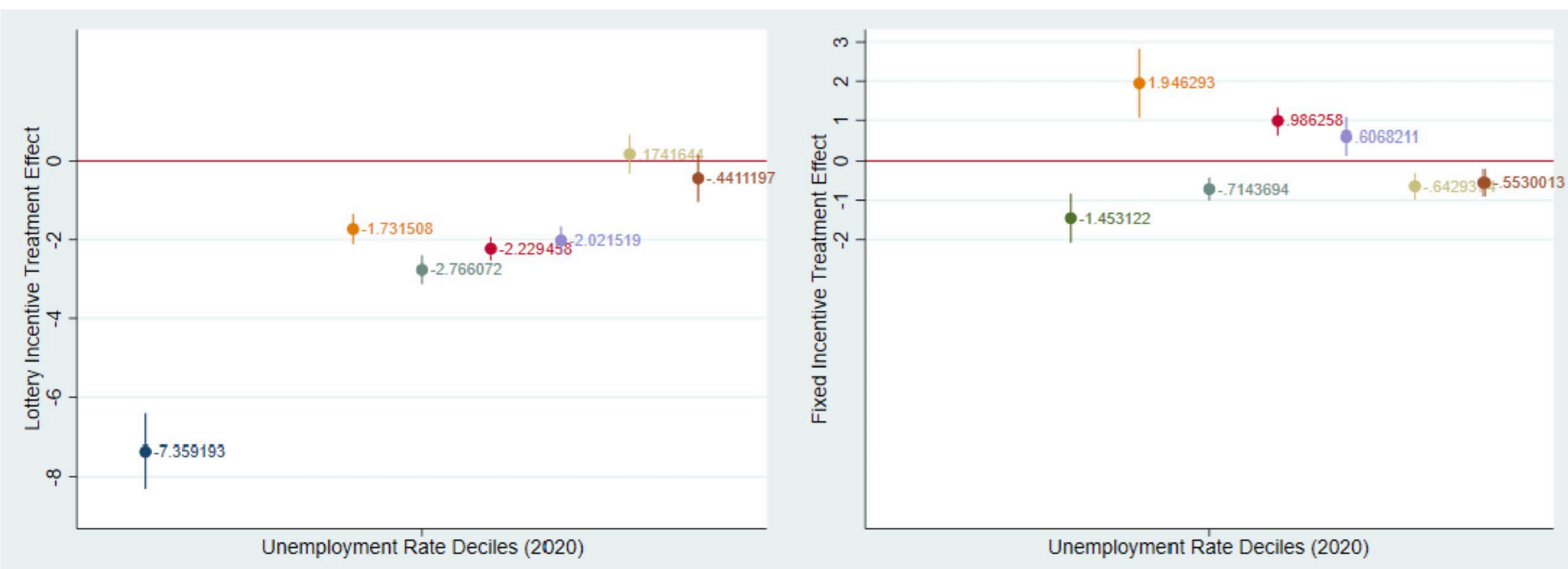
Although the fixed incentive starts to tend slightly toward positive impacts as counties become more rural, the relationship is not consistent. With the urban influence code classification, urban status maintains a neutral relationship for metropolitan and adjacent micropolitan areas. For codes greater than 6, which represent being as or less urban than the description "noncore adjacent to small metro area and contains a town of at least 2,500 residents", the fixed incentive begins to have a more positive effect (save for one outlying group), with the least urban group experiencing up to a 2.91% average increase in vaccination rates. A similar analysis using the rural-urban continuum code classification yields a roughly similar pattern, although with less consistency.

Together, these results suggest that the more rural an area is, the more sensitive its residents are to a) financial incentives in general, as well as b) the design of financial incentives. Vaccine intentions among metropolitan residents are consistently unaffected by either fixed or lottery incentives, while rural residents are significantly and systematically divided in being deterred by the lottery incentive but compelled by the fixed incentive. Notably, this study is limited by the fact that it studies only one example of each incentive type, which leaves room for the potential explanation that the division in impacts for rural residents is not necessarily a matter of generic incentive structure but also each program's specific delivery of the respective incentive structure.

d. Impacts by Unemployment Rate

In Figure 3, I plot the disaggregated estimates of the lottery and fixed incentive treatment effects across deciles of counties by unemployment rate. In counties with lower rates of unemployment, the lottery incentive tends to have more negative impacts on vaccination rates, with the lowest decile observing a 7.34% decrease in first-dose vaccinations as a result of the intervention. The fixed incentive does not appear to have a consistent or meaningful link to changes in vaccination rates.

