IN THE UNITED STATES DISTRICT COURT

FOR THE NORTHERN DISTRICT OF OHIO (CLEVELAND)

A. PHILIP RANDOLPH INSTITUTE OF OHIO, LEAGUE OF WOMEN VOTERS OF OHIO, OHIO STATE CONFERENCE OF THE NAACP, BEATRICE GRIFFIN, SARAH RIKLEEN, C. ELLEN CONNALLY, MATTHEW NOWLING, RYLLIE JESIONOWSKI, SOLI COLLINS, and MARCUS GERMANY, *Plaintiffs*, v. FRANK LAROSE, in his official capacity as Secretary of State of Ohio, *Defendant*.	CASE NO. 1:20-cv-01908-DAP

DECLARATION OF DR. DANIEL G. CHATMAN IN SUPPORT OF PLAINTIFFS' MOTION FOR PRELIMINARY INJUNCTION

I, Dr. Daniel G. Chatman, respectfully declare as follows:

1. I am an Associate Professor of City and Regional Planning at the University of California, Berkeley. I have taught undergraduate and graduate courses in urban and regional transportation planning, transportation and land use planning, and research methods.
2. I received a B.A. degree from the University of California, Berkeley in 1991, a Master's degree in Public Policy from the Kennedy School of Government at Harvard University in 1997, and a Ph.D. in Urban Planning from the University of California, Los Angeles in 2005. From 2005 to 2009 I was Assistant Professor in the Bloustein School of Planning and Public Policy at Rutgers University, where I also served as Director and Research Director of the

Alan M. Voorhees Transportation Center. I was appointed as Assistant Professor at U.C. Berkeley in 2008, and was promoted to Associate Professor with tenure in 2014.

3. I conduct research on travel behavior and the built environment, immigrants and travel in the United States, the relationships between public transportation services and the economy, and other topics related to transportation and land use planning. I have published more than 50 peer-reviewed journal articles, book chapters, research reports, and lay articles, and have given more than 100 invited or refereed talks on these topics. I have been principal investigator on transportation and land use research grants and contracts totaling about $3 million in funding.

4. In 2014, I provided a report and testified as an expert in a voting case in Texas. My analysis and testimony concerned the racial/ethnic and income distribution of transportation burdens associated with newly imposed photo identification requirements for voter eligibility in Texas (United States District Court, Southern District of Texas, Corpus Christi Division, MARC VEASEY, et al., Plaintiffs, v. RICK PERRY, et al., Defendants. Civil Action No. 2:13-cv-193 (NGR)).

<u>Questions Addressed</u>

5. I was retained to analyze both the travel burdens and the queuing delays associated with the State of Ohio rule that ballot drop boxes may be provided only at the county board of elections office in each county.

Summary of Results: Travel Burdens for Voters to Access a Ballot Drop Box

6. In the first analysis, I investigated the travel burden that would be incurred by citizens of voting age who wish to drop off their absentee ballots rather than mailing them. I focus on the time required to access a ballot drop box by car, via public transportation, or on foot, and to return home, as time is the most salient and readily quantifiable of the various costs involved in travel. The main output of this first analysis is an estimate of travel time burdens across the population of all citizens of voting age, with attention to the question of poverty rates and auto ownership, and the particular impact on the largest cities in the state.

7. I find that the Ohio prohibition on providing more than one ballot box location per county, rather than permitting multiple drop boxes or allowing absentee ballots to be dropped off at in-person polling locations, will place a substantial travel burden on citizens of voting age without access to a vehicle who find it necessary to drop off their absentee ballots rather than mail them. I define a "travel burden" as being required to travel for more than an hour and a half round trip on public transportation or on foot. This amount of additional travel would more than double the average amount of daily household travel for an Ohio resident. I calculate that the share of the population who would have to travel for more than 90 minutes is very low for households who own autos, at less than 0.1 percent of such households, but very high for carless citizens of voting age, who make up about 8 percent of voting-age citizens in the state. More than 70 percent of citizens of voting age without access to a car would have to spend more than 90 minutes to deliver their ballot to a county drop box and return home. The *average* round trip duration for these burdened individuals is more than three hours, due to a significant number of those who would be required to travel for more than five hours round trip, most of them on foot. The burden is not evenly distributed across

the state. In particular, the share of households with a travel burden exceeding 90 minutes in two cities, Cincinnati and Cleveland, is 2.5 times as high as the state average, at about 14.5 percent of all citizens of voting age.

8. The presence of households with this travel burden is highly correlated with poverty status. One of the best predictors of whether a person owns a car is their income. The median income of households without cars in Ohio is about half that of households who have a car, and the strongest predictor of whether an individual would have a travel burden to access a drop box location is whether they have access to a car in their household.

9. My detailed travel burden analysis is set forth below at pages 7 to 23. The detailed statement of my travel burden results is at pages 20 to 23. The statement of results is preceded by sections which provide background, and describe my methodology, for the travel analysis.

Summary of Results: Queueing Burdens to Access a Ballot Drop Box on Election Day

10. In the second analysis, I estimated how the restriction permitting only one location for drop boxes per county is likely to lead, particularly in counties with larger populations, to long queues of vehicles and pedestrians waiting to drop off their ballots. Per Appendix A, in the Ohio 2020 primary election there were, for example, long lines of vehicles in one such county, Hamilton, waiting to deliver ballots to the county ballot drop box. News reports state that more than 95 percent of ballots cast in the primary election were absentee. Thus in the general election in November there would appear to be the potential for millions of registered voters desiring to access a drop box, given widespread concerns about unreliability and delays associated with mail delivery of absentee ballots.

11. I carried out a queuing analysis to determine the length and waiting times likely to be associated with ballot drop box locations. Under conservative assumptions detailed below, it

is likely that at least five percent of registered voters could attempt to deliver their absentee ballots at a drop box on the day of the election. Based on experiences elsewhere, demand for drop box use will be highest on Election Day. This is all the more likely given that absentee ballots will not be counted if postmarked on the day of the election.

