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## **Long-term cultural barriers to sustaining collective effort in vaccination against COVID-19**

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# **Long-term cultural barriers to sustaining collective effort in vaccination against COVID-19**

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## **Abstract**

This study attempts to shed light on long-term cultural barriers to strengthening collective action in COVID-19 vaccination. I propose that rugged individualism, characterized by emphasis on self-reliance and strong antipathy to government intervention, is linked to a greater prevalence of resistance to inoculation against the novel coronavirus across American counties. The main hypothesis of this paper rests upon the premise that a culture of rugged individualism is conducive to the emergence and persistence of mistrust, political polarization and distrust in science, which undermine collective effort in vaccination. Using subnational data for the United States, I consistently find evidence that rugged individualism, captured by long-run exposure to the westward-moving frontier in American history, has a positive influence on the predicted share of the population that is hesitant towards voluntary vaccination against COVID-19. In addition, individualistic counties tend to suffer from under-vaccination, captured by lower rates of the population that has been fully inoculated against COVID-19. More broadly, the findings suggest that rugged individualism is an impediment to resolving collective action problems, notwithstanding the widely acknowledged positive impact of individualistic cultures on innovation and long-run economic performance.

**JEL classification:** D62, D70, I10, N41, O51.

**Keywords:** COVID-19 vaccination, Vaccine hesitancy, Collective action, Individualism, Culture, American frontier, Long-run development.

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## 1. Introduction

The COVID-19 pandemic has led to substantial loss of human life and severe disruptions in socio-economic activities worldwide (Brodeur et al., 2021). Immunization remains one of the most effective public health interventions that help achieve herd immunity against COVID-19. However, resistance to voluntary vaccination has emerged in many societies across the globe, which is a major threat to ending the global pandemic (Schmelz & Bowles, 2021).

Prior to the COVID-19 pandemic, the World Health Organization considered vaccine hesitancy as one of the top ten threats to global health in 2019.<sup>1</sup> Recent studies provide suggestive evidence of substantial variation in COVID-19 vaccination opposition across and within world economies (see, for example, Lazarus et al., 2021; Schmelz & Bowles, 2021). In addition, vaccination resistance tends to persist in many parts of the United States, which appears as one of the most serious barriers to tackling the current health crisis (Khubchandani et al., 2021). During the early phases of the vaccination rollout in the United States, anti-vaccine activists forced one of the country's largest vaccination centers to close temporarily (Kornfield, 2021). Thanks to significant investments in the development and production of vaccines, the United States was leading the world in terms of the proportion of the population vaccinated against COVID-19 during the initial rollout (Scott, 2021). However, as of September 2021, the US ranks 57<sup>th</sup> in the world in vaccination rates, according to Bloomberg's vaccine tracker. Part of the explanation for the slowdown in the pace of vaccination is the persistence and pervasiveness of vaccination resistance, which threatens to undermine the US recovery from the COVID-19 pandemic. In this regard, a better understanding of socio-economic characteristics that inhibit or encourage inoculation against the coronavirus is key to implementing a comprehensive and effective vaccination campaign.

The above discussion underlines the importance of understanding the driving forces of vaccination support. Nevertheless, a systematic analysis of long-term (cultural) barriers to sustaining collective action in COVID-19 vaccination, particularly in the United States, remains hard to find. Against this backdrop, this paper attempts to provide a plausible explanation for cross-county differences in COVID-19 vaccination opposition in the United States. More specifically, I propose that vaccination confidence has its roots in a culture of "rugged individualism", characterized by its emphasis on personal autonomy and

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<sup>1</sup> According to MacDonald (2015), vaccine hesitancy refers to "delay in acceptance or refusal of vaccination despite availability of vaccination services".

achievements, and strong opposition to government intervention and redistribution (Bazzi et al., 2020). As put forward by Bazzi et al. (2020), contemporary counties differ significantly in the level of rugged individualism, depending on long-term exposure to a westward-moving frontier in American history. This proposition builds upon an early study by Turner (1893) who proposes the well-known “Turner hypothesis” that historical experience with the American frontier, which divided settled and unsettled areas, was conducive to the emergence and persistence of cultural traits of self-reliance and strong antipathy to state intervention. Bazzi et al. (2020) advance this hypothesis and empirically establish that frontier experience is highly predictive of cross-county differences in individualistic traits of self-dependence. In addition, exposure to the American frontier is strongly associated with a prevalence of opposition to redistributive policies and measures, and widespread mistrust in state intervention (Bazzi et al., 2020). These findings provide support for the role of historical frontier experience in shaping the divergence in cultural traits of rugged individualism across American counties. As predetermined in American history, rugged individualism may provide a plausibly exogenous source of variation in contemporary resistance to COVID-19 vaccination. This points to the desirability of exploiting a historically determined measure of cultures to explain the prevalence of vaccine acceptance.

Building upon the updated collective action theory developed by Ostrom (2000), I argue that vaccination opposition tends to prevail in individualistic counties. It follows from this hypothesis that rugged individualism is an impediment to sustaining collective action in COVID-19 vaccination. The central hypothesis of this paper rests upon the premise that attempts at fostering cooperation in achieving community immunity against COVID-19 entail key features of collective action problems (Brito et al., 1991; Siegal et al., 2009; Mamani et al., 2013; Chen & Toxvaerd, 2014; White, 2021). The underlying intuition is that collective participation in vaccination programs is primarily hindered by a temptation to “free ride” on possible herd immunity (Ostrom, 2000; Siegal et al., 2009; Ibuka et al., 2014; Ferguson, 2020). This relates to an expectation that unvaccinated people can enjoy the benefits of protection provided by others being vaccinated (Bauch & Earn, 2004; Siegal et al., 2009; Ibuka et al., 2014). However, herd immunity is infeasible if a certain proportion of the population refrains from vaccination. Thus, promoting COVID-19 vaccination requires strong collective action. Collectivistic cultures that favor conformity, interdependence and cooperation are associated with greater cooperative behaviors in vaccination when people place emphasis on collective interests. By contrast, individualistic societies, through rewarding personal freedom and self-

dependence, may find it difficult to foster socially optimal behaviors due to the absence of collective efforts. On this basis, I postulate that counties with greater frontier experience tend to suffer from collective inaction in COVID-19 vaccination rollout, leading to a more prevalence of vaccination opposition. In addition to the direct influence of cultural traits on vaccination support, rugged individualism can translate into the cross-county variation in resistance to vaccination through multiple testable pathways, as articulated below.

First, American counties with greater exposure to the westward-moving frontier are characterized by *lack of civic capital*, which undermines collective action in COVID-19 vaccination. It is widely established that rational egoism, which refers to individuals' propensity to pursue their self-interests without internalizing externalities associated with their actions, hinders cooperation in resolving the tragedy of the commons (Olson, 1965; Hardin, 1968). More recently, Ostrom (2000) suggests that cooperative behaviors in a social dilemma situation can be strengthened by reciprocal trust, in which people tend to cooperate if they believe that the other stakeholders are trustworthy. By contrast, concerns about other individuals acting as free riders limit the extent to which societies can collectively achieve socially optimal outcomes. Therefore, civic capital, including pro-social preferences for reciprocity, trust, cooperation, and collective interests, is of importance when it comes to identifying effective responses to the COVID-19 pandemic, including vaccination rollout. It follows from this line of reasoning that resistance to collective vaccination is less likely to emerge when individuals care about collective interests and expect that most other people will cooperate. Turner (1893) propose that frontier experience acquired in American history was conducive to the emergence of cultural traits of self-reliance and independence because these characteristics of rugged individualism were key to the survival of frontier settlers. Therefore, rugged individualism, by rewarding autonomy and personal achievements, undermines social norms of coordination, making it more difficult to sustain collective action in vaccination. It is widely established that mistrust in the government, including health authorities and experts, is a major determinant of under-vaccination due to concerns about vaccine safety and efficacy (Larson et al., 2018; Stoop et al., 2021). Consistent with this viewpoint, the persistence of anti-statism in frontier counties may provide an explanation for a prevalence of vaccination opposition. To the extent that vaccination coverage critically requires government intervention, antipathy to control and anti-social preferences retard collective action in vaccination.

Second, I propose that rugged individualism exerts a positive influence on vaccination opposition through shaping *political partisanship*. This proposition draws on recent

contributions to understanding the role of partisanship in driving responses to the COVID-19 pandemic in the United States. Several studies document that Republican voters, relative to their Democratic counterparts, are more likely to downplay the importance of social distancing (Allcott et al., 2020), the use of face masks (Milosh et al., 2020), and the severity of COVID-19 (Barrios & Hochberg, 2021). Accordingly, exposure to contrasting sources of information about the pandemic accounts for the divergence in behaviors and beliefs about the COVID-19 pandemic between Republicans and Democrats (Allcott et al., 2020; Barrios & Hochberg, 2021).<sup>2</sup> Barrios and Hochberg (2021) also reveal that Republican supporters tend to reject mainstream views, including beliefs and risk perceptions about COVID-19. This offers an additional explanation for why Republican voters are less likely to follow voluntary social distancing measures, and exhibit greater opposition to public policy response to collective risks (Allcott et al., 2020; Milosh et al., 2020; Barrios & Hochberg, 2021; Painter & Qiu, 2021). Consistent with the theoretical model developed by Allcott et al. (2020), the partisan gaps in beliefs about the danger of the COVID-19 pandemic are key to forming the divergence in behaviors and actions adopted by Democrats and Republicans during crises, including vaccination support. Bazzi et al. (2020) find that frontier experience led to growing political polarization in the United States between 2000 and 2016, evidenced by higher public support for the Republican Party. The divergence in political ideologies is mainly driven by a transition towards less government intervention adopted by Republican leaders, including health and welfare policies (Bazzi et al., 2020). In other words, the Republican Party has experienced significantly higher support in frontier counties by aligning their policies with anti-statism ideologies of rugged individualism. These narratives underlie the logic that rugged individualism transmits to more prevalence of collective inaction in COVID-19 vaccination via promoting political partisanship across American counties.

Finally, *mistrust in science* is a final mechanism underlying the extent to which rugged individualism impedes coordination in COVID-19 vaccination programs. Previous studies facilitate our understanding of why rugged individualism is conducive to science skepticism. For example, distrust in science is regarded as a reflection of antipathy to hierarchies and elites (Shannon, 1977; Bazzi et al., 2021). This suggests that science skepticism tends to prevail in

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<sup>2</sup> There have been wide discrepancies in public information related to the COVID-19 pandemic along partisan lines in the United States (Allcott et al., 2020). While Democratic officials have placed emphasis on severe risks of the pandemic, Republican leaders and President Donald Trump have sometimes downplayed the seriousness of the pandemic (Beauchamp, 2020; Coppins, 2020; McCarthy, 2020). The same divergence has been observed in partisan media (Aleem, 2020).

frontier counties due to the persistence of strong opposition to government intervention and redistribution – key features of rugged individualism (Bazzi et al., 2020). In addition, Kahan et al. (2011) argue that individuals tend to formulate risk perceptions consistent with their values. This provides an explanation for the sharp and persistent divergence in beliefs about various scientific consensus views in the general population, including the existence of climate change and the severity of the COVID-19 pandemic. Therefore, rugged individualism, by rewarding cultural traits of non-conformity and anti-statism, fosters the emergence and persistence of distrust in science. Thus, counties with lack of trust in scientists, health authorities and the government tend to suffer from under-vaccination driven by growing concerns or misinformation about vaccine safety and effectiveness (Larson et al., 2018). Given that vaccine-related knowledge appears to be highly sophisticated for non-specialists, trust in science and scientists offers a reliable basis for individuals to assess the safety, effectiveness and importance of inoculation (Sturgis et al., 2021). Science skepticism reduces the probability that individuals rely on evidence-based decision-making processes when it comes to participating in vaccination campaigns (Sturgis et al., 2021). As such, resistance to vaccination is likely to arise from possibly inappropriate assessments of vaccine-related risks and benefits, based on costly and error-prone cognitive processes. Therefore, a successful collective effort in vaccination is more difficult to achieve in frontier counties due to distrust in science.

To preview the main empirical findings, I consistently find evidence that cultural traits of rugged individualism are associated with a greater prevalence of vaccination opposition in the United States. The baseline estimates retain their economic and statistical significance when accounting for numerous confounding factors and potential selection bias from unobservables. Moving closer towards a causal interpretation, I exploit a measure of climate-induced shocks to the westward-moving frontier driven by immigrants flows to the United States as an instrument for rugged individualism. Accordingly, increases in the plausibly exogenous part of individualistic cultures have a positive influence on resistance to COVID-19 vaccination. I also demonstrate that partisanship polarization mediates the extent to which rugged individualism transmits to the prevalence of vaccination opposition in the United States.

The remainder of the study is structured as follows. Section 2 provides a brief review of the related literature and highlights key contributions of this paper. Sections 3 and 4 provide a detailed description of the data and identification methods. Section 5 contains empirical estimates of the long-term effect of rugged individualism on vaccination opposition. Section 6 presents evidence on potential mechanisms of transmission. Section 7 concludes.

## 2. Related literature

This research contributes to a well-established line of inquiry that seeks to understand the persistent influence of cultural characteristics on comparative socio-economic development. Specifically, an emerging body of research in economics investigates why countries differ sharply in economic prosperity (Spolaore & Wacziarg, 2013).<sup>3</sup> A prominent explanation for the global divergence in economic performance relates to the fundamental role of the cultural dimension of individualism/collectivism in driving technological innovation and productivity growth. The basic intuition is that novel and innovative technologies tend to proliferate in individualistic societies that incentivize innovation by rewarding social status to personal autonomy and accomplishments (Mokyr, 1990; Markus & Kitayama, 1991). By contrast, collectivistic cultures discourage (unconventional) innovators through hindering the pursuit of novel ideas and emphasizing conformity (Mokyr, 1990; Markus & Kitayama, 1991). On this basis, collectivistic societies could end up being more underdeveloped, compared to their individualistic counterparts.