FIGURE 3: HETEROGENEITY OF LOTTERY AND FIXED INCENTIVE TREATMENT EFFECTS, BY UNEMPLOYMENT RATE DECILE



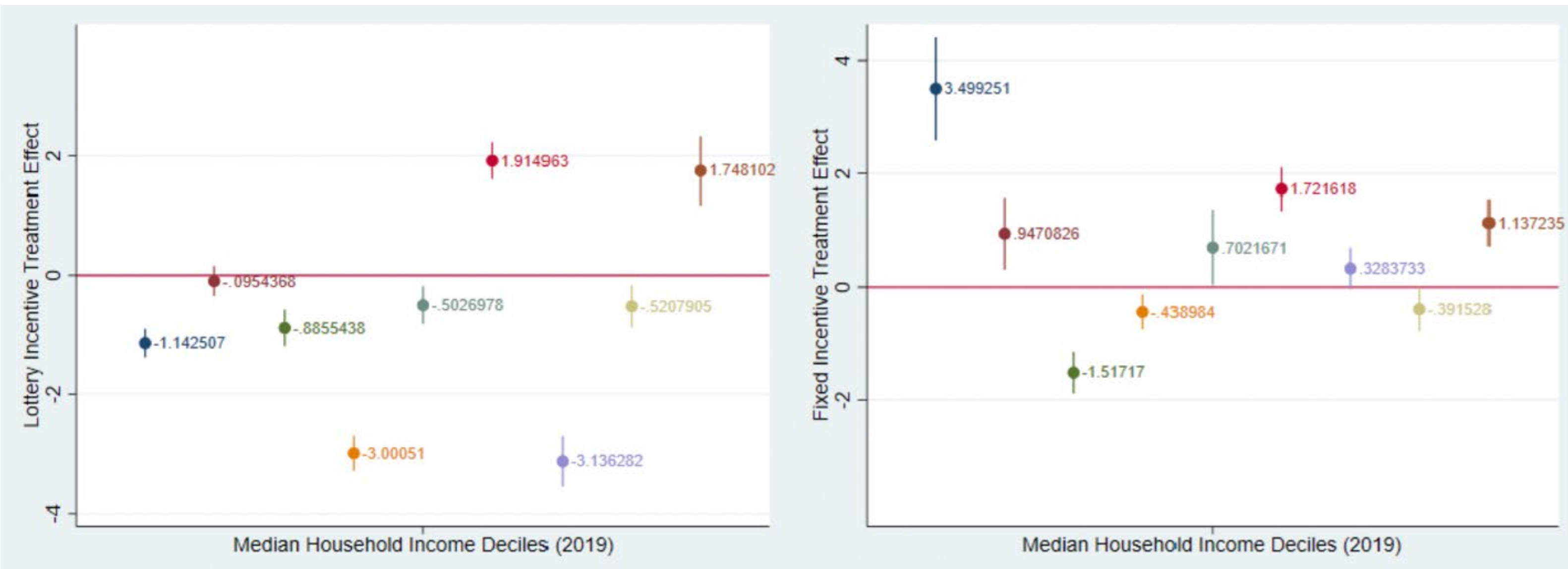
Summary: As a county's unemployment rate increases, the lottery incentive has a decreasing negative impact on first-dose vaccination rates; additionally, it has the most negative impact on counties in the lowest decile of unemployment rates. Unemployment rate has an inconclusive relationship to the treatment effect of the fixed incentive.

With some instances of empirical support (Hoskins et al., 2021), the neoclassical model expects that counties with more residents experiencing higher levels of deprivation should be more motivated by financial incentives. However, assuming that unemployment is a strong proxy for impoverishment, my results do not find evidence for this proposition. On one hand, this could suggest that, as Largent and Miller have argued, the exorbitant, potentially gimmicky campaign of the lottery incentive may have particularly diminished the voluntariness of the most socially vulnerable (including the unemployed) due to their experiences with the pandemic economy (Largent and Miller, 2021). On the other hand, this tension could also suggest that unemployment is in fact a poor approximation of impoverishment, as unemployed individuals are not always unwealthy.

e. Impacts by Median Household Income

In Figure 4, I present the inconsistent association between county median household income and the incentives' treatment effects across both incentive types. The treatment effects on each decile of median household income tend to fluctuate about the null without pattern, suggesting that there lacks a systematic relationship linking regional income with the local effectiveness of the incentives. One notable exception to this observation is the finding that counties in the lowest decile by median household income exhibit a significantly positive effect of a 3.5% increase relative to baseline vaccination trends. Assuming that household income is a strong proxy for wealth, this finding suggests that the neoclassical model of financial incentives may only hold at the most extreme levels of regional deprivation; in other words, unvaccinated individuals in counties where the most households live off the least income were the most motivated by the fixed incentive of $100, possibly because they tend to derive the greatest marginal utility from that payment. The fact that the lottery did not achieve similar effects in the lowest decile of counties suggests that the guaranteed, tangible quality of the fixed incentive may appeal more strongly to this subset of unvaccinated individuals.