12. Under one set of baseline assumptions that are relatively conservative, I calculate that queues would be intolerably long in eight counties and many voters would be forced to forgo voting. The lines would be particularly burdensome in Cuyahoga, Franklin, Hamilton, Summit, and Montgomery Counties, with between 9,500 and 35,000 voters in each of those counties waiting for 15 hours or more to drop off their ballots, unless dissuaded from voting altogether. When using less conservative but still reasonable assumptions based on experiences elsewhere, the projected queues are even longer, affecting more than 400,000 voters in the most populous counties in the state, with many of those likely to be dissuaded from casting their ballots, with wait times so long that they imply huge traffic snarls in the counties affected.

13. My detailed queueing analysis is set forth below at pages 24 to 35. The detailed statement of my queueing results is at pages 29 to 35. The statement of results is preceded by a discussion of my methodology.

Overview of Work

14. I defined and carried out the first analysis of travel burden in four parts. First, I identified a simplified set of home starting points for trips that would be undertaken by those who seek to drop off their absentee ballots at a ballot drop box, consisting of the "centroids," or central geographical coordinates, of the 9,235 Census-defined block groups in the state of Ohio. I also identified and mapped the individual locations of the county boards of elections where

ballot drop boxes are located. Second, using both geographical information system software and Google Maps, I estimated the time it would take to travel from home to the nearest ballot drop box, and back, by each of three travel modes: personal automobile, public transportation, and on foot. Third, I compiled and estimated information about the citizens of voting age (CVAs) located in the 9,235 block groups throughout the state, with a focus on those living in households without access to an auto. Fourth, I estimated the round-trip travel times to drop off a ballot for CVAs depending on household auto availability.

15. I carried out the second analysis of queue lengths and delays as follows. First, I estimated the share of registered voters in each county who are likely to attempt to deliver absentee ballots to a county drop box on the day of the election. Second, I applied queuing analysis methods along with a set of parameters regarding the capacity of each box, the share of drop-offs occurring during daily peak travel periods and off-peak, and the operating hours over which voters are likely to drop off ballots on Election Day, to estimate hour-by-hour queue lengths and time delays waiting in the queue. Third, I estimated the number of voters likely to be dissuaded from voting by using queue length at the end of the day as an approximation.

16. I was assisted in geocoding, mapping, data procurement, data management, and data analysis by four doctoral candidates and three undergraduate research assistants who were paid respectively [redacted]. I also paid Google for the use of their cloud services to procure one set of travel time estimates, in addition to calculating my own set of travel time estimates using Open Trip Planner, an open-source geographical information system software program. [redacted].

Travel Burden Analysis: Methodology and Results

A. Background

17. As noted above, for purposes of this investigation, I define "travel burden" in terms of time. This is based on a comparison with both national travel survey data and survey data from the State of Ohio.

18. The cumulative time that individuals spend traveling every day varies a great deal by household (National Household Travel Survey, 2017). In the State of Ohio, among those of income greater than $25,000, the average daily time spent traveling for all trips made for personal and household purposes is 66.4 minutes; for those making less than $25,000, the average is 72.5 minutes per day. These figures are slightly lower than the US averages for the same groups (see Table 1 below). A starting point for any definition of "travel burden" is the current amount of time that an individual already spends traveling each day, because this pattern typically reflects constraints that make it difficult to travel more without having financial impacts or causing time scarcity (Farber and Páez, 2011).

Table 1: Average minutes spent traveling per day, by income

	All persons	
	<$25,000	**>$25,000**
Ohio	72.5	66.4
U.S. Total	75.2	69.1

Source: National Household Transportation Survey, 2017

19. The average duration for a home-based trip for a non-work purpose (excluding trips taken by air or intercity bus)—that is, the time needed for the average trip from home to reach an activity such as grocery shopping, seeing the doctor, or dropping one's child off at school—is 20.3 minutes in the US and 20.6 minutes in Ohio in 2017. The average time duration of an

average round trip is higher on both public transportation and walking than in a car, reflecting slower travel speeds than for auto. Across all trip purposes, the average duration of a trip taken via public transportation or on foot is 52.8 and 22.4 minutes respectively in the US, and 41.2 and 36.8 minutes in the State of Ohio (Nationwide Household Transportation Survey, 2017). Regardless of trip purpose, almost all trips in both the US and in the State of Ohio are taken by personal vehicle, due to the relatively slow speeds and incomplete spatial coverage afforded by public transportation in most parts of the US and of Ohio, as well as the long distances between activity locations, and often hazardous or strenuous walking conditions, that often make walking impractical. Just 1.1 percent of all trips in Ohio are taken on public transportation, while 8.6 percent of all trips are taken on foot.

20. While some individuals may have time to spare for any of a number of activities, most individuals must make tradeoffs when there is any new demand on time. An increase in the amount of time required to travel can cut into discretionary time for activities like entertainment, socializing, and shopping, and then into non-discretionary time for activities like work, meals, child care, and buying groceries (Farber and Páez, 2011).

21. There are a number of burdens associated with traveling to a ballot drop box, the largest and most quantifiable of which may be time. The primary burden arises for those who do not have access to a vehicle, as those who do can either drive to the location or get a ride from someone in their household, and the physical effort involved is minimal. For those who do not have access to a vehicle, however, in order to drop off a ballot, they must rely on either a ride from someone else not living in the household, or an alternative travel mode such as public transportation or walking. Since there are only 88 ballot drop boxes locations in Ohio, a state of almost 12 million people, and since public transit services are slower and not

ubiquitously available throughout the state, travel distances and durations can be quite large. The burden is highest for those without familiarity with public transportation routes, with physical difficulties in walking, and so on.

22. While acknowledging the existence of a subjective aspect of travel burden that goes beyond travel *time*, the primary focus of this analysis is to investigate the number and share of citizens of voting age ("CVAs") who would need to undertake trips of long duration in order to drop off their absentee ballots. Calculating the travel burden based on the amount of time required to access a ballot drop box does not account for the relative inconvenience and physical discomfort associated with the walking, waiting, and in-vehicle times associated with long public transportation rides; or the physical effort involved with walking all or some of the distance to the location, along routes that may be largely inhospitable to pedestrians.