On the empirical side, Gorodnichenko and Roland (2017), by undertaking cross-country analyses, document strong evidence that individualistic cultures are conducive to long-run economic growth via fostering national innovative capacity and inclusive institutions. In a similar vein, other scholars find that individualism has a positive influence on economic development through improving the quality of institutions (Williamson & Kerekes, 2011; Kyriacou, 2016; Nikolaev & Salahodjaev, 2017), fostering an egalitarian distribution of income (Nikolaev et al., 2017), reducing gender inequality (Davis & Williamson, 2019), and strengthening innovative entrepreneurship (Assmann & Ehrl, 2021). More recently, Cai et al. (2020) indicate that collectivistic countries, relative to their individualistic counterparts, tend to experience higher levels of deforestation due to weaker property rights. In an attempt to trace the deep roots of democratization, Gorodnichenko and Roland (2021) suggest that collectivism, characterized by its emphasis on conformity and strong disinclinations towards radical institutional reforms, is associated with a lower probability of evolving towards democracy.

Overall, the existing literature establishes the positive impact of individualistic cultures on economic development across the world. However, our understanding of the extent to which

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<sup>3</sup> Previous studies put a premium on the long-term effect of deeply rooted factors on long-run economic development, including geographical, institutional, cultural and human characteristics (see, for example, Acemoglu et al., 2001; Bockstette et al., 2002; Sachs, 2003; Rodrik et al., 2004; Spolaore & Wacziarg, 2009; Ashraf & Galor, 2013; Gorodnichenko & Roland, 2017; Owen, 2017).



individualism matters for the ability to resolve collective action problems remains limited. While the cultural dimension of individualism strengthens innovative activities, it plausibly undermines coordination in social dilemmas by encouraging individuals to pursue their self-interests. Against this background, this research contributes to previous studies by exploring the contribution of individualism to collective action, based on variation in resistance to COVID-19 vaccination across counties in the United States. An improved understanding of the long-term legacy of individualism for coordination failures helps formulate relevant policies during crises. In contrast to most previous studies, this paper focuses on the negative impact of individualism on long-run economic performance through undermining collective action during socio-economic crises. As such, fostering sustainable economic development critically requires attention to a potential trade-off between innovation and coordination failures in crises driven by individualistic cultures. An additional distinguishing feature of this study lies in its investigation of the relationship between cultural traits and collective action in vaccination at the regional level in the United States. Given that American counties are subject to largely similar markets and institutions, a subnational analysis within a single large economy helps controls for numerous confounding factors that could explain away the relationship between cultures and development outcomes.

Additionally, this paper belongs to a rapidly growing empirical literature that attempts to explain variation in the consequences of COVID-19 and the pattern of responses to the global pandemic across world economies and American regions (see Brodeur et al., 2021 for a comprehensive review). Using cross-country data, Ozkan et al. (2021) establish that countries with greater climate risk, less preparedness for changing climate conditions, and individualistic cultures tend to suffer from severe consequences of the COVID-19 pandemic, measured by confirmed COVID-19 fatalities as a proportion of the number of total confirmed cases. The divergence in responses to the COVID-19 pandemic in the United States has also received much attention. Several scholars argue that social capital (Barrios & Hochberg, 2021), political polarization (Allcott et al., 2020; Milosh et al., 2020; Barrios & Hochberg, 2021; Painter & Qiu, 2021), and science skepticism (Brzezinski et al., 2020) are key driving forces of risk perceptions and compliance with social distancing measures across American counties. In addition, a recent study by Bazzi et al. (2021) examines the extent to which the cultural dimension of individualism matters for compliance with social distancing and mask wearing in the United States. It documents evidence that individualistic counties are characterized by weaker responses to the COVID-19 pandemic. In a similar vein, Bian et al. (2021) indicate that

American counties with greater exposure to the westward-moving frontier find it difficult to foster compliance with social distancing measures that help contain the novel coronavirus. Other studies provide suggestive evidence of the importance of ethnic diversity (Egorov et al., 2021) and social capital (Durante et al., 2021) in affecting mobility reduction in response to the COVID-19 pandemic in Russia and Italy.

As reviewed by Brodeur et al. (2021), existing studies in the COVID-related literature have predominantly focused on the fundamental role of socio-economic characteristics in shaping individuals' compliance with social distancing measures. To my knowledge, little attention, if any, has been given to exploring factors driving collective action in COVID-19 vaccination. There exists ample evidence of positive externalities of vaccination (Brito et al., 1991; White, 2021). Hence, fostering vaccination coverage offers one of the most promising prospects for ending the current global health crisis. In this regard, a better understanding of the fundamental drivers of vaccination is relevant for formulating policies that promote recovery from the COVID-19 pandemic. It is also widely acknowledged that coordination failures are a major barrier to sustaining vaccination coverage (Siegal et al., 2009; Mamani et al., 2013; Chen & Toxvaerd, 2014). This paper sheds light on the existing literature by documenting evidence that rugged individualism, deeply rooted in American history, fundamentally drives collective inaction in COVID-19 vaccination in the United States.

As mentioned above, the main inquiry of this paper draws on recent empirical studies by Bazzi et al. (2021) and Bian et al. (2021) arguing that individualism is an impediment to sustaining collective action during the COVID-19 pandemic in the United States. A major distinguishing aspect of this study is that it attempts to provide a plausible explanation for considerable and persistent variation in vaccination opposition in the United States. In addition, I employ numerous empirical methods to achieve a causal interpretation of the relationship between rugged individualism and vaccination resistance. Another contribution of this paper is to use up-to-date data on vaccination coverage across American counties to identify the cultural origins of under-vaccination. This research also extends the existing literature by providing empirical evidence that political partisanship is a key mechanism underlying the extent to which rugged individualism impedes collective effort in COVID-19 vaccination.

It is noteworthy that Bian et al. (2021) document some evidence of the relationship between individualism and vaccine hesitancy in the United States. However, the main interest of Bian et al. (2021) lies in understanding the extent to which individualism transmits to cross-county differences in compliance with social distancing measures. Hence, the current study is

the first attempt to provide a systematic analysis of the long-term legacy of cultural traits for COVID-19 vaccination opposition. In contrast to Bian et al. (2021), I use a nationally representative and up-to-date dataset on county-level vaccine hesitancy, constructed based on survey data from the Census Bureau’s Household Pulse Survey between May 26 and June 7, 2021. This potentially offers a more comprehensive understanding of the relationship between cultures and resistance to vaccination in the United States.

### **3. Data description**

#### ***Rugged individualism***

Following Bazzi et al. (2020), I use a measure of total frontier experience to capture the variation in rugged individualism across counties in the United States. The frontier experience index reflects historical exposure to the westward-moving frontier between 1790 and 1890. Figure 1 illustrates the cross-county variation in total frontier experience, in which darker counties are characterized by a greater prevalence of cultural traits of rugged individualism.

Following Porter et al. (1890) and Turner (1893), Bazzi et al. (2020) track the expansion of the American frontier, defined as a border beyond which population density is less than two people per square mile. For each year across the period 1790 – 1890, Bazzi et al. (2020) identify counties exposed to frontier life as those with geographic proximity to the frontier margin (within 100km) and population density falling below six people per square mile. On this basis, accumulated frontier experience corresponds to the number of decades spent in the American frontier belt, with higher values corresponding to a greater prevalence of rugged individualism within a modern county (Turner, 1893; Bazzi et al., 2020). Consistent with the definition of the American frontier proposed by Porter et al. (1890) and Turner (1893), this historically determined measure of culture encapsulates two key characteristics of frontier life: isolation from urban centers and population sparsity. These geographic conditions made frontier life “rough, crude, hard, and dangerous” with limited social infrastructure and the absence of interaction with the federal government (Overmeyer, 1944; Bazzi et al., 2020). In this regard, cultural traits of non-conformity and inventiveness were conducive to forming the resourcefulness of people living at the frontier (Shannon, 1977; Stewart, 2006). This led to the emergence and persistence of the cultural dimension of rugged individualism, which represents a combination of self-dependence and strong opposition control. As established by Bazzi et al. (2020), there are two main mechanisms underlying the intergenerational transmission of cultural traits of rugged individualism in frontier counties. First, self-reliant and innovative

settlers had a greater probability of survival and success in rough and dangerous frontier life (Shannon, 1977; Kitayama et al., 2010). Second, due to selective migration, individualistic settlers were attracted to frontier societies, thereby contributing to the pervasiveness of rugged individualism in frontier counties (Bazzi et al., 2020).

### ***COVID-19 vaccination opposition rates***

To capture cross-county differences in resistance to COVID-19 vaccination, I employ a measure of predicted vaccine hesitancy rates provided by the Assistant Secretary for Planning and Evaluation (ASPE) of the Department of Health and Human Services.<sup>4</sup> Figure 2 depicts the cross-county variation in COVID-19 vaccination opposition, in which darker areas are characterized by lack of cooperation in collective vaccination.

ASPE relies on survey data from the Census Bureau’s Household Pulse Survey (HPS), collected from May 26 through June 7, 2021, to estimate the rates of vaccine hesitancy in the United States. HPS is a nationally representative dataset on the impacts of the COVID-19 pandemic on American residents’ lives. In addition to socio-demographic and geographic information, HPS data collected in Week 31 of Phase 3.1 contain information on survey respondents’ resistance to COVID-19 vaccines. More specifically, survey participants were asked to respond to the following question “*Once a vaccine to prevent COVID-19 is available to you, would you ... get a vaccine?*”. Responses to this interview question include (1) “*definitely get a vaccine*”, (2) “*probably get a vaccine*”, (3) “*unsure*”, (4) “*probably not get a vaccine*”, and (5) “*definitely not get a vaccine*”.<sup>5</sup> Next, ASPE follows a two-stage regression analysis to predict the rates of vaccination opposition at the county level. In particular, the first-stage regression involves estimating key socio-demographic and economic factors shaping survey respondents’ attitudes towards COVID-19 vaccination, based on HPS survey data. In the second-stage analysis, ASPE, by exploiting the empirical estimates derived from the previous analysis, predicts vaccination attitudes for survey participants aged 18 years and older in the Census Bureau’s American Community Survey in 2019. The estimated results are averaged across individuals within a county to obtain a measure of predicted rates of vaccination opposition. This offers a nationally representative dataset of estimated rates of resistance to COVID-19 vaccination across American counties.

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<sup>4</sup> Data on vaccine resistance rates, available at the state and county level, can be accessed via this link (<https://aspe.hhs.gov/reports/vaccine-hesitancy-covid-19-state-county-local-estimates>).

<sup>5</sup> According to ASPE, survey participants with no response are excluded from the construction of vaccine hesitancy indicators. Furthermore, people who had taken a COVID-19 vaccine were considered “not hesitant”.

For ease of comparison, I adopt three measures of predicted vaccination opposition at the county level. *Strongly hesitant* is the proportion of people they would “definitely not” get a COVID-19 vaccine. *Hesitant* captures the estimated share of residents who would “definitely not” or “probably not” get a COVID-19 vaccine. *Hesitant or Unsure* represents the fraction of people who would “definitely not” or “probably not” get a vaccine, or be “unsure” about their intention to take COVID-19 vaccines. These indicators capture different levels of resistance to COVID-19 vaccination, with higher values corresponding to greater vaccine hesitancy. One could expect that counties characterized by higher rates of resistance to voluntary vaccination find it difficult to implement a comprehensive and effective campaign of vaccination rollout, evidenced by lower inoculation rates. Therefore, I employ the share of the total population that has been fully vaccinated against COVID-19 (*Completeness*) as an alternative outcome variable. Data on vaccination rates, updated as of 21 September 2021, are provided by the Centers for Disease Control and Prevention.

#### 4. Empirical framework and strategy

##### 4.1. The baseline model

To explore the role of rugged individualism in shaping the variation in resistance to COVID-19 vaccination across American counties, I specify the following econometric model:

$$Y_c = \alpha + \beta TFE_c + \delta X_c + State_c + \varepsilon_c$$

in which  $Y$  is the dependent variable, which captures the prevalence of vaccination opposition within county  $c$ . As discussed previously, I employ four alternative measures of vaccination resistance in the main analysis, including *Strongly hesitant*, *Hesitant*, *Hesitant or Unsure*, and *Completeness*.  $TFE$  is the total frontier experience index that proxies for rugged individualism, based on the length of time each county spent in the westward-moving frontier in American history. Consistent with the main hypothesis, the estimated coefficient on  $TFE$  is expected to be positive when using the estimated rates of vaccine hesitancy as the outcome variables ( $\beta > 0$ ). Due to lack of vaccine confidence, individualistic counties are hypothesized to experience a lower share of the total population that has been fully vaccinated against COVID-19. Hence,  $\beta$  is expected to have a negative sign when regressing *Completeness* on  $TFE$  ( $\beta < 0$ ). The baseline model specification is augmented with a set of county-level geographic controls, including latitude, distance to coast, mean levels of temperature and precipitation, terrain ruggedness, rainfall risk and land suitability for agriculture. *State* stands for state fixed effects

that account for unobserved time-invariant heterogeneity across states.  $\varepsilon$  is a county-specific disturbance term.

#### *4.2. Identification*

It is noteworthy that the adoption of a historically determined measure of rugged individualism largely avoids reverse causation. One could argue that contemporary resistance to COVID-19 vaccination across counties in the United States plausibly exerts no direct influence on cultural traits of rugged individualism, deeply rooted in historical exposure to the American frontier between 1790 and 1890. However, a major threat to identification of the long-term effect of rugged individualism on collective action in COVID-19 vaccination relates to selection on unobservables. Furthermore, measurement errors in the total frontier experience index, if it exists, can lead to biased and inconsistent estimates of long-term cultural barriers to cooperation in COVID-19 vaccination. To provide a valid basis for causal inference, I adopt three alternative strategies of identification, including controlling for various confounding factors, assessing the importance of selection on unobservables and isolating a plausibly exogenous source of variation in rugged individualism.

##### *Controlling for potential confounding characteristics*

To alleviate plausible concerns about omitted variable bias, I allow several potential confounding factors to enter the baseline regression model. It is argued that the long-term legacy of cultures for vaccination support can be driven by failure to control for county-level fundamental (fixed) geographic factors. More specifically, exogenous geographic characteristics can be correlated with both the formation of rugged individualism and resistance to vaccination, leading to biased and inconsistent estimates of  $\beta$ .