FIGURE 4: HETEROGENEITY OF LOTTERY AND FIXED INCENTIVE TREATMENT EFFECTS, BY MEDIAN HOUSEHOLD INCOME DECILE



Summary: Median household income has an inconclusive relationship to the treatment effect of the lottery incentive. The fixed incentive has the greatest positive impact for counties in the lowest decile of median household income; in higher deciles, the link becomes inconsistent.

V. Discussion and Policy Recommendations

a. The Effectiveness of Financial Incentives Is Mixed but Limited

The results of this study find that although financial incentives for COVID-19 vaccination have insignificant impact on vaccination rates overall, they can have larger and more significant effects in specific demographic contexts. The fixed $100 incentive program in Wisconsin improved vaccine rates by up to 3.5% among counties in the lowest decile by median household income, relative to baseline trends among comparable counties in Iowa that could not access the incentive. The effectiveness of the fixed incentive also demonstrates a slightly positive association with county ruralness, with the most rural counties experiencing the greatest impact, though vaccination rates in metropolitan and adjacent micropolitan counties do not demonstrate any significant change attributable to the incentive. The lottery incentive program in Illinois had polarized effects along partisan lines, with counties that lean Democrat on average experiencing positive impacts of around 1.2% on their vaccination rates and those that lean Republican experiencing negative impacts of also around 1.2%. Furthermore, the effectiveness of the lottery incentive demonstrated negative associations with multiple indicators analyzed in this study: the lottery produces an increasingly negative impact on vaccination rates as counties become more rural or experience higher rates of unemployment.

These results suggest for policymakers that, contrary to predictions by the current literature on the ineffectiveness of COVID-19 vaccine incentives, cash incentives can be used to motivate vaccination at moderate rates when they are designed to intentionally target specific demographics. When their effects were disaggregated by indicators chosen for this study, fixed and lottery COVID-19 vaccine incentives were found to boost vaccination rates by up to over 3% among select groups. While this measurement of change is statistically significant, its magnitude is modest next to the sizable vaccine-hesitant population that the incentives were meant to mobilize; as of June 2021, the proportion of the state population without a first dose of the vaccine was 37% and 32% in Wisconsin and Illinois respectively (Gamio and Walker, 2021), over 8 times the maximal increase that this study was only able to find in limited settings. Nonetheless, this study has at least begun to show that the effectiveness of vaccine incentives can vary systematically for different groups, and identifying other demographic traits such as race and education level or interacting multiple demographic traits (e.g. measuring the effect of being in a county that both is rural and has a Republican majority) in future replications of this study may potentially yield larger degrees of impact.

b. Direct Engagement With Specific Barriers Can Be More Effective

Ultimately, this study is limited by the fact that it could measure the causal impact of the incentives but not identify the specific mechanisms that explain their relationship to vaccination outcomes. The literature reveals many tensions in financial incentives' rational and behavioral qualities which contribute to both positive and negative effects, and the findings of this study cannot definitively parse out the mechanisms that dominated over others in each type of context, though they are suggestive of certain theories of change. Given the limited magnitude of positive impacts even with demographic disaggregation, my results overall suggest that absent more robust understandings of the different sources of vaccine-hesitancy in the US and who they affect, lottery and fixed incentives still may not be reliably effective policy tools, and their theoretical proposition as an efficient catch-all solution lacks empirical support.

As the pandemic continues to evolve, efforts to mobilize the remaining unvaccinated population or to promote completion of the vaccination and boosters sequence require further research into the mechanisms that have made the cash incentives of summer 2021 more or less effective among different groups. Since blanket financial incentives have failed to deliver sufficient impact, policymakers must now pursue issue-specific solutions that directly engage stakeholders' various barriers to vaccination, even if they are more costly to implement.