23. There is some scientific literature that has translated these qualitative facts about accessing and egressing public transportation on foot into estimates of the valuation of time associated with waiting, walking, and riding on vehicles in transit, by analyzing survey data for the purpose of predicting choices between travel modes. Based on a set of 192 studies of walk time values and 77 of waiting time values, the time that people spend waiting for public transportation or walking to and from public transportation stops is about 1.6 times as burdensome as time spent traveling in a personal vehicle (Abrantes and Wardman, 2011, Table 21). In turn, time spent riding the bus or rail is somewhat more burdensome than time spent in a personal vehicle. One quantitative figure averaging a smaller set of studies puts the value at 1.2 for the disutility of time spent on a bus compared to time spent in a car (Abrantes and Wardman, 2011, Table 19).

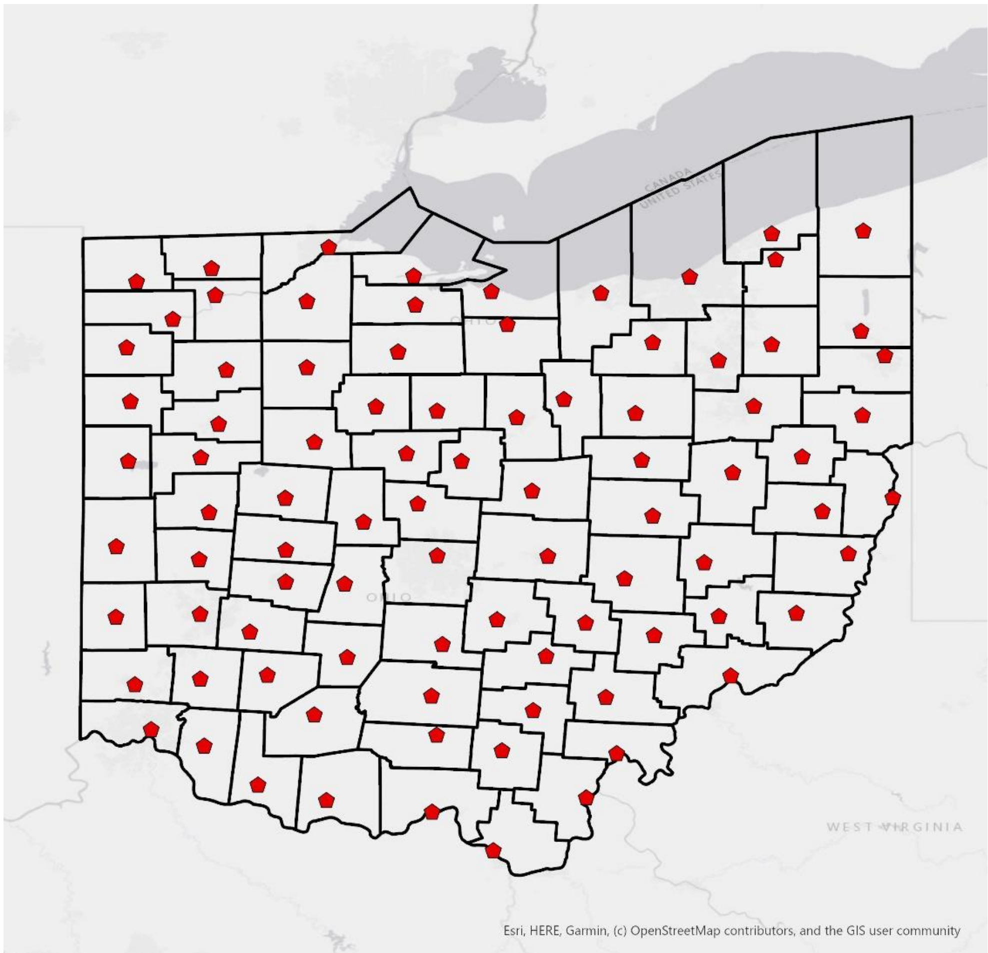
24. In addition, people of lower income can be expected to have more difficulty than people of higher income in managing to find additional time to drop off their ballots. Those of lower income usually do not have the option of purchasing services to reduce time requirements in other areas, such as paying for child care, laundry service, home cleaning services, meals out, or prepared food. Travel becomes particularly burdensome when it requires difficult choices such as whether to work fewer hours in the week (and thus to pay in dollar terms, not just in time terms); to require children to stay up later than normal in order to accommodate the lengthened schedule for that day; or to forgo a trip to the doctor that week. Because these kinds of burdens are more likely to be borne by those of lower income, but cannot be otherwise measured directly with available data, I also investigated whether the travel time burden is associated with poverty status in the State of Ohio, as discussed later in the report.

25. For the purpose of this analysis I define a travel burden as a round trip that exceeds 90 minutes. I focus on trips on foot or via public transit, which are more onerous than trips undertaken in a private vehicle, as explained above. Just 1.3 percent of trips in Ohio exceeded 45 minutes one way (90 minutes round trip) on public transportation or on foot, according to the most recent data for Ohio from the National Household Travel Survey (2017). The fact that such long trips on foot or via public transportation are so rare suggests that people avoid them whenever possible.

B. <u>Methodology: Travel Starting and Ending Points; Calculation of Travel Times</u>

26. I obtained online listings of the 88 county board of elections offices where ballot drop boxes are or will be located, and geocoded these using Google Maps. Figure 1 (below) displays the geocoded ballot drop box locations on a county map of Ohio.