Conventional wisdom in the comparative development literature is that climate conditions, such as distance to waterways, proximity to the equator, temperature and precipitation, can exert an influence on productivity and long-run growth through climatological, institutional and trade-related mechanisms (Andersen et al., 2016). Hence, these factors plausibly contribute to shaping cross-county differences in vaccination opposition through their persistent influence on numerous proximate causes of economic development, such as income and education. Other scholars suggest that the aforementioned geographic attributes, by shaping the historical disease environment, matter for the cultural dimension of individualism/collectivism (Gorodnichenko & Roland, 2017; Nikolaev & Salahodjaev, 2017). In addition, Michalopoulos (2012) indicate that geographic isolation, caused by rugged

terrains, may increase the cost of interaction between groups within a society, possibly leading to a greater prevalence of self-dependence. Recent studies provide evidence of the influence of climate risk on social norms of cooperation (Buggle & Durante, 2021) and the transmission of cultural traits across generations (Giuliano & Nunn, 2021). It follows from these discussions that the proposed association between rugged individualism and vaccination resistance merely proxies for the long-term legacy of key fundamental causes of economic development. Consistent with existing studies in the persistence literature, I incorporate several county-level geographic controls in the benchmark regression analysis, including *latitude*, *distance to coast*, average *temperature* and *precipitation*, *terrain ruggedness*, *rainfall risk* (precipitation variability), and *agri-suitability* (the suitability of land for agriculture).

### ***Selection bias from unobservables***

An alternative strategy of identification relies on assessing the relative importance of selection on unobservables in explaining away the long-term effect of rugged individualism on vaccination resistance. A conventional approach to addressing omitted variable bias is to observe the stability of the estimated coefficient when relevant control variables are included in the standard regression model. However, Oster (2019) contends that the plausibility of this widely adopted method critically hinges on the assumption that selection on observed confounders is informative about selection on unobserved confounders.

Against this backdrop, I perform the coefficient stability test developed by Oster (2019) to evaluate robustness to potential selection bias from unobservables. Consistent with an earlier contribution by Altonji et al. (2005), Oster (2019) proposes that the degree of selection bias from unobserved confounders can be assessed by the reduction in selection bias when the standard regression analysis is augmented with a set of observed confounding characteristics. In addition to evaluating the stability of the estimated coefficients, Oster (2019) considers movements in *R*-squared values from a regression model with a restricted set of control variables, and one with a full set of control variables. It is argued that trivial movements in the *R*-squared statistic derived from incorporating observed control variables in the regression increase the likelihood that unobserved confounders are highly correlated with the main variable of interest, thereby causing a large bias in the treatment effect (Oster, 2019). The methodology of Oster (2019), therefore, accounts for the empirical relevance of control variables in explaining the variation of the dependent variable.

As proposed by Oster (2019), I calculate the coefficient of proportionality ( $\delta$ ) required for  $\beta = 0$ . The  $\delta$  statistic reflects what the degree of correlation between *TFE* and unobserved confounding characteristics, relative to that between *TFE* and observed control variables, needs to be in order to attenuate the baseline coefficient on rugged individualism towards zero. Therefore,  $\delta$  captures the relative importance of selection on unobservables required to completely absorb the statistical significance of the baseline estimates. I also construct Oster's bound estimates based on the assumption that observed and unobserved confounding characteristics are equally important in explaining away the benchmark estimates ( $\delta = 1$ ). To this end, I estimate the bias-adjusted coefficient ( $\beta^*$ ) that would capture the influence of rugged individualism on vaccination opposition if one were to account for all unobserved confounding factors.<sup>6</sup> To the extent that the interval bounded by  $\beta^*$  and the baseline coefficient ( $\beta$ ) safely excludes zero, the established relationship between rugged individualism and resistance to COVID-19 vaccination in the United States is unlikely to be fully attributed to possible selection bias from unobserved confounders (Oster, 2019).<sup>7</sup>

### ***Using a plausibly exogenous component of rugged individualism***

A final method of identification exploits the log of predicted immigration flows to the United States, induced exogenously by historical climate shocks in Europe, as an instrumental variable (IV) for *TFE* that helps explain the variation in vaccination resistance (Bazzi et al., 2020). The IV strategy draws on the idea that European immigrants accelerated the westward-moving process of the American frontier by giving rise to population pressure on the east coast, and by migrating west themselves (Bazzi et al., 2020).

Following Sequeira et al. (2020), I employ the inflows of European immigrants to the United States exogenously induced by historical shocks to climate conditions in Europe between 1820 and 1890. In particular, the method of construction of the IV involves estimating various country-specific regressions to predict the flows of immigrants from each European country to the US, based on country-specific temperature and precipitation shocks in the previous year (Sequeira et al., 2020). The fitted values obtained from country-specific regressions are averaged to derive a measure of predicted inflows of immigrants to the US

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<sup>6</sup> As suggested by Oster (2019), the construction of the  $\beta^*$  statistic requires specifying the  $R$ -squared statistic of a hypothetical model ( $R_{max}$ ) that incorporates all observed and unobserved control variables in the regression. In this regard, I rely on the most restrictive assumption that  $R_{max} = 1$ .

<sup>7</sup> See also Altonji et al. (2005) and Oster (2019) for a more detailed description of this method, and empirical validation of the coefficient stability test.



across the period 1820 – 1890 (Sequeira et al., 2020). Then, the IV at the county level is calculated by the predicted average annual inflows of immigrants to the US over a period of 30 years commencing in the year when a specific county is proximate to the west of the American frontier (Bazzi et al., 2020). Hence, the IV corresponds to climate-driven emigration to the US just prior to the settlement process of local frontier life for each county.

The underlying intuition behind the IV approach is that climate shocks in European countries were conducive to the mass migration flows to the US. Therefore, climate shocks promoted the westward expansion of the American frontier, thereby lowering exposure to frontier life for counties that were in the frontier when the shocks happened. This provides support for the relevance of the IV. Given that historical climate-driven shocks to the settlement process of local frontier life are exogenous to county-specific conditions, the IV reasonably exerts no direct influence on present-day socio-economic performance at the county level except through its correlation with TFE. This permits a closer movement towards causal inference of the long-term legacy of rugged individualism for vaccination resistance in the US.

## **5. Empirical estimates**

### *5.1. Main findings*

#### ***OLS estimates***

Table 1 contains OLS estimates of the long-term effect of rugged individualism, captured by the number of decades spent in the American westward-moving frontier, on different measures of resistance to COVID-19 vaccination. In column (1), the dependent variable is the estimated proportion of the population that is hesitant to taking COVID-19 vaccines. In column (2), I use the estimated rates of the population that is hesitant or unsure about vaccination. In the third column of Table 1, the outcome variable is measured by the predicted share of the population that would strongly resist COVID-19 vaccination. In column (4), I exploit the share of the population that has been fully vaccinated against COVID-19, as of September 2021 as an alternative dependent variable.

As demonstrated in Table 1, the estimated coefficients of *TFE* are positive and statistically significant at the 1% level when using the estimated rates of resistance to vaccination as the dependent variables. The main results suggest that individualistic counties are characterized by a greater prevalence of COVID-19 vaccine hesitancy. This provides empirical support for the main hypothesis that cultural traits of rugged individualism are impediments to sustaining collective action in COVID-19 vaccination in the United States. The

coefficient on *TFE* reported in column (3) of Table 1 reveals that an addition decade spent in the American frontier is associated with a 0.2-percentage-point increase in the predicted rates of the population that exhibits strong hesitancy towards voluntary vaccination. It follows from the core results that frontier counties would find it more difficult to achieve herd immunity against COVID-19 due to the persistent influence of rugged individualism on vaccination support. Consistent with this argument, I document evidence that American societies with greater frontier experience tend to suffer from COVID-19 under-vaccination, captured by lower rates of the population that has been fully inoculated against the coronavirus. Accordingly, *TFE* enters the baseline regression with a negative and statistically significant coefficient when adopting *Completeness* as the dependent variable (Column 4, Table 1).

In addition, the long-term legacy of individualistic cultures for vaccination opposition is robust to accounting for the impacts of several geographic factors that are widely regarded as key fundamental determinants of economic development. Therefore, the established relationship between rugged individualism and vaccination hesitancy is unlikely to be attributed to the fundamental role of geographic characteristics in shaping long-run development. All the regressions are augmented with state dummies to account for unobserved time-invariant heterogeneity across states. It is important to re-emphasize that attempts to identify and incorporate all potential confounding characteristics in the regression are infeasible. To alleviate plausible concerns about omitted variables bias, I present the results of the coefficient stability test proposed by Oster (2019) in Table 1. In line with my earlier arguments, the baseline estimates are unlikely to be purely driven by selection on unobservables because the  $\delta$  statistic is consistently larger than unity. As suggested by Oster (2019), the association between plausible unobserved confounders and *TFE* must be 3.65 times larger than the correlation between *TFE* and observed confounders in order to attenuate the coefficient on *TFE* towards zero (Column 3, Table 1). Furthermore, none of Oster's bound estimates contains zero because the bias-adjusted coefficients remain statistically distinguishable from zero in all cases. Therefore, the benchmark estimates would retain their statistical significance if one were to account for all potential unobserved factors (Oster, 2019). Overall, my findings appear to be insensitive to possible omitted variables bias.

#### ***IV estimates***

Table 2 presents IV estimates of the contribution of the plausibly exogenous part of *TFE*, created by the predicted immigration inflows to the United States, to shaping the variation in COVID-19 vaccination hesitancy across American counties. In line with the baseline OLS

estimates, accumulated frontier experience has a positive and statistically significant effect on the predicted rates of vaccination resistance in the United States (Panel A, Table 2). The size of the estimated impact of *TFE* on vaccine hesitancy is comparable to that established in the OLS analysis. The stability of the magnitude and statistical precision of the coefficient on *TFE* indicates that the hypothesized relationship between rugged individualism and vaccination opposition is unlikely to be explained away by potential endogeneity issues. These results help rule out a key concern that my findings merely proxy for possible unobserved confounding characteristics and/or measurement errors in *TFE*.

Consistent with the previous discussion, the predicted inflows of European immigrants to the United States are strongly correlated with *TFE* (Bazzi et al., 2020; Sequeira et al., 2020). In particular, the first-stage estimates reveal that an increase in the inflows of immigrants reduced frontier experience through accelerating the westward expansion of the American frontier. This provides evidence of the strength of the IV in the first-stage regression. To check for weak instrument bias, I also construct the first-stage *F*-statistic of excluded instruments developed by Olea and Pflueger (2013). The value of the *F*-statistic is much larger than the rule-of-thumb threshold of 10. This helps rule out the likelihood that the IV estimates can be confounded by using weak instruments. Following Andrews et al. (2019), I also report identification-robust Anderson-Rubin (AR) confidence intervals, which offer efficient estimates regardless of the relevance of the IV in the first-stage regression analysis. Accordingly, the AR confidence intervals safely exclude zero in all cases. This lends support to the main results that rugged individualism exerts a statistically significant influence on resistance to COVID-19 voluntary vaccination across American counties.

### ***Rugged individualism and COVID-19 under-vaccination over time***

The main findings of this study lend credence to the main hypothesis that cultural traits of rugged individualism play a pivotal role in driving the prevalence of COVID-19 vaccination opposition across American counties. As explored below, the long-term legacy of rugged individualism for collective action in vaccination is explained by a lack of civic capital, political partisanship and distrust in science. Consistent with these arguments, frontier counties are more likely to suffer from persistent under-vaccination, making it difficult to achieve community immunity against the coronavirus. To the extent that deeply rooted cultures exert a long-term impact on collective action in vaccination, the empirical estimates should hold regardless of the period chosen to measure self-reported vaccine hesitancy. Therefore, empirical validation of the persistent influence of rugged individualism on vaccination

opposition requires tracking the evolution of vaccine hesitancy within American counties over time. However, obtaining a nationally representative dataset on self-reported vaccination resistance over time appears to be challenging. One could also argue that vaccination support reasonably varies from month to month, depending on the severity of the pandemic and/or the opportunity to observe other people being inoculated (Mesch & Schwirian, 2019).<sup>8</sup> If these arguments are correct, the divergence in vaccination resistance across counties in the United States may exhibit different patterns over time. As such, my findings can be exclusively attributed to the period chosen to measure the predicted rates of vaccine hesitancy.

Against this background, I replicate the baseline estimates reported in Column (4) of Tables 1 and 2 using *Completeness* measured as of the end of each month between January and September of 2021. It is argued that frontier counties would consistently suffer from COVID-19 under-vaccination due to the long-term influence of slowly evolving cultural traits of rugged individualism on vaccination opposition. Figure 3 depicts the point estimates and 95% confidence interval of the effect of *TFE* on *Completeness*. In line with the benchmark results in Column (4) of Tables 1 and 2, the estimated coefficient on *TFE* remain negative and statistically significant at conventional levels in all cases, except when using data as of February 2021 to measure *Completeness*. This lends support for my arguments that under-vaccination tends to proliferate in frontier counties due to the positive impact of rugged individualism on resistance to vaccination. The magnitude and statistical precision of the estimated coefficient on *TFE* turn out to be relatively stable when using more updated data on vaccination rates. A potential explanation for these findings is that the cross-county variation in vaccination rates during the early months of 2021 could be driven by supply-related barriers to vaccination rollout. Using recent data, therefore, helps reduce measurement errors when it comes to capturing cross-county differences in demand-driven under-vaccination. However, I consistently obtain precise estimates that rugged individualism transmits to under-vaccination in the United States regardless of the periods chosen to measure vaccination rates. Importantly, these findings indicate that the long-term legacy of rugged individualism for vaccination opposition withstand accounting for possible changes in vaccination behaviors within a county over time.

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<sup>8</sup> It is argued that growing death rates from the coronavirus may reduce concerns about vaccine, thus resulting in less resistance to vaccination. Furthermore, having an opportunity to observe others' vaccination experience may affect one's own decision to be inoculated.