For many groups, attitude barriers that stem from systemic mistrust of public healthcare, misinformation regarding the safety of the vaccine, or lack of awareness on the severity of the pandemic require complex and committed methods of engagement that realistically feasible financial incentives cannot compensate for. A majority of unvaccinated Republicans have already reported staunch resistance against vaccination even for an incentive payment (Colvin and Slodysko, 2021), and my findings show that the lottery hurt vaccine intent among Republican-majority counties. While partisan attitudes are not the only predictor of vaccine resistance, the two are strongly associated: as of February 2022, more than a third of Republican adults with at least one dose of the vaccine reported intentions to “definitely not” get a booster shot, while the prevalence of this response is only 6% and 23% among Democrats and Independents respectively (Hamel et al., 2021). Thus, attitude barriers surrounding the heavily politicized COVID-19 vaccine must be tackled through more effective messaging, awareness campaigns, and collaborative dialogue through trusted messengers for vaccine-resistant communities; existing evidence suggests that the transactional approach of incentives may only alienate these groups and reduce voluntariness.

For others, structural barriers can be addressed with greater resource efficiency when the government focuses on resolving them directly, as opposed to compensating individuals for their inconvenience. For instance, physical accessibility to vaccination is a significant challenge in West Virginia, a state where mountainous terrain and forest cover 78% of the land, and the health system achieved successes through aggressive efforts to distribute pop-up clinics, mobilize vaccination vans, and collaborate with local health departments and faith-based organizations to reach vulnerable groups and communities of color (American Hospital Association). The Illinois lottery incentive gave away $10 million in prizes without significantly motivating vaccination in the state, at times also deterring vaccine intent; the same resources could have been allocated to support structural interventions such as those launched in West

Virginia, which can improve policymakers' control over effective implementation and reduce the likelihood of unintended negative effects or waste (i.e. in the case of the lottery, $10 million was a locked-in expenditure regardless of the resulting turnout).

c. Further Research Is Needed on the Role of External Factors

A secondary observation from my study finds that the external factors captured by the time-varying variable λ_t played a much larger role in explaining county vaccination increases across the board, in comparison to the size of the incentives' treatment effects. In more intuitive terms, baseline vaccination trends in Iowa counties as well as in treatment counties before and after the incentive periods have demonstrated considerable steady, positive change over time that is not attributable to the incentives. While this pattern may be partially explained by the naturally staggered timing of vaccine-embracing individuals seeking out their first doses at different times, with those most inherently eager getting vaccinated earlier and those less enthusiastic taking their time, there may also be other external factors that have played a role in motivating greater vaccine intention over time, and future research parsing apart those effects may suggest evidence for other types of interventions. For instance, underlying factors that may have generally improved vaccine intents over time include the gradual expansions of convenient access, grassroots organizing, restrictions applied to public and private spheres of daily activity, and increased confidence in vaccine safety and effectiveness, among others. The design of my model cannot testify to whether any of these external influences alone was more successful than the lottery and fixed incentives studied, or the extent to which they were attributable to intentional policy choices that could be scaled up. However, my study suggests that cash incentives have explained relatively little of the observed rise in vaccination rates, and further research should pursue other potentially more impactful contributing factors to identify opportunities for effective public intervention.

VI. Conclusion

Despite the gradual rise of vaccination rates around the country, the evolving COVID-19 pandemic continues to pose a serious risk to public health as vaccine and booster hesitation remains prevalent. COVID-19 infection remains one of the leading causes of death in all age groups, and nearly all COVID-19 deaths today occur among unvaccinated individuals (Gamio and Walker, 2021). Adults who are unvaccinated and not recently infected continue to be 23 times more likely to be hospitalized from COVID-19 than those who are fully vaccinated with a booster shot (Danza, 2022), presenting a persistent threat to their own long-term health as well as to health systems and their capacity to treat non-COVID-19 conditions. Yet, as of February 2022, still an all-time high of 16% of the American public insists that they will “Definitely not” get a first dose of the vaccine, while 23% those who have say that they will “Definitely not” get a booster dose (Hamel et al., 2022). Without stronger efforts to expand vaccination among eligible Americans, the SARS-CoV-2 virus’s ability to mutate into more transmissible variants will continue to prolong the pandemic and strain society’s resources, while socially and physiologically vulnerable groups bear the brunt of the consequences.

Cash incentives grew popular during the US’s national experiment on vaccine campaigning in 2021, as many states were drawn to its administrative simplicity and relative affordability. Theoretically, these incentives promised a universal solution that could address most causes of vaccine hesitancy; in practice, however, multiple empirical analyses show that they hardly improved vaccination rates from the baseline trend observed in comparable states that did not use financial incentives. Since the incentives made no significant difference to the overall progression of vaccine intents in the country, the tens of millions of public dollars paid out to lottery winners and those who claimed the fixed cash prizes effectively went to waste.