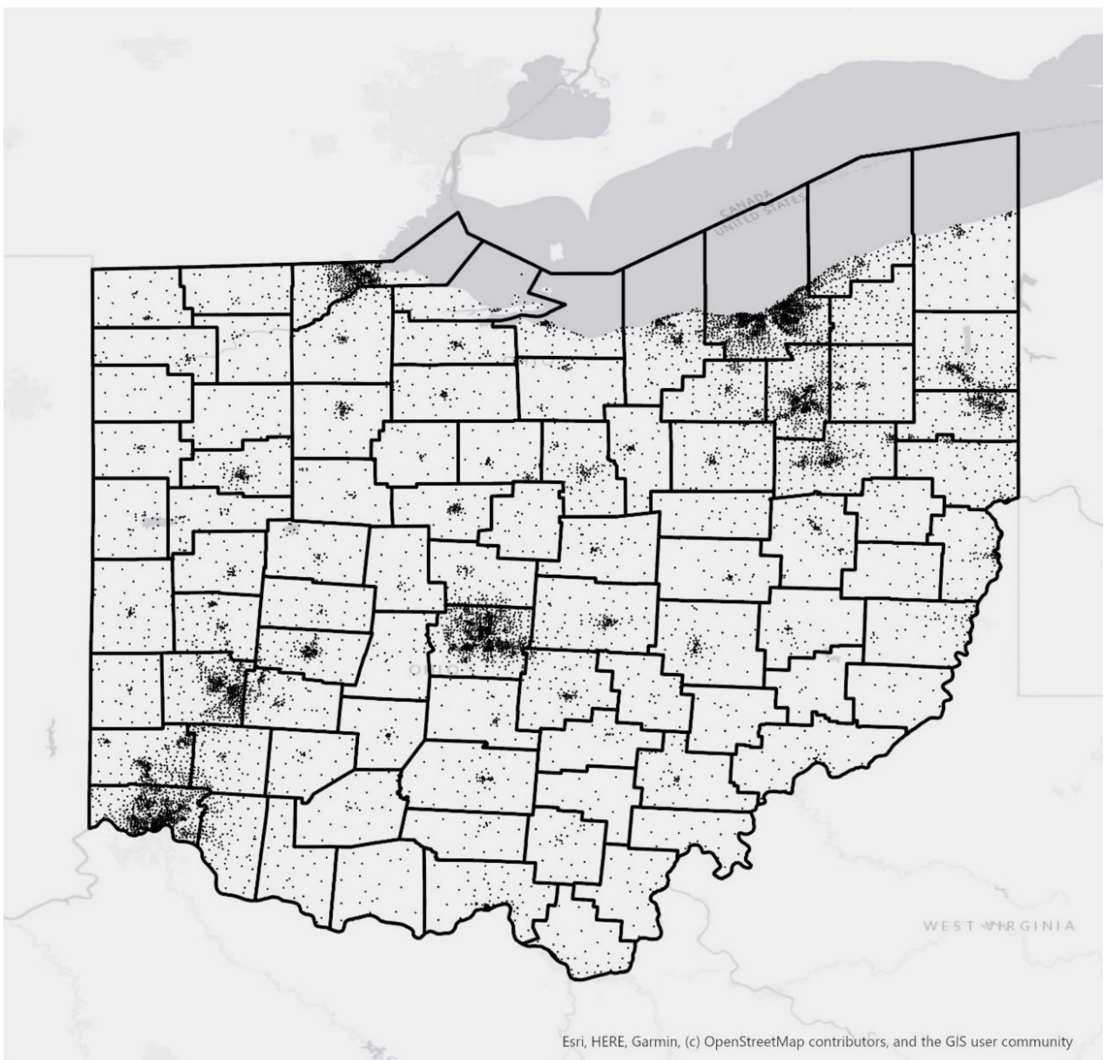
Figure 1: Geocoded ballot drop box locations in the state of Ohio



27. There were about 4.7 million occupied housing units in the State of Ohio as of 2018 (U.S. Census Bureau, 2020), and therefore I used a set of simplified home locations to estimate the travel times for those who may seek to deliver their ballots to a county drop box. These consisted of Census block groups, which typically include between 200 and 1,000 housing units (with an average of 504 housing units). I defined the location for all households in the block group as consisting of the centroid of the block group (the spatial center of gravity of the block group polygon). Figure 2 (below) displays the centroids, and county boundaries are also shown. (Block group boundaries are not shown.)

28. Figure 2 also illustrates the fact that any meaningful spatial error in identifying the locations of specific housing units is likely of most concern in locations in the outlying and less dense parts of the state. In these locations it is more likely that travel time estimates are inaccurate because the block group centroid may be located farther from the average household than in block groups in the most densely populated parts of the state. However, by the same token, this error exists only with regard to a small fraction of the Ohio population.

Figure 2: Block group centroids (estimated home locations)



29. For each block group centroid I estimated the travel time to the ballot drop box location within that county. There are many possibilities to obtain data to estimate travel times, but the best estimates are based on distances along the road network, travel times on public transportation, and distances along the pedestrian network. I used network and schedule-based estimates rather than more commonly calculated "zone to zone" estimates of travel time, which rely on aggregated information about trip destinations and are therefore less accurate.

Public Transportation Times

30. There are six large public transportation agencies (with at least 2 million one-way trips per year) in the State of Ohio serving the metropolitan areas of Cleveland, Columbus, Cincinnati, Dayton, Toledo, and Canton. Of these, two metropolitan regions offer rail transit and bus services. Rail transit offered in the State of Ohio includes one heavy rail line operating in the Cleveland metropolitan area. Lower-capacity rail lines in Ohio include the Cincinnati streetcar Bell Connector, and three light rail lines serving also the Cleveland metropolitan area. In addition to the transit services offered in these five large metropolitan areas, which encompasses 11 counties, there are also local agencies providing fixed-route bus services, paratransit, or a combination of both in other 50 counties, according to the Ohio Department of Transportation. At least 27 counties do not provide any local public transportation service at all.