### ***Rugged individualism and influenza under-vaccination***

Consistent with the main hypothesis of the current study, it is expected that frontier counties tend to suffer from lower rates of influenza vaccination due to the prevalence of cultural traits of rugged individualism. To explore this possibility, I replicate the main analysis by regressing a measure of influenza vaccination coverage at the county level on *TFE*. In contrast to the availability of county-level data on COVID-19 vaccination rates, little attention has been paid to measuring the cross-county variation in seasonal influenza vaccination in the United States.<sup>9</sup> For this reason, I employ the predicted rates of the population aged 18 years and older that has received an influenza vaccine within the past 12 months as the dependent variable. Data are taken from the Centers for Disease Control and Prevention. More specifically, this indicator is constructed through estimating socio-economic and demographic factors that determine the uptake of influenza vaccines, based on data from the 2019 Behavioral Risk Factor Surveillance System. These results are utilized to obtain county-level estimates of influenza vaccination coverage using data from the 2015 – 2019 American Community Survey and 2019 Census.<sup>10</sup>

I report the point estimate and 95% confidence interval of the estimated effect of *TFE* on influenza vaccination coverage in Figure 4. Accordingly, the OLS results are negative and statistically significant at the 1% level. This is suggestive of the negative influence of rugged individualism on seasonal influenza vaccination coverage, in line with the core findings. As illustrated in Figure 4, the coefficient on *TFE* enters the IV regression analysis with a negative sign. However, it is imprecisely estimated at conventionally accepted levels of statistical significance. A possible explanation for the statistical imprecision of the estimates is the adoption of county-level predicted rates of influenza vaccination. It is also noteworthy that cooperative behaviors in vaccination against COVID-19 are more likely to be hindered by distrust in the government, scientists, health experts and political partisanship. On this basis, the cultural dimension of rugged individualism arguably has a more significant impact on resistance to COVID-19 vaccination, relative to cooperation in inoculation against the seasonal flu. Overall, the results depicted in Figure 4 are broadly consistent with the main hypothesis that rugged individualism is a cultural barrier to sustaining collective action in vaccination.

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<sup>9</sup> To my knowledge, data on influenza vaccination coverage are mainly available at the state level.

<sup>10</sup> See also <https://www.cdc.gov/flu/fluview/index.htm> for a more detailed description.

## 5.2. Robustness checks

### ***Robustness to controlling for socio-economic development***

It is plausible that the variation in resistance to vaccination across American counties can be driven by county-level economic development (Hudson & Montelpare, 2021). For this reason, a major threat to identification of the influence of rugged individualism on vaccine hesitancy relates to the pivotal role of socio-economic conditions in shaping vaccination behaviors.

For example, several studies find that lower income is negatively associated with trustful attitudes towards vaccination due to mistrust in the healthcare system (Wu et al., 2008). Hudson and Montelpare (2021) contend that high-income individuals, typically characterized by greater educational attainment, are more likely to exhibit vaccine confidence, *ceteris paribus*.<sup>11</sup> Other scholars suggest that educational attainment plays a key role in fostering voluntary vaccination through affecting public awareness of vaccines' safety and efficacy (Vikram et al., 2012; Larson et al., 2016). An additional explanation for the association between education and vaccine hesitancy rests upon the premise that educated people are more inclined to undertake evidenced-based decision-making processes, leading to greater vaccination confidence. It follows from these narratives that vaccination skepticism tends to prevail in rural areas due to poorer socio-economic conditions, *ceteris paribus*. To avoid obtaining spurious estimates, I allow numerous measures of county-level economic development to enter the main analysis, including the log of income per capita, average years of schooling, urbanization and unemployment rates, and the fraction of the population below the poverty line.<sup>12</sup> As shown in Table 3, the inclusion of these variables fails to explain away the main findings. Hence, the established relationship between rugged individualism and resistance to COVID-19 vaccination is not exclusively driven by county-specific economic conditions.<sup>13</sup>

### ***Robustness to controlling for barriers to vaccination rollout***

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<sup>11</sup> It is noteworthy that previous studies provide highly mixed findings when it comes to analysing the effect of income on vaccination behaviours in different countries. See Hudson and Montelpare (2021) for a more detailed review of the related literature.

<sup>12</sup> Data are obtained from the United States Census Bureau (<https://data.census.gov/>).

<sup>13</sup> It is important to note that the causal relationship between these proximate determinants of vaccination opposition and the outcome variable may operate in both directions. Thus, empirical estimates of these additional controls on vaccination resistance, not reported for space conservation, do not necessarily carry causal inference. This also provides a motivation for the exclusion of these additional control variables from the main analysis.

A recent study by Mishra et al. (2021) introduces a novel index of COVID-19 vaccine coverage (CVAC) that captures potential barriers to fostering vaccination rollout across U.S. counties.<sup>14</sup> Specifically, Mishra et al. (2021) conduct a thorough review of the related literature to identify factors shaping low vaccination rates of existing immunization programs. On this basis, they construct a regionally comparable measure of the underlying demand- and supply-side impediments to achieving high coverage of COVID-19 vaccination in the United States. The comprehensive CVAC index consists of 28 sub-indicators, classified into five different themes. Counties with higher values of the CVAC index are expected to experience greater barriers to accelerating an equitable and comprehensive rollout of COVID-19 vaccines. As articulated below, the CVAC index is relevant for explaining the variation in resistance to vaccination within the United States. The inclusion of this indicator in the regression helps rule out the possibility that the hypothesized relationship between rugged individualism and vaccination opposition across American communities is driven by numerous socio-demographic factors, which are of importance for shaping individuals' willingness to be vaccinated against the coronavirus.

Table 4 re-estimates the benchmark model by incorporating the CVAC index and its sub-components in the regression. In Column (1), I control for the comprehensive CVAC index. In Columns (2) to (6), I gradually include five different themes of the CVAC index in the baseline model specification. The first theme relates to historic under-vaccination that provides important insights into the prevalence of COVID-19 vaccination resistance. It captures the cross-county divergence in the administration rates of flu and other standard vaccines, and non-medical (personal) refusal rates of vaccines (Mishra et al., 2021). Exploring American residents' intention to vaccinate against COVID-19, several studies demonstrate that people who have not received the seasonal flu vaccine are less likely to express positive attitudes towards vaccination (Pogue et al., 2020; Ruiz & Bell, 2021). For this reason, historic under-vaccination is highly predictive of cross-county differences in COVID-19 vaccination rates in the United States (Mishra et al., 2021).

The second CVAC theme captures potential socio-demographic impediments to achieving high coverage of COVID-19 vaccination in each county. Historical under-vaccination is commonly observed among racial minority groups, such as Black, Hispanic and Native Americans. There also exists evidence that racial minority individuals are less inclined

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<sup>14</sup> Data can be accessed via this link <https://vaccine.precisionforcovid.org/>.

to vaccinate against COVID-19, and face significant barriers to accessing pandemic-related resources (Fisher et al., 2020; Ruiz & Bell, 2021). Other marginalized groups of a society, characterized by low income or educational attainment and widespread poverty/unemployment, are also less likely to express positive attitudes towards COVID-19 vaccination campaigns (Fisher et al., 2020; Ruiz & Bell, 2021). Against this background, the second theme of the CVAC index attempts to measure the presence of these disadvantaged and marginalized groups with a county, and the lack of adequate access to information (Mishra et al., 2021). The third CVAC theme reflects the quality and capacity of the healthcare system, including public health infrastructure, human resources, the quality of care, and health spending and healthcare funding per capita (Mishra et al., 2021).

I also attempt to rule out the possibility that individuals experiencing considerable challenges with accessing healthcare services are less likely to engage in voluntary vaccination by controlling for the fourth CVAC component. Johnson et al. (2008), for example, document evidence that individuals' intention to be vaccinated can be hindered by healthcare cost and transportation barriers to accessing healthcare services. Hence, the fourth CVAC theme accounts for the confounding effects of healthcare accessibility barriers (Mishra et al., 2021). The final group of CVAC sub-indicators reflects the prevalence of irregular care-seeking behaviors, captured by the rates of individuals without a designated medical home or the inability to seek regular care (Mishra et al., 2021). This helps address a key concern that people with regular care-seeking behaviors tend to be cooperative in collective vaccination against COVID-19 (La et al., 2018). As illustrated in Table 4, the coefficient on *TFE* retains its sign and statistical significance in all cases. Therefore, my findings are robust to accounting for numerous socio-economic and demographic characteristics that help explain the cross-county variation in resistance to voluntary COVID-19 vaccination in the US.

### ***Robustness to controlling for the severity of the COVID-19 pandemic***

As argued earlier, attitudes towards voluntary vaccination can be shaped by an individual's exposure to the severity of the pandemic (Mesch & Schwirian, 2019). A sense of fear of the coronavirus may trigger greater cooperative behaviors in collective vaccination against COVID-19. In this regard, a major threat to identification arises when cross-county differences in vaccination hesitancy are driven by exposure to the impact of the COVID-19 pandemic on loss of human life, among others. To account for this possibility, I employ the cumulative number of COVID-19 deaths at the county level to capture the variation in the severity of the pandemic within the United States. It is noteworthy that the cross-county



variation in loss of human life attributed to the COVID-19 pandemic plausibly evolves from month to month, possibly leading to changes in self-reported resistance to vaccination. Therefore, I use accumulated deaths calculated at different numbers of weeks prior to the collection of HPS survey data adopted to create the estimated rates of vaccination opposition.

Specifically, I replicate the main analysis by controlling for cumulative COVID-19 deaths updated up to different numbers of weeks before May 26, 2021, and illustrate the results in Figure 5. Accordingly, rugged individualism exerts a positive influence on the prevalence of vaccination opposition in the United States once controlling for cross-county differences in cumulative COVID-19 deaths measured at different points of time. The estimated coefficients of *TFE* retain their sign and statistical precision in all cases. The stability of the magnitude and statistical significance of the main results indicate that the relationship between rugged individualism and vaccination resistance is not affected by potential fluctuations in the severity of the COVID-19 pandemic across American counties.

### ***Robustness to controlling for other factors***

Previous studies demonstrate that vaccination behaviors differ between residents of densely populated areas and those living in remote regions (Hudson & Montelpare, 2021). Specifically, the divergence in vaccination confidence stems from differences in (transportation) costs that may be incurred when accessing health care services (Hudson & Montelpare, 2021). People living in areas with high population density are presumably exposed to greater risks from the coronavirus, leading to higher vaccine uptake. Consistent with the previous arguments, rural populations, on average, have less education and lower levels of income, which are key proximate causes of vaccination confidence. Hence, I allow a measure of contemporary population density to enter the regression. I also account for cross-county differences in demographic structure by including the share of different age groups in the total population.<sup>15</sup> The basic intuition is that resistance to vaccination plausibly varies across age groups, depending on perceived susceptibility to the pandemic and concerns about vaccines' effectiveness and safety (Luyten et al., 2019; Hudson & Montelpare, 2021). As such, the proposed relationship between rugged individualism and vaccination opposition can be confounded by the variation in demographic structure across American counties.

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<sup>15</sup> To be more specific, I incorporate the proportions of five age groups in the county-level population, including 15 – 29 years, 30 – 44 years, 45 – 54 years, 55 – 64 years, and 65 years and older.

It is also established that resistance against COVID-19 vaccination in the United States typically prevails among racial and ethnic minority populations (see, for example, Khubchandani & Macias, 2021). This reveals that the racial composition of the population may explain why some American counties tend to suffer from collective inaction during the COVID-19 pandemic. To address this issue, I augment the regression analysis with the numbers of Hispanics, Whites, Asians and Blacks as a proportion of the total population. The existing literature also documents suggestive evidence of the importance of religious identity in shaping vaccination behaviors (Lovett, 2021). According to the Public Religion Research Institute, evangelical Protestants are more likely to resist voluntary COVID-19 vaccination, compared to other religious groups. Hence, I control for the share of the county-level population practicing major religions, including Protestants and Catholics. It is important to note that counties characterized by a prevalence of religiosity may experience higher rates of vaccination opposition because people with strong religious beliefs tend to exhibit greater distrust in science and scientists (Sjöberg, 2004). To capture the level of religiosity at the county level, I rely on data from the American Religion Data Archive to construct the number of religious adherents as a proportion of the total population.

Figure 6 depicts the point estimate and 95% confidence interval of the estimated coefficient on *TFE* when incorporating additional control variables in the regression.<sup>16</sup> All demographic data are collected from the United States Census Bureau. Accordingly, the influence of rugged individualism on vaccination resistance retains its sign and statistical precision across various model specifications. Therefore, my findings are unlikely to merely proxy for the role of numerous demographic, racial and religious factors in driving the pattern of COVID-19 vaccination resistance in the United States.

### ***Robustness to using alternative measures of individualism***

The main analysis of this paper exploits long-term exposure to frontier life driven by the westward-moving frontier in American history to capture the cross-county variation in cultural traits of individualism. To check whether the main results are driven by using *TFE* as a proxy for rugged individualism, I replicate the benchmark regression analysis using two alternative measures of individualism, including the prevalence of infrequent names and the absence of patronymic/matronymic names.

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<sup>16</sup> The full estimates, not reported for brevity, are available upon request.

The adoption of name-based measures of individualistic cultures is mainly motivated by Hofstede (1991) and Triandis (1995) who propose that individualism is reflected in its emphasis on self-dependence, the importance of personal autonomy and self-interests, and deviation from social norms. As established in the social psychology literature, the prevalence of infrequent names captures an inclination to stand out, which is consistent with key cultural ideologies of individualism (Twenge et al., 2010). By contrast, the use of common names reflect a desire to fit in, which reflects collectivistic traits. In addition, Brown et al. (2014) propose that the absence of matronymics or patronymics captures preferences for self-independence – a key feature of individualistic cultures. In line with Bazzi et al. (2020) and Bian et al. (2021), the pervasiveness of infrequent names is measured by the fraction of babies whose names are outside the top 10 within one’s Census division, and the proportion of children whose names are different from their parents’ names.<sup>17</sup> Table 5 demonstrates that counties with a larger proportion of infrequent names or the absence of patronymic/matronymic names tend to suffer from greater resistance to COVID-19 vaccination. Hence, the main findings are insensitive to using alternative cultural measures.

### ***Robustness to the validity of the exclusion restrictions***

Following Sequeira et al. (2020) and Bazzi et al. (2020), the main analysis exploits the climate-induced immigration inflows from Europe to the US as a plausibly exogenous source of variation in rugged individualism that helps explain variation in resistance to COVID-19 vaccination across American counties. As argued previously, the exogeneity requirements are likely to hold because historical climate shocks in European countries are largely exogenous to frontier counties’ local conditions. It follows from this argument that historical weather shocks are largely uncorrelated with county-level socio-economic performance except through shaping cultural traits of individualism. As such, the climate-induced inflows of immigrants to the United States transmit to cross-county disparities in vaccination opposition exclusively through affecting rugged individualism. Admittedly, the orthogonality condition cannot be validated by empirical statistical evidence due to the unobservable nature of the disturbance term. To provide additional support for the validity of my identification strategy, I apply the “plausibly exogenous” instruments framework developed by Conley et al. (2012). This method

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<sup>17</sup> Using different methods of identifying infrequent names, Bazzi et al. (2020) demonstrate that the prevalence of infrequent names remains highly predictive of the variation in individualistic cultures across American counties. See also Bazzi et al. (2020) and Bian et al. (2021) for a more detailed description.

permits evaluating the extent to which the baseline IV estimates can be explained away by possible deviations from the orthogonality condition.