Using a differences-in-differences method, this study analyzed county-level vaccination data to identify whether certain subsets of counties experienced significant impacts to their vaccination rates as a result of the Illinois lottery incentive and the Wisconsin fixed incentive programs in the summer of 2021, in order to meet the gap in evidence on the potentially demographic-dependent effects of these incentives. I found that counties' responses to the financial incentives did differentiate systematically along the lines of partisan majority, ruralness, unemployment, and (to a limited extent) median household income, and that fixed and lottery incentives contributed to different impacts for various types of counties. However, even though many of the disaggregated treatment effects were statistically significant from the null, they were mostly limited in magnitude and small relative to the size of the unvaccinated population that had to be mobilized at the time.

The literature on financial incentives, their capacity to modify health behavior, and today's vaccine-hesitancy trends joins the findings of this study to suggest that financial incentives cannot reliably affect vaccine intention at scale, regardless of their payout structure, and policy solutions that directly engage the complex and differentiated barriers to vaccine access are critical to expanding COVID-19 vaccination in the US. As frequent booster shots potentially become a key solution to the evolving pandemic, further research and innovation is needed to illuminate the root causes of vaccine-hesitancy so that policymakers can address them with greater control, efficiency, and effectiveness.

VII. Appendix

1. <u>2013 Urban Influence Code</u>

Code	Description
Metropolitan counties	
1	In large metro area of 1+ million residents
2	In small metro area of less than 1 million residents
Nonmetropolitan counties	
3	Micropolitan area adjacent to large metro area
4	Noncore adjacent to large metro area
5	Micropolitan area adjacent to small metro area
6	Noncore adjacent to small metro area and contains a town of at least 2,500 residents
7	Noncore adjacent to small metro area and does not contain a town of at least 2,500 residents
8	Micropolitan area not adjacent to a metro area
9	Noncore adjacent to micro area and contains a town of at least 2,500 residents
10	Noncore adjacent to micro area and does not contain a town of at least 2,500 residents
11	Noncore not adjacent to metro or micro area and contains a town of at least 2,500 residents
12	Noncore not adjacent to metro or micro area and does not contain a town of at least 2,500 residents

Source: US Department of Agriculture Economic Research Service.

2. <u>2013 Rural-Urban Continuum Code</u>

Metro counties:

- 1 (Counties in metro areas of 1 million population or more)
- 2 (Counties in metro areas of 250,000 to 1 million population)
- 3 (Counties in metro areas of fewer than 250,000 population)

Nonmetro counties:

- 4 (Urban population of 20,000 or more, adjacent to a metro area)
- 5 (Urban population of 20,000 or more, not adjacent to a metro area)
- 6 (Urban population of 2,500 to 19,999, adjacent to a metro area)
- 7 (Urban population of 2,500 to 19,999, not adjacent to a metro area)
- 8 (Completely rural or less than 2,500 urban population, adjacent to a metro area)
- 9 (Completely rural or less than 2,500 urban population, not adjacent to a metro area)

VIII. References

Bartik, Alexander, Marianne Bertrand, Guglielmo Briscese, Zoe Cullen, Edward Glaeser, Michael Luca, Christopher Stanton, Patricia van Hissenhoven, Jamil Mirabito, and Manal Saleh. "Small Business COVID-19 Survey Results." *UChicago Poverty Lab*, August 2020.

Bertrand, Marianne, Guglielmo Briscese, Maddalena Grignani, and Salma Nassar. "The Impact of COVID-19 on American Households: Insights From a Longitudinal Survey." *UChicago Poverty Lab*, 2020, 20.

BLS. "Table 6. Selected Paid Leave Benefits: Access." Bureau of Labor Statistics, 2021. https://www.bls.gov/news.release/ebs2.t06.htm.

Bravo, Fernanda, Jingyuan Hu, and Elisa Long. "Optimal COVID-19 Vaccination Facility Location." *SSRN Electronic Journal*, 2022. https://doi.org/10.2139/ssrn.4008669.

Carpio, Carlos E., Ioana A. Coman, Oscar Sarasty, and Manuel García. "COVID-19 Vaccine Demand and Financial Incentives." *Applied Health Economics and Health Policy* 19, no. 6 (November 2021): 871–83. https://doi.org/10.1007/s40258-021-00687-9.

CDC. "COVID-19 Vaccination." Centers for Disease Control and Prevention, April 2, 2022. https://www.cdc.gov/coronavirus/2019-ncov/vaccines/stay-up-to-date.html.