31. About 81 percent of the population of Ohio lives in counties with some form of public transportation. This does not mean that every individual is served by a public transportation line, and provides little information on the quality of service. To provide more granular

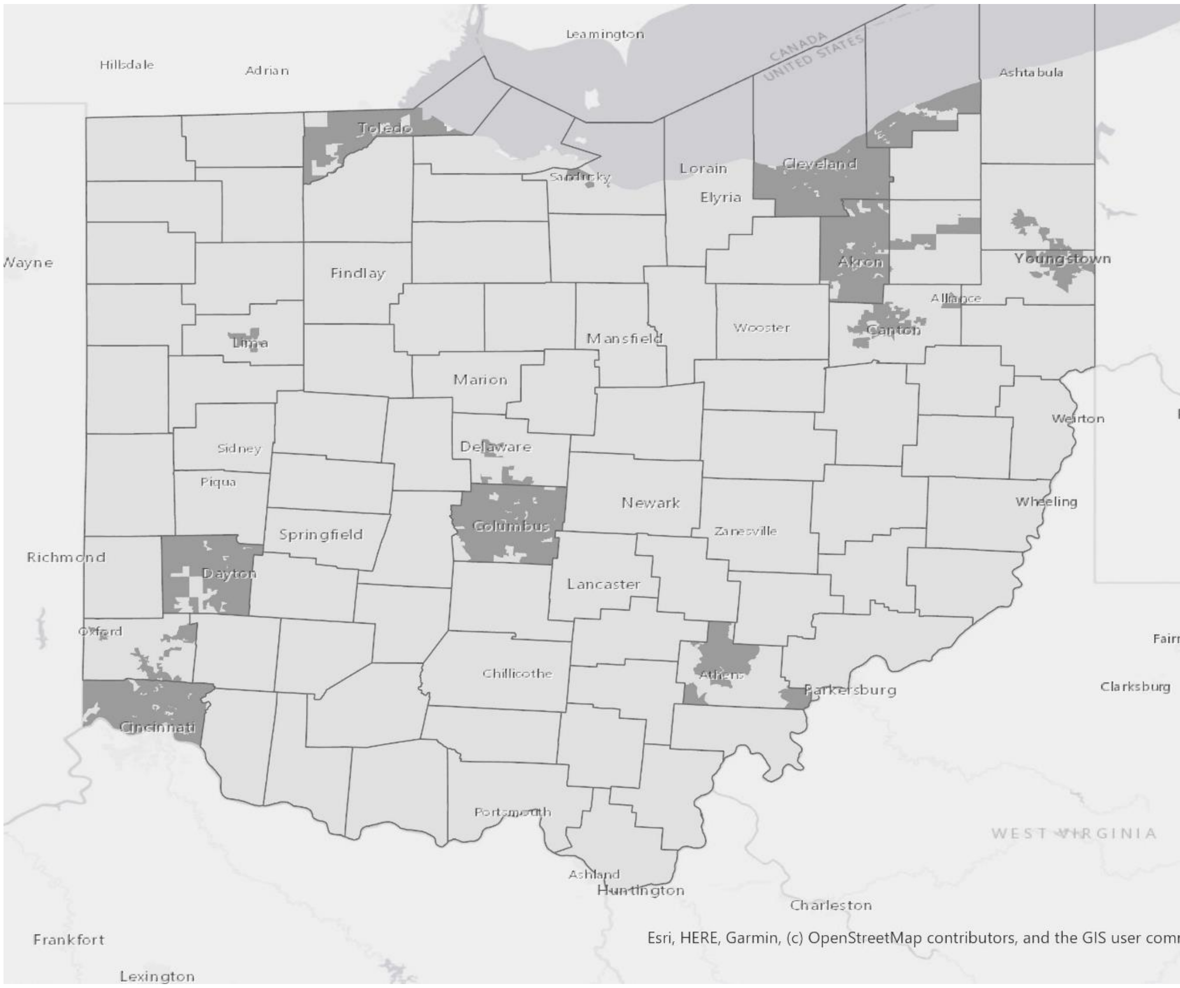
public transportation information I have calculated public transportation travel times across the state.

32. I used both Google Maps and Open Trip Planner (OTP) along with Open Street Map software and General Transit Feed Specification (GTFS) data to estimate public transportation times from block group centroids to ballot drop box locations. Having two independent sources for travel times acts as a check to ensure the accuracy of the results, and in some cases a public transportation estimate was available using one method but not the other. The estimates rely on spatially specific information about the routes of public transportation vehicles, location of stops, and schedules in GTFS data. These make it possible to estimate public transportation travel times that take into account actual service frequency, scheduled public transportation times, and waiting times between transit vehicles. The OTP software includes estimation of walking routes to and from public transportation stops and between public transportation lines when transfers are necessary. In the end I relied primarily on OTP estimates, supplemented by Google Maps estimates for a few locations in which Google Maps apparently had access to GTFS data that I was not able to procure myself. Analysis of OTP and Google maps that were performed?

33. The travel time by public transportation was estimated from each block group centroid to the nearest ballot drop box location when transit was available. Figure 3 (below) shows the geographical areas of the state in which public transportation was faster than walking to get to the county drop box location. By this definition, 44 percent of the block groups could be defined as accessible.

Why harsh barriers along county lines?
OTP —> makes sense
Google Maps —> confusing.