Assuming that the exclusion restrictions are not satisfied, the baseline model can be re-specified as follows:

$$Y_c = \alpha + \beta TFE_c + \gamma IV_c + \delta X_c + State_c + \varepsilon_c$$

in which  $\gamma$  captures the direct effect of the predicted immigration inflows to the US, denoted as  $IV$ , on the dependent variable. The validity of the exogeneity condition is conditional on the assumption that  $\gamma = 0$ . Under the violation of the exclusion restrictions ( $\gamma \neq 0$ ), Conley et al. (2012) propose that it would be possible to obtain reliable inference based on the IV approach if one were to observe the true effect of the IV on the outcome variable.<sup>18</sup> Unfortunately, the true magnitude of  $\gamma$  is unknown. For this reason, Conley et al. (2012) suggest estimating the above model based on different priori assumptions about the true direct effect of the IV on vaccination resistance in the United States. Assuming that  $\gamma \sim N(0, \delta^2)$ , I calculate the 95% confidence intervals of the estimated coefficient on  $TFE$ . As demonstrated by Conley et al. (2012), these bound estimates provide valid inference on the long-term influence of rugged individualism on vaccination opposition even under non-orthogonality conditions.

Table 6 presents lower and upper bound estimates of the effect of rugged individualism on resistance to vaccination when allowing for different levels of violations of the exclusion restrictions. Specifically, I hypothesize that the direct influence of the IV on the outcome variable equates up to 10% – 50% of the estimated partial impact of  $TFE$  on vaccination opposition, established in the main IV analysis. For ease of interpretation, I also replicate the benchmark IV results. As demonstrated in Table 6, none of the bound estimates contains zero. This suggests that the core findings remain statistically significant at the 5% level under non-orthogonality conditions. It is important to note that the results retain their statistical significance even when allowing the direct impact of the IV to be 50% of the marginal effect of  $TFE$ . This assumption reflects an implausibly large violation of the exclusion restrictions. Hence, the baseline results are insensitive to accounting for the excludability of the IV.

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<sup>18</sup> In particular, performing IV regressions requires removing the direct effect of the IV by subtracting  $\gamma IV_c$  from both sides of the equation.

## 6. Mechanisms of influence

As discussed previously, strengthening cooperative behaviors in COVID-19 vaccination typically represents a collective action problem. On this basis, I postulate that rugged individualism transmits to the prevalence of vaccination opposition across American counties *via* hindering the formation of civic capital, including lack of trust in the government. I also demonstrate that political partisanship and distrust in science underlie the hypothesized relationship between rugged individualism and resistance to COVID-19 vaccination in the US. This section, therefore, seeks to provide insights into the role of (i) *civic capital*, (ii) *political partisanship*, and (iii) *distrust in science* in explaining the extent to which rugged individualism undermines collective action in COVID-19 vaccination. For this purpose, I regress different potential mechanisms on *TFE*, conditional on baseline control variables. This helps understand whether the cultural dimension of rugged individualism accounts for cross-county differences in these proposed mechanisms. Furthermore, I empirically assess the extent to which the long-term legacy of rugged individualism for vaccination resistance in the United States is mediated through the aforementioned channels of transmission.

To capture regional differences in civic capital in the United States, I employ a measure of institutional health developed by the Social Capital Project of the United States Joint Economic Committee. This indicator reflects the variation in civic engagement, measured by voting rates in presidential elections across the period 2012 – 2016, and 2010 census response rates. It also captures confidence in institutions through using the proportion of self-reported confidence in corporations, in the media and in public schools. Political participation has been widely employed as a proxy for the level of social capital and civic engagement (Putnam, 2001). Previous studies also document that higher levels of political participation are linked to greater pro-social preferences and cooperative behaviors in resolving social dilemmas (Bolsen et al., 2014). According to Barrios et al. (2021), voting typically entails private costs, but a society collectively benefits from higher levels of voter engagement. Hence, voting turnout may capture individuals' propensity to internalize externalities and contribute to the common goods (Barrios et al., 2021). This helps explain why American residents of counties with higher voting turnout are more likely to engage in social distancing during the COVID-19 pandemic (Barrios et al., 2021). As shown in Column (1) of Table 7, *TFE* is negatively associated with the measure of social capital in all the regressions. This provides suggestive evidence that rugged individualism, characterized by its emphasis on self-dependence and anti-statism, is an impediment to forming civic capital within a society.

Following Barrios and Hochberg (2021), I employ an index of vote shares in the U.S. presidential election in 2016 as a measure of political partisanship.<sup>19</sup> In particular, I calculate the proportion of Republican votes in total votes to capture the polarization in political ideologies. As proposed by Bazzi et al. (2020), the Republican party came to embrace the fundamental ideologies of rugged individualism between 2000 and 2016, including resistance to tax redistribution, welfare spending and other forms of anti-statism. In line with these arguments, the results reported in Column (2) of Table 7 indicate that historical experience with the American frontier is positively correlated with the share of Republican votes.

To proxy for distrust in science, I use the estimated fraction of the population that expresses disbelief in climate change, obtained from Howe et al. (2015). There exists a strong consensus among scientists when it comes to documenting evidence on changing climate conditions and the human causes of this global issue. However, global warming disbelief remains pervasive and differs considerably across American counties (Howe et al., 2015). This plausibly proxies for variation in science skepticism (Brzezinski et al., 2020). Columns (3) and (4) of Table 7 contain empirical estimates of the impact of rugged individualism on science skepticism. Accordingly, *TFE* enters the regression with a positive and statistically significant coefficient. In line with my earlier arguments, these results reveal that distrust in science tends to prevail in counties with greater frontier experience due to the persistence of strong resistance to hierarchies, elites and government intervention (Shannon, 1977; Bazzi et al., 2020).

After establishing the role of rugged individualism in explaining cross-county differences in the proposed mechanisms, I undertake a mediation analysis based on the method developed by Acharya et al. (2016). This permits an investigation of the extent to which the aforementioned mechanisms can account for the long-term effect of rugged individualism on resistance to vaccination across American counties. Following Acharya et al. (2016), I estimate the Average Controlled Direct Effect (ACDE) of rugged individualism on vaccination opposition, holding the potential mediators (mechanisms) of interest fixed at a particular level. Specifically, I rely on a two-step regression technique to obtain the ACDE estimates. The first-stage regression involves replicating the benchmark model by including the mediators in the regression. Using these empirical estimates, I obtain the transformed (demediated) outcome

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<sup>19</sup> Data are taken from the MIT Election Data Science and Lab.

variable by removing the effect of the mediators.<sup>20</sup> In the second-stage regression, the demediated outcome variable is regressed on the treatment variable (*TFE*), controlling for geographic characteristics and state dummies. The coefficient on *TFE* obtained from the second-stage regression corresponds to the ACDE of rugged individualism on vaccination resistance when accounting for potential mechanisms. According to Acharya et al. (2016), one can obtain insights into the role of the proposed mechanisms in mediating the relationship between rugged individualism and vaccination resistance by comparing the benchmark treatment effect to the ACDE. In particular, the mediator of interest can account for a significant proportion of the treatment effect when there is a reduction in the economic and statistical significance of the ACDE estimates, relative to the baseline estimates (Acharya et al., 2016). By contrast, the effect of rugged individualism on vaccination resistance can be direct or mediated through other mechanisms if the ACDE estimates are comparable to the benchmark results in terms of the magnitude and statistical precision.

Table 8 reports the full ACDE estimates. For ease of comparison, I plot the baseline estimates and the ACDE results in Figure 7. Accordingly, I find that the magnitude and statistical significance of the ACDE of rugged individualism on vaccination opposition decrease considerably when I account for the impact of *political partisanship*. The other mediators of interest, including *civic capital* and *distrust in science*, do not account for a significant share of the established relationship between rugged individualism and resistance to vaccination in the United States. These results provide support for the main hypothesis that rugged individualism is associated the divergence in political ideologies within the United States, leading to greater resistance to COVID-19 vaccination. I also explore the role of political polarization in shaping the influence of rugged individualism on vaccination opposition by replicating the benchmark analysis using two different samples of Democratic and Republic counties.<sup>21</sup> As depicted in Figure 8, the estimated coefficient on *TFE* remains positive and statistically significant at the 1% level when using a sample of Republican counties. However, the effect of rugged individualism on vaccination opposition turns out to be imprecisely estimated at conventionally accepted levels of statistical significance when

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<sup>20</sup> Consistent with Acharya et al. (2016), I calculate the fitted value of the dependent variable, holding the mediators fixed at a particular level. For this reason, the predicted value of the outcome variable reflects the cross-county variation in vaccination opposition that cannot be attributed to the variation in the mediators.

<sup>21</sup> The classification of political polarization is based on the electoral votes for the United States presidential election in 2016. I define Republican and Democratic counties as areas with a larger vote share for, respectively, Donald Trump and Hilary Clinton.

using a sample of Democratic counties. It follows from these findings that rugged individualism plays a more important role in shaping the prevalence of resistance to COVID-19 vaccination in Republican counties. This is consistent with the main hypothesis of this paper that rugged individualism undermines collective action in vaccination through giving rise to political polarization in the United States.

## **7. Concluding remarks**

Existing studies in the comparative development literature establish that individualistic traits are conducive to economic performance through strengthening the creation of innovative technologies. Despite the pivotal role of individualism in shaping innovation and long-run economic growth, this paper demonstrates that individualistic cultures undermine cooperation in resolving collective action problems. In particular, this study seeks to understand the extent to which rugged individualism – a combination of individualistic traits and strong opposition to state intervention – helps shape substantial variation in resistance to COVID-19 vaccination across American counties. I propose that vaccination opposition tends to prevail in counties with a prevalence of cultural traits of rugged individualism due to the emergence and persistence of mistrust, political polarization and distrust in science. It follows from the main hypothesis of this study that rugged individualism is an impediment to achieving a comprehensive and effective rollout of COVID-19 vaccination.

To explore the long-term impact of cultures on COVID-19 vaccination resistance, I use a historically determined measure of rugged individualism developed by Bazzi et al. (2020). In particular, Bazzi et al. (2020) rely on the length of time spent in the American westward-moving frontier between 1790 and 1890 to measure cross-county differences in rugged individualism in the United States. They establish that historical exposure to frontier life gave rise to cultural traits of self-dependence and anti-statism. Leveraging a novel dataset on resistance to COVID-19 vaccination at the county level, I provide evidence that deeply rooted rugged individualism is positively associated with vaccination opposition. The results withstand accounting for numerous confounding characteristics and potential selection bias from unobserved factors. I also find that the plausibly exogenous component of rugged individualism, isolated by climate-induced inflows of European immigrants to the United States, has a positive and statistically significant influence on resistance to COVID-19 vaccination. Overall, the results lend credence to the important role of cultures in determining herd immunity against the novel coronavirus, which offers one of the most promising avenues for recovery from the COVID-19 pandemic.



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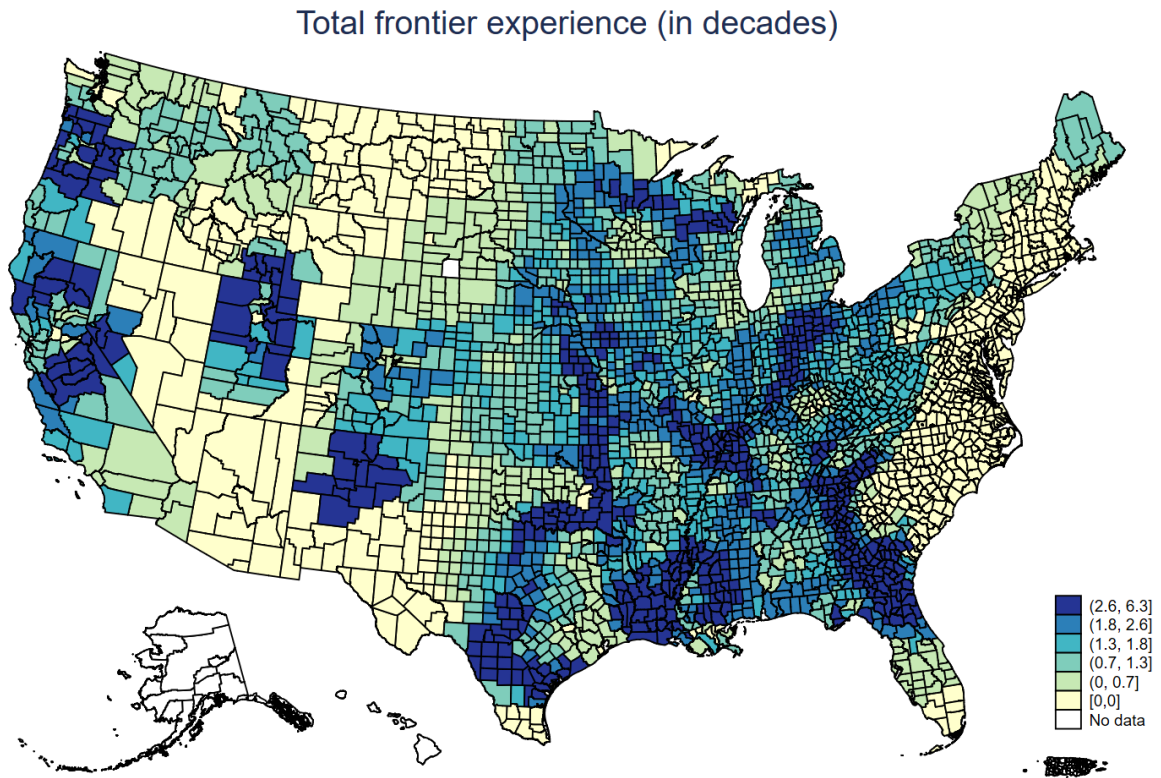
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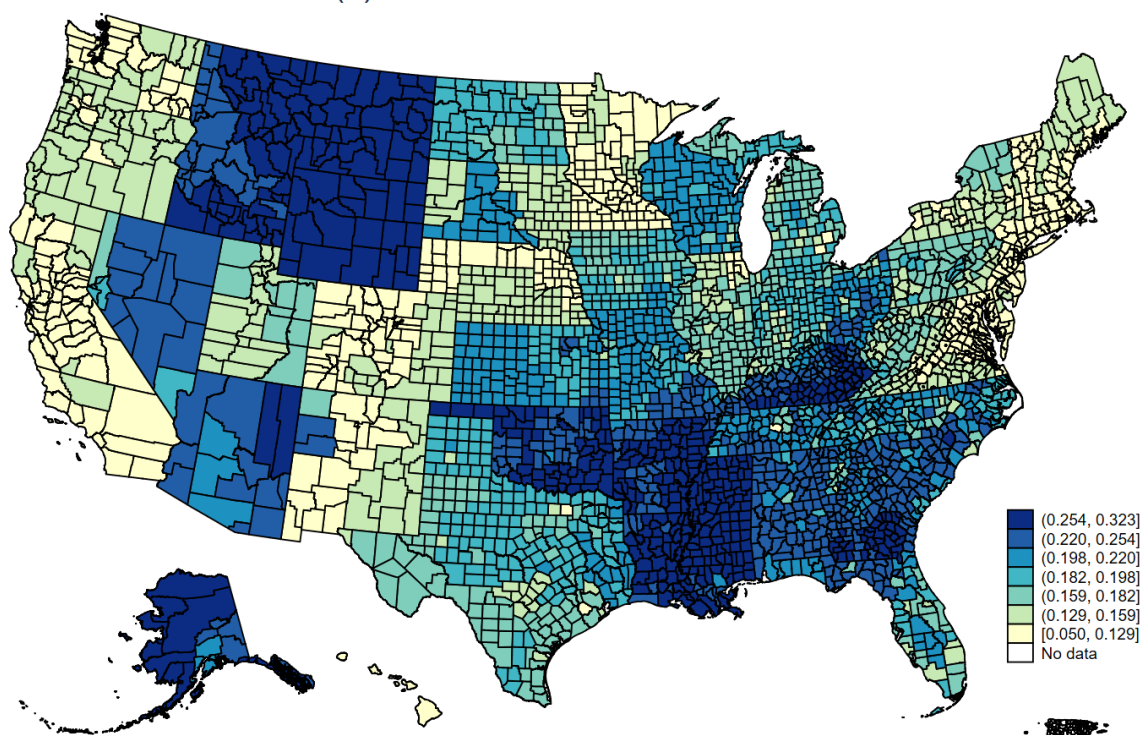