Colvin, Jill, and Brian Slodysko. "In Shift, GOP Ramps up Vaccine Push as Resistance Hardens." AP NEWS, July 23, 2021. https://apnews.com/article/joe-biden-health-government-and-politics-coronavirus-pandemic-0433cfa3b684b50d0c67ed254f8d8c39.

Cox, Daniel A. "Peer Pressure, Not Politics, May Matter Most When It Comes to Getting the COVID-19 Vaccine." *The Survey Center on American Life* (blog), 2021. https://www.americansurveycenter.org/commentary/peer-pressure-not-politics-may-matter-most-when-it-comes-to-getting-the-covid-19-vaccine/.

Cryder, Cynthia E., Alex John London, Kevin G. Volpp, and George Loewenstein. "Informative Inducement: Study Payment as a Signal of Risk." *Social Science & Medicine* 70, no. 3 (February 2010): 455–64. https://doi.org/10.1016/j.socscimed.2009.10.047.

Danza, Phoebe, Tae Hee Koo, Meredith Haddix, Rebecca Fisher, and Elizabeth Traub. "SARS-CoV-2 Infection and Hospitalization Among Adults Aged ≥18 Years, by Vaccination Status, Before and During SARS-CoV-2 B.1.1.529 (Omicron) Variant Predominance — Los Angeles County, California, November 7, 2021–January 8, 2022." *MMWR. Morbidity and Mortality Weekly Report* 71 (2022). https://doi.org/10.15585/mmwr.mm7105e1.

Dave, Dhaval, Andrew I. Friedson, Benjamin Hansen, and Joseph J. Sabia. "Association Between Statewide COVID-19 Lottery Announcements and Vaccinations." *JAMA Health Forum* 2, no. 10 (October 15, 2021): e213117. https://doi.org/10.1001/jamahealthforum.2021.3117.

Elamroussi, Aya. "Some People in Missouri Are Getting Vaccinated in Secret to Avoid Backlash from Loved Ones, Doctor Says." CNN, July 2021. https://www.cnn.com/2021/07/29/health/vaccines-in-secret-missouri/index.html.

FDA. "Emergency Use Authorization." Food and Drug Administration. FDA, April 14, 2022. https://www.fda.gov/emergency-preparedness-and-response/mcm-legal-regulatory-and-policy-framework/emergency-use-authorization.

Furman, Lydia. "Should We Pay Mothers Who Receive WIC to Breastfeed?" *Pediatrics* 139, no. 3 (March 1, 2017): e20163828. https://doi.org/10.1542/peds.2016-3828.

Gamio, Lazaro, and Amy Schoenfeld Walker. "See Which States Are Falling Behind Biden's Vaccination Goal." *The New York Times*, June 3, 2021, sec. U.S. https://www.nytimes.com/interactive/2021/06/03/us/virus-vaccine-states.html.

Gandhi, Linnea, Katherine L. Milkman, Sean Ellis, Heather Graci, Dena Gromet, Rayyan Mobarak, Alison Buttenheim, et al. "An Experiment Evaluating the Impact of Large-Scale, High-Payoff Vaccine Regret Lotteries." *SSRN Electronic Journal*, 2021. https://doi.org/10.2139/ssrn.3904365.

Giles, Emma L., Shannon Robalino, Elaine McColl, Falko F. Sniehotta, and Jean Adams. "The Effectiveness of Financial Incentives for Health Behaviour Change: Systematic Review and Meta-Analysis." Edited by Hamid Reza Baradaran. *PLoS ONE* 9, no. 3 (March 11, 2014): e90347. https://doi.org/10.1371/journal.pone.0090347.

Gorin, M., and H. Schmidt. "'I Did It For the Money': Incentives, Rationalizations and Health." *Public Health Ethics* 8, no. 1 (April 1, 2015): 34–41. https://doi.org/10.1093/phe/phu034.

Haff, Nancy, Mitesh S. Patel, Raymond Lim, Jingsan Zhu, Andrea B. Troxel, David A. Asch, and Kevin G. Volpp. "The Role of Behavioral Economic Incentive Design and Demographic Characteristics in Financial Incentive-Based Approaches to Changing Health Behaviors: A Meta-Analysis." *American Journal of Health Promotion* 29, no. 5 (May 2015): 314–23. https://doi.org/10.4278/ajhp.140714-LIT-333.

Hamel, Liz, Lunna Lopes, Mellisha Stokes, Grace Sparks, and Mollyanne Brodie. "KFF COVID-19 Vaccine Monitor: April 2021." *KFF* (blog), May 6, 2021. https://www.kff.org/coronavirus-covid-19/poll-finding/kff-covid-19-vaccine-monitor-april-2021/.