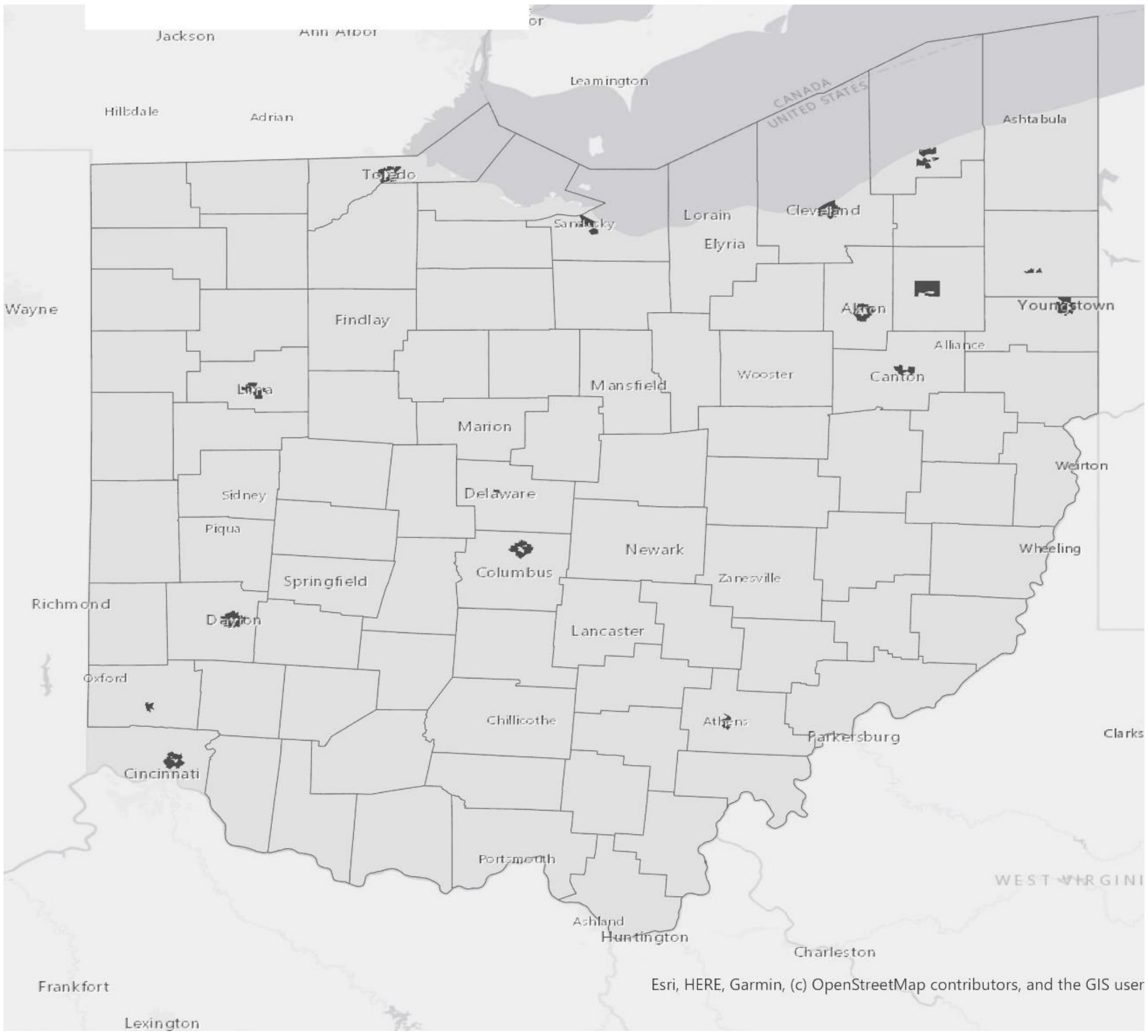
Figure 3: Block group locations in which public transportation saves time over walking (dark shaded areas)



34. Another way of looking at the question of transit "access" is to note that many of the locations depicted in Figure 3 are of block groups in which travelers would be forced to walk more than an hour on either the outgoing trip to the county drop box location or the return trip. Figure 4 (below) shows those block group locations for which walk times are less than an hour in both directions. By this definition, only 628 of the block groups in the state (6.8 percent) were defined as accessible. (This calculation does not account for any on-demand transit or paratransit services that may be available in the state.) Block groups that most

people would consider "transit accessible" are a much smaller fraction of the state than what is implied in Figure 3.

Figure 4: Block groups with public transportation trips requiring less than a one-hour walk (dark shaded areas)



35. For every trip on public transportation, travel time includes walking to the nearest bus or rail stop from home, waiting for a bus or train, and walking from the closest available stop to the ballot drop box. These public transportation travel time estimates assume the best-case scenario of highest schedule availability and no travel delay. Specifically, it is assumed that everyone can make their trip to the ballot drop box on Tuesday morning (a weekday morning, typically the highest frequency public transportation schedule) despite the fact that

many people will find it difficult to travel at that time of day due to obligations like work. Those who travel on public transportation to a drop box during the middle of the day, at the end of the work day, or on a weekend, could encounter a much less frequent schedule than what is assumed here, and would almost never encounter a more frequent schedule.

36. For the 4,673 block groups for which public transportation travel times were calculated and were faster than walking time, the average total time to travel from home to the nearest ballot drop box, including walking time, was 155 minutes, round trip. There was substantial variance. For example, ten percent of block groups where public transportation is faster than walking the whole distance have a one-way trip exceeding two hours to arrive at a ballot drop box, or more than four hours round trip.

Travel Times by Auto

OTP Driving results not needed?

37. To estimate the driving time between Census block group centroids and ballot drop boxes, I used an automated batch interface for Google Maps using a cloud services account, which provided a time estimate for a standard, time-efficient route that accounted for any habitual travel delays caused by road congestion and traffic signals. I calculated the driving time from the geographic center of each Census block group to the county ballot drop box location and the return trip as well, under the assumption that the beginning of the trip was at 9 am on a Tuesday. The average road distances from block group centroids to ballot drop boxes ranged from just over a tenth of a mile to 48 miles, with a median one-way distance of 8.5 miles. The round-trip times ranged from as little as one minute to as long as 3.2 hours, with a median round trip value of 30 minutes when averaged over block groups. More than 95 percent of block group centroids had round trip travel times via auto of less than 55 minutes.

Travel Times on Foot

38. I calculated walking distances and durations using both Google Maps and Open Trip Planner GIS software to identify the shortest route within each county to each county ballot drop box from the geographic center of each Census block group using the road network. The distance to the nearest EIC location were very similar to the road distances (above). Walk times were estimated based on the assumption that travelers walk at 2.8 to 3 miles to the hour. This is conservative (i.e., faster than realistic) over a long distance, given that the main observational study upon which the standard walk speed assumption is based comes from measured speeds of a sample of 230 adult volunteers taken over a 25-foot expanse of floor (Bohannon, 1997). The walk time figures were estimated using both Google Maps and Open Trip Planner. There was relatively little difference in the estimates. This resulted in estimated walk times as long as 37 hours and as short as four minutes.

C. Methodology: Geographic Distribution of CVAs by Auto Ownership

39. The location of ballot drop boxes is relevant to people of voting age who are both eligible due to citizenship status and are registered to vote. There currently are no secondary data available to me to determine the locations of individuals—and therefore the travel times of those individuals—who are also registered to vote. Therefore, for the analysis presented here, I focus on estimating the locations and characteristics of citizens of voting age, by auto ownership.

40. Calculating the travel burden associated with dropping off a ballot requires, first, knowing how many citizens of voting age there are in each Census block group. I obtained block group counts of the number of residents in each Census block group who were of voting age (18 or over) from the 2013-2018 American Community Survey (ACS). There are 9,235 block groups in the state. These are the most accurate data currently available for a base count of

the population by age, even though changes to the population may have occurred in the last two years.