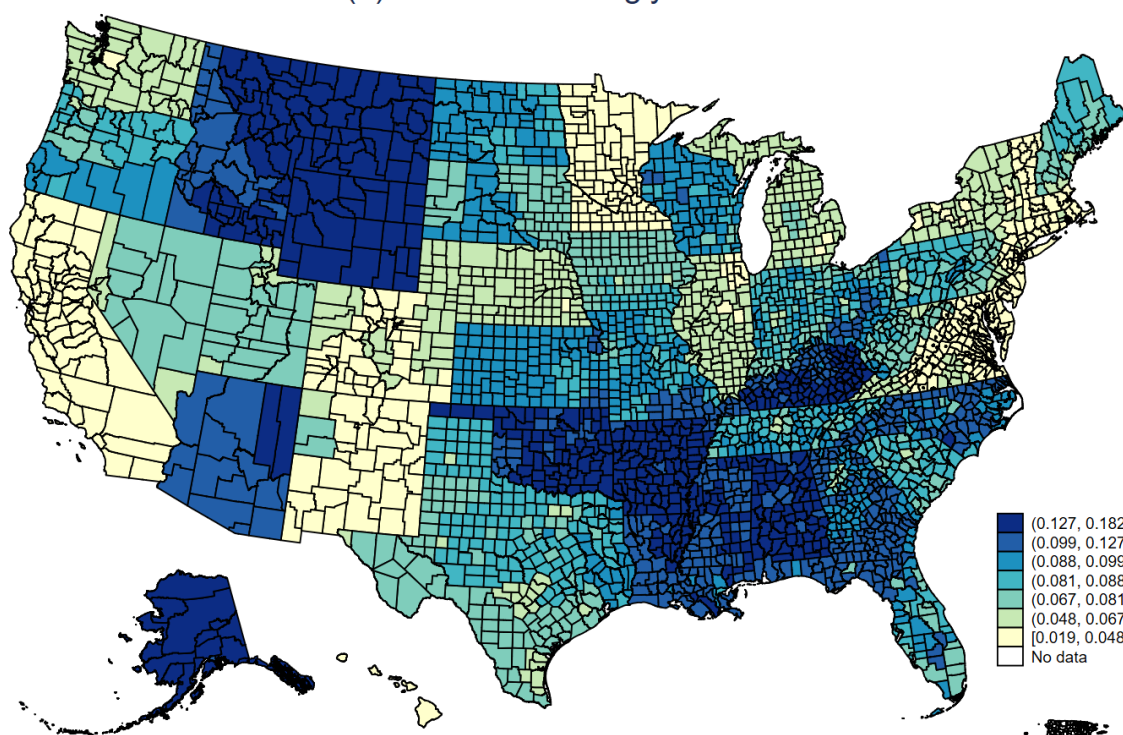
**Figure 1. The cross-county variation in total frontier experience**

*Notes:* This figure depicts cross-county differences in rugged individualism, measured by the number of decades spent in the American frontier between 1790 and 1890. Darker areas correspond to counties with more prevalence of cultural traits of rugged individualism. Data are obtained from Bazzi et al. (2020).

(a) Estimated hesitant or unsure



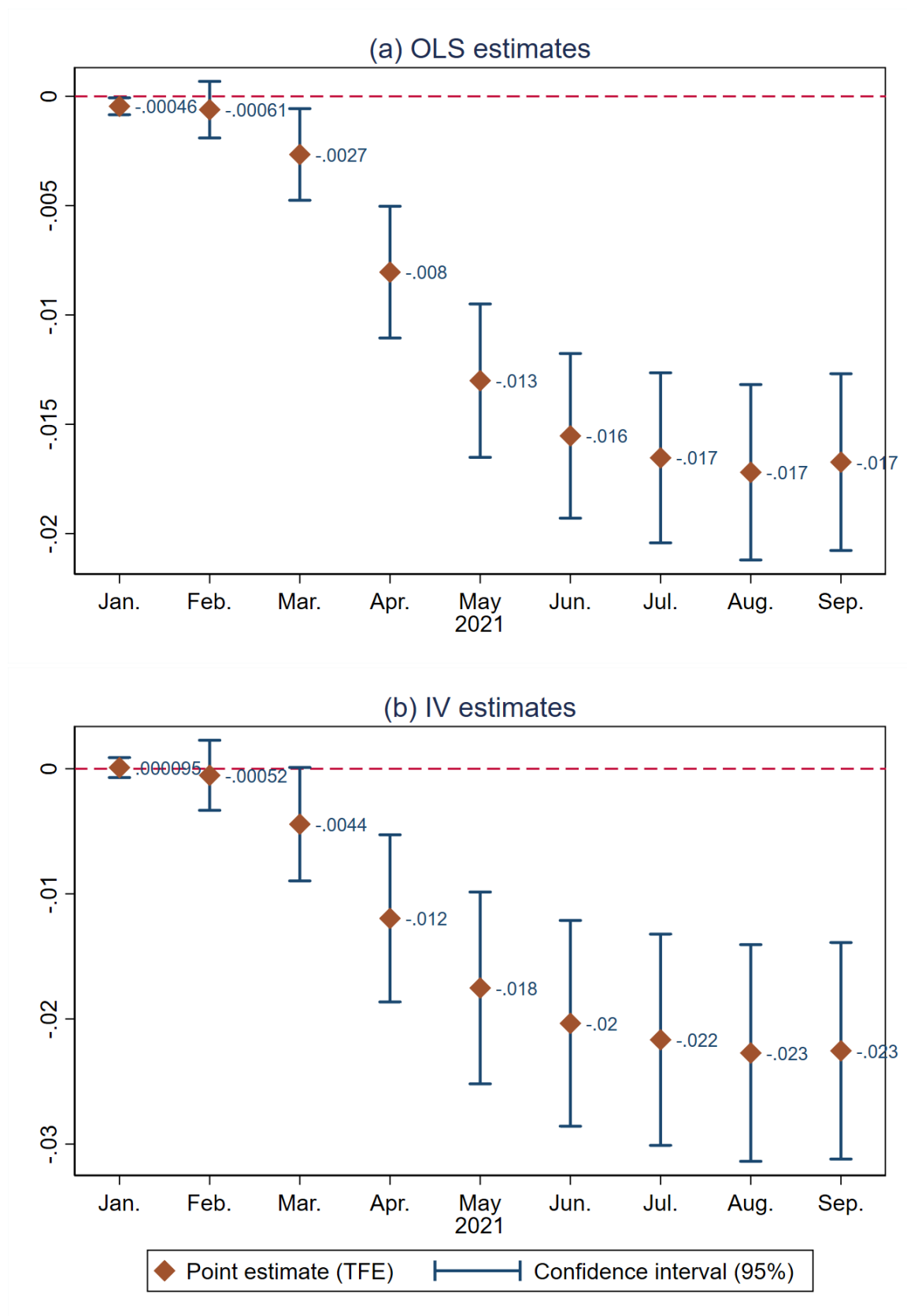
(b) Estimated strongly hesitant



**Figure 2. The cross-county variation in vaccination resistance**

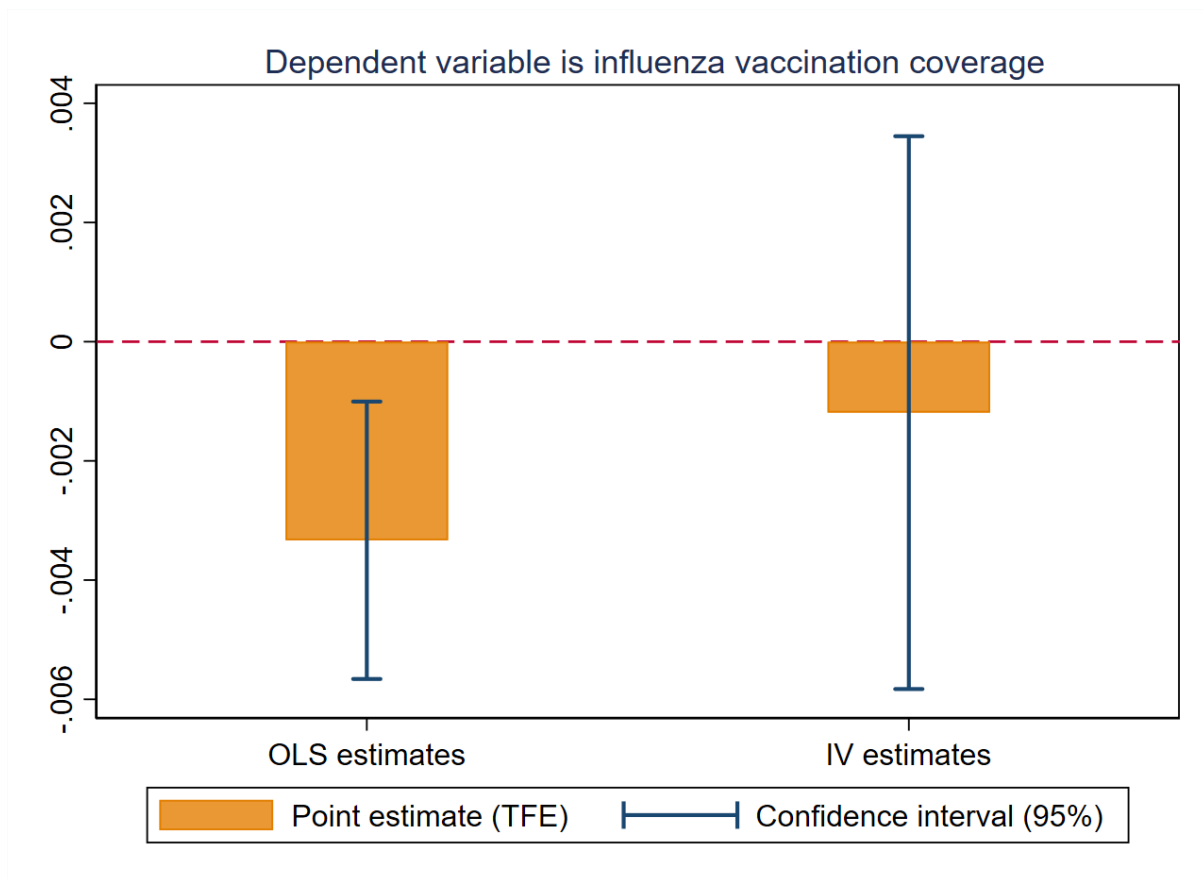
*Notes:* This figure depicts cross-county differences in the estimated proportion of the population that exhibits strong resistance towards COVID-19 vaccination in the United States. Darker areas correspond to more prevalence of vaccination hesitancy.