Hoskins, Katelin, Connie M. Ulrich, Julianna Shinnick, and Alison M. Buttenheim. "Acceptability of Financial Incentives for Health-Related Behavior Change: An Updated Systematic Review." *Preventive Medicine* 126 (September 2019): 105762. https://doi.org/10.1016/j.ypmed.2019.105762.

Johnson, Maxine, Barbara Whelan, Clare Relton, Kate Thomas, Mark Strong, Elaine Scott, and Mary J. Renfrew. "Valuing Breastfeeding: A Qualitative Study of Women's Experiences of a Financial Incentive Scheme for Breastfeeding." *BMC Pregnancy and Childbirth* 18, no. 1 (December 2018): 20. https://doi.org/10.1186/s12884-017-1651-7.

Kahneman, Daniel, and Amos Tversky. "Prospect Theory: An Analysis of Decision under Risk." *Econometrica* 47, no. 2 (March 1979): 263. https://doi.org/10.2307/1914185.

Kreps, Sarah, Nabarun Dasgupta, John S. Brownstein, Yulin Hswen, and Douglas L. Kriner. "Public Attitudes toward COVID-19 Vaccination: The Role of Vaccine Attributes, Incentives, and Misinformation." *Npj Vaccines* 6, no. 1 (December 2021): 73. https://doi.org/10.1038/s41541-021-00335-2.

Largent, Emily A., and Franklin G. Miller. "Problems With Paying People to Be Vaccinated Against COVID-19." *JAMA* 325, no. 6 (February 9, 2021): 534–35. https://doi.org/10.1001/jama.2020.27121.

Mantzari, Eleni, Florian Vogt, and Theresa M. Marteau. "Financial Incentives for Increasing Uptake of HPV Vaccinations: A Randomized Controlled Trial." *Health Psychology* 34, no. 2 (February 2015): 160–71. https://doi.org/10.1037/hea0000088.

Marti, Joachim, Marcus Bachhuber, Jordyn Feingold, David Meads, Michael Richards, and Sean Hennessy. "Financial Incentives to Discontinue Long-Term Benzodiazepine Use: A Discrete Choice Experiment Investigating Patient Preferences and Willingness to Participate." *BMJ Open* 7, no. 10 (October 2017): e016229. https://doi.org/10.1136/bmjopen-2017-016229.

National Academies of Sciences, Engineering, and Medicine. *Increasing Uptake of COVID-19 Vaccination Through Requirement and Incentive Programs*. Washington, D.C.: National Academies Press, 2022. https://doi.org/10.17226/26545.

Niza, Claudia, Caroline Rudisill, and Paul Dolan. "Vouchers versus Lotteries: What Works Best in Promoting Chlamydia Screening? A Cluster Randomized Controlled Trial." *Applied Economic Perspectives and Policy* 36, no. 1 (March 2014): 109–24. https://doi.org/10.1093/aepp/ppt033.

Noordraven, Ernst L., Maartje H. N. Schermer, Peter Blanken, Cornelis L. Mulder, and André I. Wierdsma. "Ethical Acceptability of Offering Financial Incentives for Taking Antipsychotic Depot Medication: Patients' and Clinicians' Perspectives after a 12-Month

Randomized Controlled Trial." *BMC Psychiatry* 17, no. 1 (December 2017): 313. https://doi.org/10.1186/s12888-017-1485-x.

Park, Hee Jin, Soo Hyun Kim, Yong Wook Jung, Sung Shin Shim, Ji Yeon Kim, Yeon Kyung Cho, Antonio Farina, Margherita Zanello, Kyoung Jin Lee, and Dong Hyun Cha. "Screening Models Using Multiple Markers for Early Detection of Late-Onset Preeclampsia in Low-Risk Pregnancy." *BMC Pregnancy and Childbirth* 14, no. 1 (December 2014): 35. https://doi.org/10.1186/1471-2393-14-35.

Parker, Kim, Rachel Minkin, and Jesse Bennett. "Economic Fallout From COVID-19 Continues To Hit Lower-Income Americans the Hardest." *Pew Research Center's Social & Demographic Trends Project* (blog), September 24, 2020. https://www.pewresearch.org/social-trends/2020/09/24/economic-fallout-from-covid-19-continues-to-hit-lower-income-americans-the-hardest/.