41. The block group level data from the ACS tells us how many people of voting age there in each block group, but not whether they are citizens and not whether they have access to a personal vehicle in their household. To estimate citizenship and personal vehicle access, I used the 2013-2018 ACS five-year estimates at the Census tract level to obtain the share of voting-age residents who were citizens in each Census tract and the share of households with access to at least one personal vehicle in each Census tract. There are 2,949 Census tracts in Ohio, containing between one and eight block groups, with a median of three block groups. To estimate citizens of voting age in each block group, I first calculated the share of adults of voting age that are citizens in the five-year sample for each Census tract. I then multiplied this ratio by the number of people 18 or older in each block group to estimate the CVAs in each block group (Chapa et al., 2011). I performed a similar calculation to estimate access to an auto: I first calculated the share of households in the Census tract that reported availability of at least one personal vehicle, and I multiplied this ratio by the estimated number of citizens aged 18 or older in each Census block group to distinguish those CVAs without auto access from those with access to an auto in their household.

42. The American Community Survey five-year block group and Census tract estimates are based on a one percent sample conducted every year. Because the ACS is conducted upon a sample of the population, rather than a complete count, its estimates are subject to sampling variability, but the five-year estimates are the most precise and spatially specific available given that the Decennial Census data are a full decade old.

43. Because there is no generally accepted methodology for aggregating confidence intervals from the Census tract level to higher levels of geography (e.g., to the county or state levels), I report these estimates without confidence intervals. Statewide figures presented in this report are statistically significant at the 0.001 level or better.

D. <u>Results: Travel Times and Auto Ownership for Counties, Cities and the State</u>

44. To assign a round-trip travel time to any given citizen of voting age in any given Census block, I followed the following deterministic algorithm. First, individuals living in a household with an auto available will either drive or be driven by another household member to the county ballot drop box, unless taking public transportation or walking is faster, in which case the faster of those alternative modes will be assigned. Second, individuals living in a household without an automobile will take public transportation if it is faster than walking, and will otherwise walk to the county ballot drop box.

45. As it turns out, the fastest travel time between the home location (block group centroid) and the nearest county ballot drop box was always via driving. Of the 9,235 simplified home locations (block group centroids), in no case was public transportation or walking faster. In turn, walking was the best option in roughly half of the block groups in which a vehicle was not available, most obviously in those counties where public transportation is not offered.

46. In order to evaluate the extent to which all Ohio citizens seeking to drop off their absentee ballot will encounter a travel burden, I identified all of the citizens of voting age in the state who I estimate would have to carry out a round trip of more than 90 minutes. This duration is significant because, as noted above, having to carry out a round trip of that duration more than doubles the average amount of travel carried out per day by an individual in the state of Ohio.

47. Of the estimated 8.8 million citizens of voting age, I calculated that about 8.1 million have access to a vehicle owned by the household (a "car"), and about 679,000 do not. Of the estimated 8.1 million CVAs with a car available, only about 800 (0.1 percent) have a round trip to access an EIC location of more than 90 minutes. Of the estimated 679,000 CVAs without a car, about 477,000 (70.2 percent) have a round-trip travel time via either transit or walking that exceeds 90 minutes. In total, my analysis finds that 5.8 percent of the state's population of CVAs would experience a significant travel burden if they wish to deliver their ballots to a drop box.

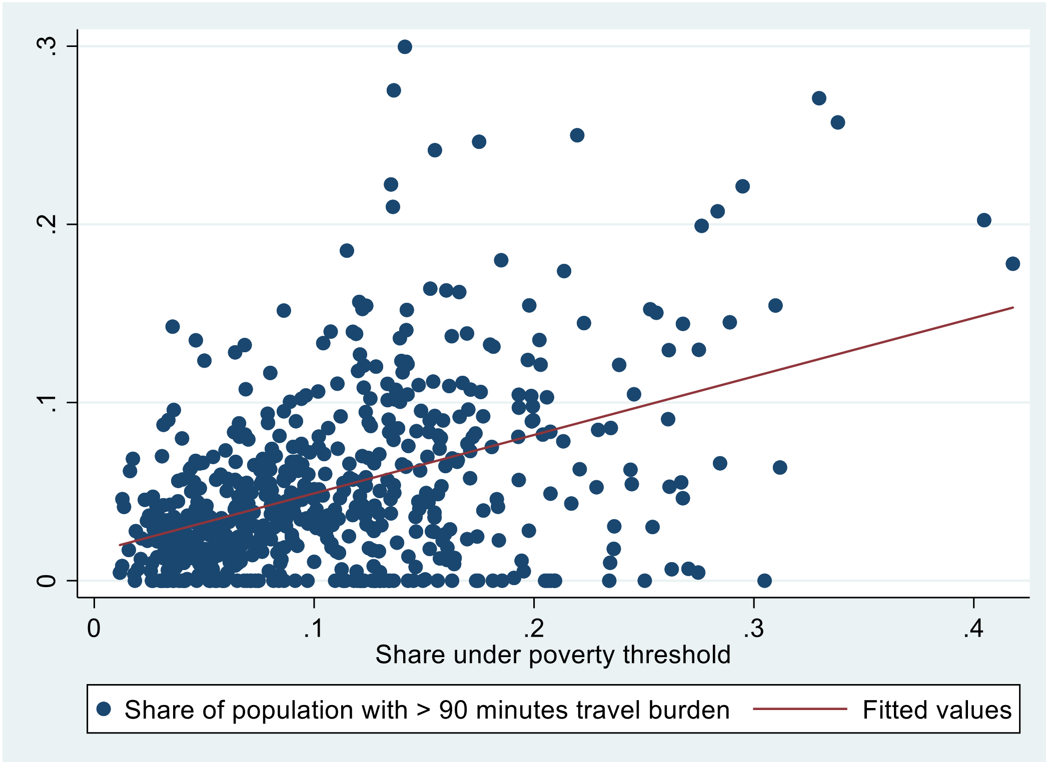
48. The majority of CVAs with a travel burden to reach a ballot drop box live in seven of the 88 counties in the state, the same counties containing most or all of its six largest cities: Cuyahoga (Cleveland), Franklin (Columbus), Hamilton (Cincinnati), Summit (Akron), Lucas (Toledo), Montgomery (Dayton) and Lorain (Cleveland-adjacent). The cities of Cincinnati and Cleveland have a particularly large share of CVAs with an expected travel time exceeding 90 minutes, at 14.5 and 14.4 percent respectively, or about 2.5 times as high as the state average. Table 2 (below) shows, for the twenty largest cities in the state, the estimated share of households with round-trip public transportation or walking travel exceeding 90 minutes to access a county ballot drop box. More than half of these cities have travel burden shares significantly exceeding the state average of 5.8 percent, while four have significantly less than that share.