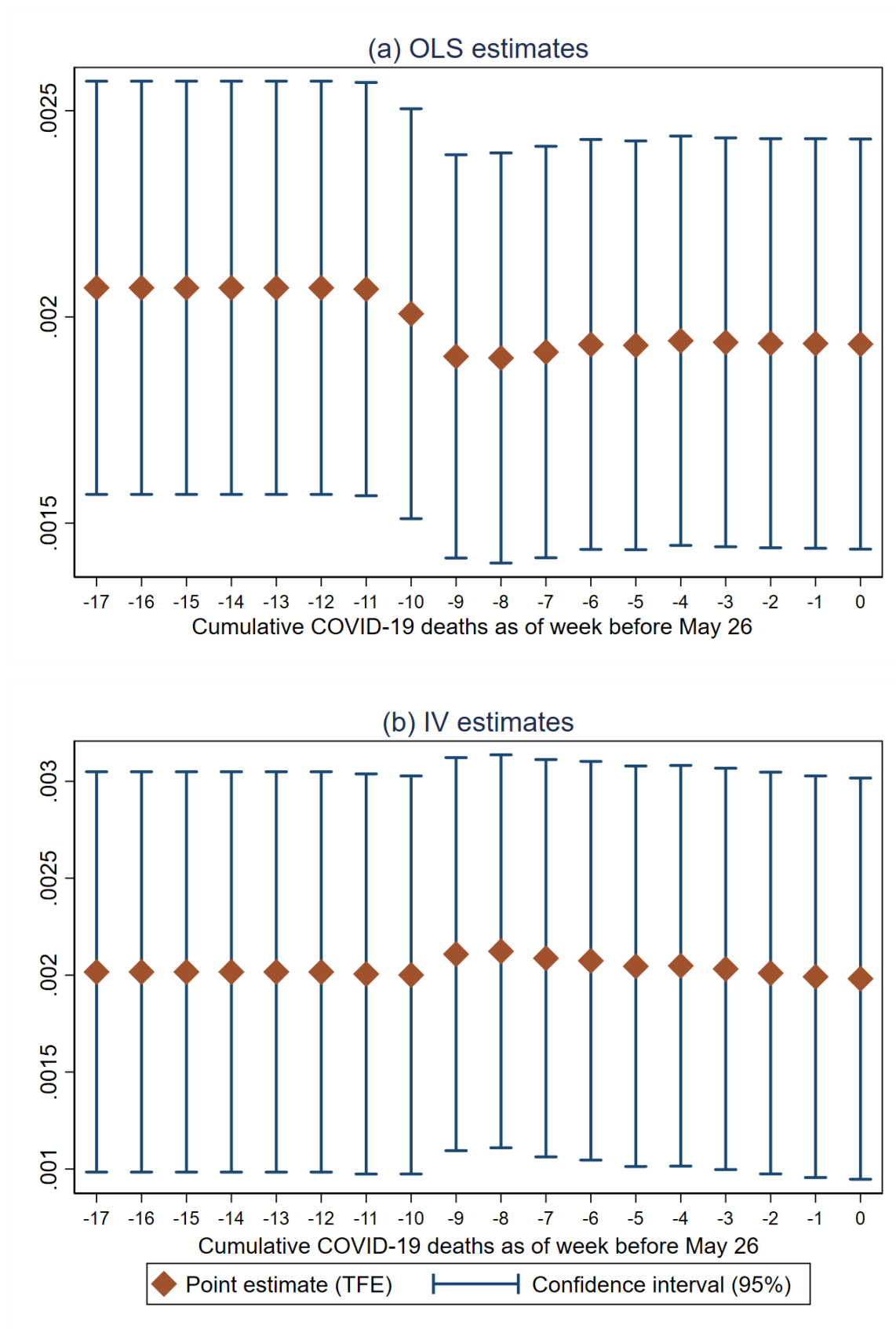
**Figure 3. Rugged individualism and under-vaccination over time**

*Notes:* This figure depicts the effect of *TFE* on *Completeness* measured as of the end of each month between January and September 2021.



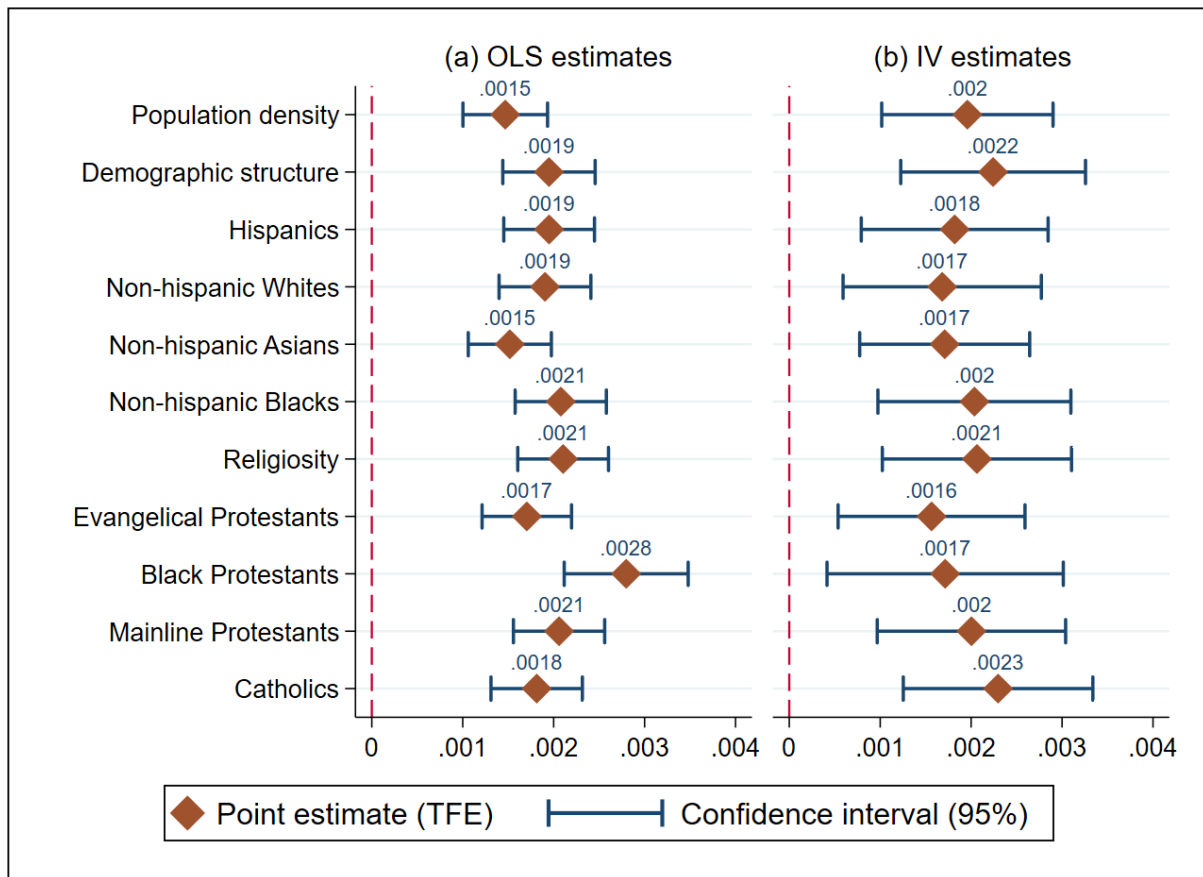
**Figure 4. The effect of rugged individualism on influenza vaccination coverage**

*Notes:* This figure depicts the effect of rugged individualism on predicted rates of influenza vaccination coverage across counties in the United States.



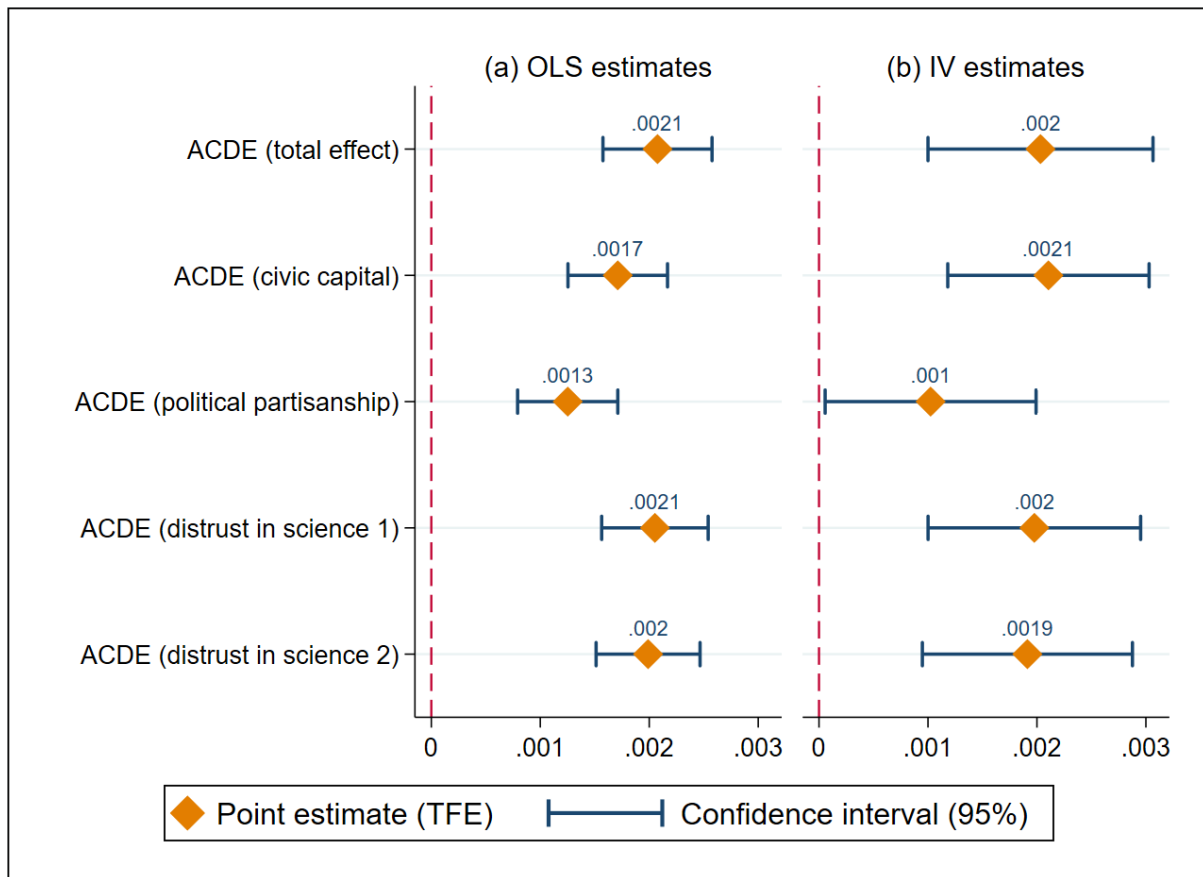
**Figure 5. Robustness to controlling for the severity of the COVID-19 pandemic**

*Notes:* This figure depicts the effect of *TFE* on *Strongly hesitant*, controlling for cumulative COVID-19 deaths updated as of various weeks before May 26, 2021.



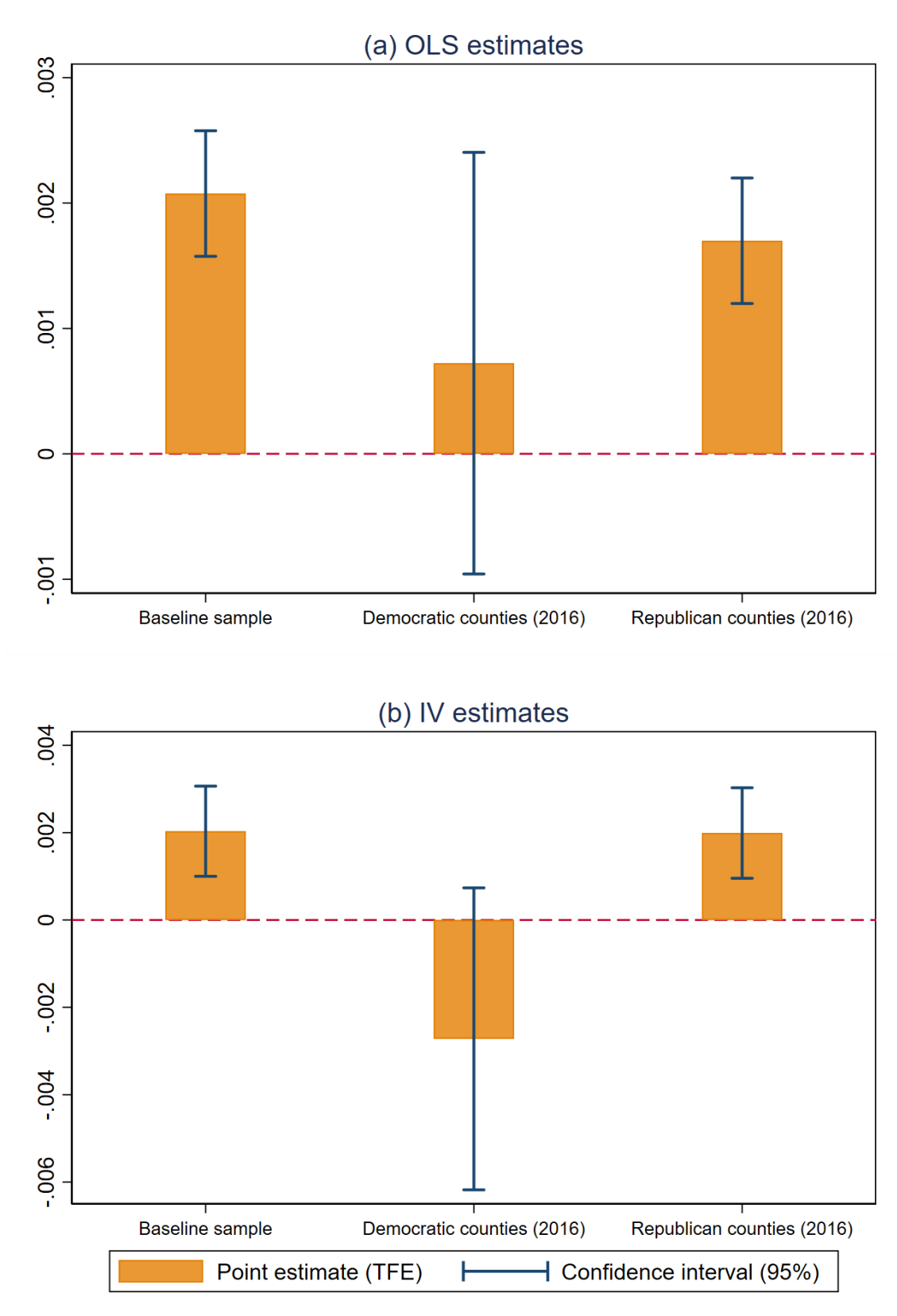
**Figure 6. Robustness to incorporating additional control variables**

*Notes:* This figure depicts OLS estimates of the effect of *TFE* on *Strongly hesitant*, controlling for additional demographic, ethnic and religious factors. I plot the point estimate and 95% confidence interval of the estimated coefficient on *TFE*. The full estimates are available on request. All the regressions are augmented with main geographic controls and state dummies.