Priebe, Stefan, Stephen A Bremner, Christoph Lauber, Catherine Henderson, and Tom Burns. "Financial Incentives to Improve Adherence to Antipsychotic Maintenance Medication in Non-Adherent Patients: A Cluster Randomised Controlled Trial." *Health Technology Assessment* 20, no. 70 (September 2016): 1–122. https://doi.org/10.3310/hta20700.

Rader, Benjamin, Christina M Astley, Karla Therese L Sy, Kara Sewalk, Yulin Hswen, John S Brownstein, and Moritz U G Kraemer. "Geographic Access to United States SARS-CoV-2 Testing Sites Highlights Healthcare Disparities and May Bias Transmission Estimates." *Journal of Travel Medicine* 27, no. 7 (November 9, 2020): taaa076. https://doi.org/10.1093/jtm/taaa076.

Robertson, Christopher, Daniel Scheitrum, Aleks Schaefer, Trey Malone, Brandon R McFadden, Kent D Messer, and Paul J Ferraro. "Paying Americans to Take the Vaccine—Would It

Help or Backfire?" *Journal of Law and the Biosciences* 8, no. 2 (August 1, 2021): lsab027. https://doi.org/10.1093/jlb/lsab027.

Robertson, Christopher T, K Aleks Schaefer, Daniel Scheitrum, Sergio Puig, and Keith Joiner. "Indemnifying Precaution: Economic Insights for Regulation of a Highly Infectious Disease." *Journal of Law and the Biosciences* 7, no. 1 (July 25, 2020): lsaa032. https://doi.org/10.1093/jlb/lsaa032.

Rosenblum, Hannah G., Julianne Gee, Ruiling Liu, Paige L. Marquez, Bicheng Zhang, Penelope Strid, Winston E. Abara, et al. "Safety of MRNA Vaccines Administered during the Initial 6 Months of the US COVID-19 Vaccination Programme: An Observational Study of Reports to the Vaccine Adverse Event Reporting System and v-Safe." *The Lancet Infectious Diseases* 0, no. 0 (March 7, 2022). https://doi.org/10.1016/S1473-3099(22)00054-8.

Sato, Ryoko, and Benjamin Fintan. "Effect of Cash Incentives on Tetanus Toxoid Vaccination among Rural Nigerian Women: A Randomized Controlled Trial." *Human Vaccines & Immunotherapeutics* 16, no. 5 (May 3, 2020): 1181–88. https://doi.org/10.1080/21645515.2019.1672493.

Siese, April. "New York, Maryland and Oregon Announce COVID-19 Vaccine Lottery Promotions," May 2021. https://www.cbsnews.com/news/covid-vaccine-lottery-new-york-maryland/.

Thomson, Gill, Heather Morgan, Nicola Crossland, Linda Bauld, Fiona Dykes, Pat Hoddinott, and on behalf of the BIBS team. "Unintended Consequences of Incentive Provision for Behaviour Change and Maintenance around Childbirth." Edited by Jacobus van Wouwe.

PLoS ONE 9, no. 10 (October 30, 2014): e111322. https://doi.org/10.1371/journal.pone.0111322.

Tressler, Stacy, and Ruchi Bhandari. "Interventions to Increase Completion of Hepatitis B Vaccination in People Who Inject Drugs: A Systematic Review and Meta-Analysis." *Open Forum Infectious Diseases* 6, no. 12 (December 1, 2019): ofz521. https://doi.org/10.1093/ofid/ofz521.

Volpp, Kevin G., George Loewenstein, and Alison M. Buttenheim. "Behaviorally Informed Strategies for a National COVID-19 Vaccine Promotion Program." *JAMA*, December 14, 2020. https://doi.org/10.1001/jama.2020.24036.

Walkey, Allan J., Anica Law, and Nicholas A. Bosch. "Lottery-Based Incentive in Ohio and COVID-19 Vaccination Rates." *JAMA* 326, no. 8 (August 24, 2021): 766. https://doi.org/10.1001/jama.2021.11048.

WBAY news. "COVID-19 Case Numbers, Vaccination Rates Both Rising." https://www.wbay.com. Accessed April 18, 2022. https://www.wbay.com/2021/08/27/covid-19-cases-vaccinations-both-rising/.

Wertheimer, A., and F. G. Miller. "Payment for Research Participation: A Coercive Offer?" *Journal of Medical Ethics* 34, no. 5 (May 1, 2008): 389–92. https://doi.org/10.1136/jme.2007.021857.

Wolff, J. "Paying People to Act in Their Own Interests: Incentives versus Rationalization in Public Health." *Public Health Ethics* 8, no. 1 (April 1, 2015): 27–30. https://doi.org/10.1093/phe/phu035.