**Figure 7. The ACDE of rugged individualism on vaccination resistance**

*Notes:* This figure depicts the average controlled direct effect (ACDE) of *TFE* on *Strongly hesitant* (see also Table 7). For example, ACDE (civic capital) corresponds to the contribution of rugged individualism to shaping the cross-county variation in vaccination opposition once accounting for the effect of civic capital. For ease of comparison, I also illustrate the baseline treatment effect – ACDE (total effect). All the regressions are augmented with main geographic controls and state dummies.



**Figure 8. Heterogeneous effects of rugged individualism on vaccination resistance**

*Notes:* This figure illustrates the estimated impact of rugged individualism on COVID-19 vaccination resistance across Democratic and Republican counties. All the regressions are augmented with main geographic controls and state dummies.

**Table 1. The effect of rugged individualism on vaccination resistance**

Dep_var	(1)	(2)	(3)	(4)
	Hesitant	Hesitant or Unsure	Strongly hesitant	Completeness
TFE	0.003*** [0.000]	0.004*** [0.001]	0.002*** [0.000]	-0.017*** [0.002]
Latitude	0.002*** [0.001]	0.002*** [0.001]	0.001*** [0.000]	0.004 [0.004]
Distance to coast	-0.001*** [0.000]	-0.002*** [0.000]	-0.001*** [0.000]	-0.004** [0.002]
Temperature	0.001*** [0.001]	0.002*** [0.001]	0.001*** [0.000]	0.002 [0.004]
Precipitation	0.009** [0.004]	0.005 [0.006]	0.006** [0.003]	-0.035 [0.026]
Terrain ruggedness	0.030*** [0.010]	0.028* [0.015]	0.025*** [0.007]	0.089 [0.058]
Rainfall risk	-0.032 [0.027]	-0.038 [0.040]	-0.029 [0.019]	0.138 [0.187]
Agri_suitability	0.001 [0.006]	0.004 [0.009]	0.002 [0.004]	0.109** [0.043]
State fixed effects	Yes	Yes	Yes	Yes
Oster $\delta$ statistic	3.02	1.70	3.65	1.669
Oster bound estimates	[0.002, 0.003]	[0.001, 0.004]	[0.001, 0.002]	[-0.008, -0.017]
Observations	2,036	2,036	2,036	2,036
R-squared	0.910	0.867	0.907	0.762

*Notes:* This table reports OLS estimates of the effect of rugged individualism on COVID-19 vaccination resistance across counties in the United States. Robust standard errors in squared brackets. \*\*\*, \*\*, and \*, respectively, denote statistical significance at the 1%, 5% and 10% levels.

**Table 2. IV estimates based on predicted migration flows**

Dep_var	(1)	(2)	(3)	(4)
	Hesitant	Hesitant or Unsure	Strongly hesitant	Completeness
<b>Panel A. Second-stage estimates</b>				
TFE	0.003*** [0.001]	0.003*** [0.001]	0.002*** [0.001]	-0.022*** [0.004]
<b>Panel B. First-stage estimates. Dependent variable is <i>TFE</i></b>				
Log of average <i>predicted</i> annual migration flows	-1.711*** [0.080]	-1.711*** [0.080]	-1.711*** [0.080]	-1.711*** [0.080]
<b>Panel C. Additional information</b>				
Geographic controls	Yes	Yes	Yes	Yes
State fixed effects	Yes	Yes	Yes	Yes
Observations	2,036	2,036	2,036	2,036
First-stage <i>R</i> -squared	0.453	0.453	0.453	0.453
First-stage <i>F</i> -statistic	459.59	459.59	459.59	459.59
AR confidence intervals	[0.001, 0.004]	[0.001, 0.005]	[0.001, 0.003]	[-0.031, -0.014]

*Notes:* This table reports IV estimates of the effect of rugged individualism on COVID-19 vaccination resistance across counties in the United States. I also present the first-stage *F*-statistic of excluded instruments developed by Olea and Pflueger (2013). Following Andrews et al. (2019), the Anderson-Rubin identification robust confidence intervals are reported to provide evidence on robustness to weak instrument bias. Robust standard errors in parentheses. \*\*\*, \*\*, and \*, respectively, denote statistical significance at the 1%, 5% and 10% levels.



**Table 3. Robustness to controlling for socio-economic development**

	(1)	(2)	(3)	(4)	(5)	(6)
<b>Panel A. OLS estimates. Dependent variable is <i>Strongly hesitant</i></b>						
TFE	0.001*** [0.000]	0.001*** [0.000]	0.001*** [0.000]	0.002*** [0.000]	0.001*** [0.000]	0.001*** [0.000]
<b>Panel B. IV (second-stage) estimates. Dependent variable is <i>Strongly hesitant</i></b>						
TFE	0.001*** [0.000]	0.001** [0.000]	0.001*** [0.000]	0.002*** [0.001]	0.002*** [0.000]	0.001*** [0.000]
<b>Panel C. IV (first-stage) estimates. Dependent variable is <i>TFE</i></b>						
Log of average predicted annual migration flows	-1.621*** [0.083]	-1.609*** [0.084]	-1.632*** [0.082]	-1.657*** [0.082]	-1.644*** [0.083]	-1.660*** [0.083]
<b>Panel D. Additional information</b>						
Geographic controls	Yes	Yes	Yes	Yes	Yes	Yes
State fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Log of income per capita	Yes					Yes
Average years of schooling		Yes				Yes
Urbanization rate			Yes			Yes
Unemployment rate				Yes		Yes
The fraction of the population below poverty line					Yes	Yes
Observations	1,979	1,979	1,979	1,979	1,979	1,979
First-stage <i>F</i> -statistic	382.61	370.36	394.73	404.63	395.59	400.85
AR confidence interval	[0.0005, 0.0021]	[0.0001, 0.0018]	[0.0006, 0.0024]	[0.0007, 0.0027]	[0.0008, 0.0026]	[0.0003, 0.0018]

*Notes:* This table replicates the main analysis by including numerous socio-economic factors in the regression. Robust standard errors in parentheses. \*\*\*, \*\*, and \*, respectively, denote statistical significance at the 1%, 5% and 10% levels.

**Table 4. Robustness to controlling for numerous barriers to vaccination rollout**

	(1)	(2)	(3)	(4)	(5)	(6)
<b>Panel A. OLS estimates. Dependent variable is <i>Strongly hesitant</i></b>						
TFE	0.002*** [0.000]	0.002*** [0.000]	0.002*** [0.000]	0.002*** [0.000]	0.002*** [0.000]	0.002*** [0.000]
<b>Panel B. IV (second-stage) estimates. Dependent variable is <i>Strongly hesitant</i></b>						
TFE	0.002*** [0.000]	0.002*** [0.001]	0.002*** [0.000]	0.002*** [0.001]	0.002*** [0.000]	0.002*** [0.001]
<b>Panel C. IV (first-stage) estimates. Dependent variable is <i>TFE</i></b>						
Log of average predicted annual migration flows	-1.715*** [0.079]	-1.729*** [0.077]	-1.729*** [0.080]	-1.710*** [0.080]	-1.716*** [0.080]	-1.710*** [0.080]
<b>Panel D. Additional information</b>						
Geographic controls	Yes	Yes	Yes	Yes	Yes	Yes
State fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
COVID-19 vaccine coverage index (CVAC)	Yes					
CVAC theme 1: historic under-vaccination		Yes				
CVAC theme 2: socio-demographic barriers			Yes			
CVAC theme 3: resource-constrained healthcare system				Yes		
CVAC theme 4: healthcare accessibility barriers					Yes	
CVAC theme 5: irregular care-seeking behaviors						Yes
Observations	2,036	2,036	2,036	2,036	2,036	2,036
First-stage <i>F</i> -statistic	464.36	498.60	469.71	458.93	462.17	455.52
AR confidence interval	[0.001, 0.003]	[0.001, 0.003]	[0.001, 0.003]	[0.001, 0.003]	[0.001, 0.003]	[0.001, 0.003]

*Notes:* This table replicates the main analysis by controlling for potential barriers to vaccination rollout, captured by the COVID-19 vaccine coverage index and its sub-components. Robust standard errors in parentheses. \*\*\*, \*\*, and \*, respectively, denote statistical significance at the 1%, 5% and 10% levels.

**Table 5. Robustness to using alternative measures of individualism**

	(1)	(2)	(3)	(4)
	OLS estimates		IV estimates	
Panel A. OLS and IV (second-stage) estimates. Dependent variable is Strongly hesitant				
Infrequent names	0.087*** [0.006]		0.212*** [0.049]	
Non-patronymic/Matronymic names		0.177*** [0.009]		0.365*** [0.087]
Panel B. IV (first-stage) estimates. Dependent variables are alternative measures of individualism				
Log of average predicted annual migration flows			-0.016*** [0.003]	-0.009*** [0.002]
Panel C. Additional information				
Geographic controls	Yes	Yes	Yes	Yes
State fixed effects	Yes	Yes	Yes	Yes
Observations	2,036	2,036	2,036	2,036
First-stage <i>F</i> -statistic			26.87	19.49
AR confidence interval			[0.162, 0.332]	[0.116, 0.201]

*Notes:* This table replicates the main analysis by using alternative measures of individualistic cultures, including the prevalence of infrequent names and the absence of patronymic/matronymic names. Robust standard errors in parentheses. \*\*\*, \*\*, and \*, respectively, denote statistical significance at the 1%, 5% and 10% levels.

**Table 6. Robustness to the validity of the exclusion restrictions**

Dep_var	(1)	(2)	(3)	(4)
	Hesitant	Hesitant or Unsure	Strongly hesitant	Completeness
<b>Panel A. IV (second-stage) estimates.</b>				
TFE	0.003*** [0.001]	0.003*** [0.001]	0.002*** [0.001]	-0.022*** [0.004]
<b>Panel B. 95% confidence intervals for TFE under <math>\gamma \sim N(0, \delta^2)</math></b>				
CI ( $2\delta = 10\%$ )	[0.0013, 0.0043]	[0.0001, 0.0044]	[0.0006, 0.0029]	[-0.0304, -0.0111]
CI ( $2\delta = 15\%$ )	[0.0013, 0.0044]	[0.0001, 0.0046]	[0.0006, 0.0031]	[-0.0304, -0.0098]
CI ( $2\delta = 25\%$ )	[0.0013, 0.0046]	[0.0001, 0.0050]	[0.0006, 0.0033]	[-0.0304, -0.0074]
CI ( $2\delta = 50\%$ )	[0.0013, 0.0050]	[0.0001, 0.0058]	[0.0006, 0.0038]	[-0.0304, -0.0012]
<b>Panel C. Additional information</b>				
Geographic controls	Yes	Yes	Yes	Yes
State fixed effects	Yes	Yes	Yes	Yes
Observations	2,036	2,036	2,036	2,036
R-squared	0.048	0.036	0.052	0.036

*Notes:* This table presents empirical estimates of the influence of rugged individualism on COVID-19 vaccination resistance when allowing for potential deviations from the exogeneity condition, based on the “plausible exogenous” instruments framework of Conley et al. (2012). Panel A reports the baseline IV estimates for ease of interpretation (see also Table 2). Panel B reports lower and upper bound estimates of the estimated coefficient on *TFE* under non-orthogonality conditions. For example, CI ( $2\delta = p\%$ ) should read as the 95% confidence intervals of the estimated effect of *TFE* on vaccination resistance when allowing the direct effect of the IV to be up to  $p\%$  of the marginal effect of *TFE*, presented in Panel A.

**Table 7. The effect of “rugged individualism” on proposed mechanisms**

Potential mechanisms	(1)	(2)	(3)	(4)
	Civic capital	Political partisanship	Distrust in science 1 (Don’t believe in climate change)	Distrust in science 2 (Don’t believe in human causes of climate change)
<b>Panel A. OLS estimates. Dependent variables are proposed mechanisms</b>				
TFE	-0.059*** [0.014]	0.033*** [0.003]	0.369*** [0.086]	0.337*** [0.082]
<b>Panel B. IV (second-stage) estimates. Dependent variables are proposed mechanisms</b>				
TFE	0.014 [0.029]	0.041*** [0.006]	0.828*** [0.167]	0.476*** [0.162]
<b>Panel C. IV (first-stage) estimates. Dependent variable is TFE</b>				
Log of average predicted annual migration flows	-1.722*** [0.080]	-1.711*** [0.080]	-1.711*** [0.080]	-1.711*** [0.080]
<b>Panel D. Additional information</b>				
Geographic controls	Yes	Yes	Yes	Yes
State fixed effects	Yes	Yes	Yes	Yes
Observations	2,021	2,036	2,036	2,036
First-stage <i>F</i> -statistic	464.68	459.59	459.59	459.59
AR confidence interval	[-0.041, 0.069]	[0.029, 0.052]	[0.514, 1.142]	[0.172, 0.780]

*Notes:* This table reports empirical estimates of the effect of rugged individualism in shaping the cross-county variation in the proposed mechanisms, including civic capital, political partisanship and distrust in science. Robust standard errors in parentheses. \*\*\*, \*\*, and \*, respectively, denote statistical significance at the 1%, 5% and 10% levels.

**Table 8. The ACDE of rugged individualism on vaccination resistance**

	(1)	(2)	(3)	(4)
Mediators	Civic capital	Political partisanship	Distrust in science 1 (Don't believe in climate change)	Distrust in science 2 (Don't believe in human causes of climate change)
<b>Panel A. OLS estimates. Dependent variables are proposed mechanisms</b>				
TFE	0.002***	0.001***	0.002***	0.002***
[Bootstrapped standard errors]	[0.000]	[0.000]	[0.000]	[0.000]
<b>Panel B. IV (second-stage) estimates. Dependent variables are proposed mechanisms</b>				
TFE	0.002***	0.001**	0.002***	0.002***
[Bootstrapped standard errors]	[0.000]	[0.000]	[0.000]	[0.000]
<b>Panel C. Additional information</b>				
Geographic controls	Yes	Yes	Yes	Yes
State fixed effects	Yes	Yes	Yes	Yes
Observations	2,021	2,036	2,036	2,036

*Notes:* This table reports the Average Controlled Direct Effect (ACDE) of rugged individualism on vaccination opposition in the United States. Following Acharya et al. (2016), these estimates are computed based on a two-step regression technique discussed in the main text. The standard-error estimates are derived from a bootstrapping procedure with 1000 replications. \*\*\*, \*\*, and \*, respectively, denote statistical significance at the 1%, 5% and 10% levels.