Table 2: Travel burden for top 20 cities by Population

City	Population	Share exceeding 90 minutes travel
Columbus	807,035	7.7%
Cleveland	387,135	14.5%
Cincinnati	302,821	14.5%
Toledo	275,851	7.8%
Akron	199,648	8.1%
Dayton	147,656	5.4%
Parma	79,559	5.5%
Canton	67,560	6.2%
Hamilton	64,748	4.4%
Youngstown	64,734	0.5%
Lorain	63,756	10.3%
Springfield	58,020	10.4%
Kettering	56,399	5.1%
Dublin	52,440	2.4%
Lakewood	51,516	12.0%
Elyria	50,295	9.6%
Cuyahoga Falls	49,996	5.9%
Middletown	48,645	9.7%
Euclid	47,456	18.0%
Mentor	47,062	3.7%

49. Finally, I conducted some analysis of the relationship between the poverty rate at the block group and city level and the share of CVAs who would have to travel more than 90 minutes round trip to access a ballot drop box. I found that the level of poverty predicts the share of travel burden at a high rate and at a high level of statistical significance, with each 10 percent increase in the poverty share being associated with a three percent increase in the share of the population experiencing a travel burden, and statistical significance at the 99.999 percent level. I show the relationship graphically in Figure 5, below.

Figure 5: Travel burden as a function of the poverty rate, for Ohio cities



50. To corroborate the relationship between income and the travel burden I looked at data from the Nationwide Household Travel Survey of 2017 (see Table 3).

Table 3: Household Income by Vehicle Ownership

Household Vehicle Ownership	Mean Income Bracket
No vehicle available	$15,000 to $24,999
One or more vehicles	$50,000 to $74,999

Source: National Household Transportation Survey, 2017

51. The table shows that household income among households with access to at least one auto is about twice as high as households without a car. This relationship is also highly statistically significant. As noted previously, auto ownership is the mediating relationship that associates poverty status with a travel burden to access a ballot drop box location.

Queuing Analysis: Methodology and Results

52. In this analysis I estimated the length of queues and average waiting times hour by hour on Election Day by county across the state. This was carried out in three steps. First, I estimated Election Day demand, i.e. the estimated number of individuals attempting to drop off ballots on Election Day, for each county. Second, I conducted a simple deterministic input-output analysis to estimate queue length and delays on an hour by hour basis. Third, I estimated the number of voters likely to be dissuaded from voting due to extraordinarily long queue lengths and delays, by county.

A. Methodology: Estimating Election Day Demand for Drop Boxes

53. To conduct the queueing analysis, I first estimated overall demand for ballot drop boxes by county. This required obtaining data and making inferences about the following parameters: (a) the number of registered voters in each county; (b) the share of registered voters who will request and receive absentee ballots; (c) the share of those holding absentee ballots choosing to deliver those ballots to a county drop box location; and (d) the share of those drop box ballots which will be delivered on Election Day. As described below, in estimating the latter parameters (b), (c) and (d), I tested several in order to help provide a probable range of outcomes for all the counties in the state.

54. For parameter (a), the number of registered voters in each county, I used the list made available by the state from the March 2020 primary election in the State of Ohio (available at https://www.sos.state.oh.us/globalassets/elections/2020/pri/turnoutbycounty.xlsx). The number of registered voters no doubt has slightly changed since that time, but I was not able to obtain more recent figures.

55. In estimating (b), the share of registered voters voting absentee, I used two data inputs to generate a range of results. The first was an announcement by the Ohio Secretary of State

that the state expects about 2.4 million absentee ballots in the general election (see https://www.ohiosos.gov/media-center/press-releases/2020/2020-08-18-a/). This is 30.9 percent of the number of registered voters in the state as of March 2020. I thus used 30 percent as one estimate of this parameter. For a second estimate of the parameter I relied on a declaration to be filed in this case by Inajo Davis Chappell, an elections official for Cuyahoga County, that the general election will see at least a doubling of the absentee ballots cast in that county in the 2020 primary (181,000). This amount—that is, 362,000 absentee ballots—is approximately 45 percent of the registered voters in Cuyahoga County. I thus used 45 percent as a second estimate of parameter (b) for use across counties in the state.

56. In estimating parameter (c), the share of absentee voters choosing to deliver their ballots to a drop box, I refer to the Declaration (in this litigation) of Paddy McGuire, the Auditor of Mason County, Washington, which presents data on the share of absentee ballots delivered to drop boxes ranging from 45 to 57 percent in the last four general elections in the State of Washington. There are fewer drop boxes in Ohio, and a shorter tradition of using them. But it appears likely that absentee voters may have a strong tendency to distrust returning absentee ballots by mail due to widespread publicity about the possible inability of the U.S. postal service to return ballots on time. Furthermore, because absentee ballots tend to be returned at the last minute, based on inspecting detailed returns data from several locales in the United States including Washington and Colorado; and because Ohio does not permit absentee ballots to be postmarked on the day of the election if they are to be counted, this will also increase demand for drop boxes for absentee ballot holders who do not manage to mail their ballots before Election Day. Nevertheless, I reduced this figure substantially downward from the Washington case. To reflect the fact that there is more uncertainty about this estimate, I

used three different figures– 30 percent, 35 percent, and 40 percent – to represent three possible scenarios for the use of drop boxes by those who choose to vote absentee. These shares are about 50 percent lower than the shares in Washington.

57. In estimating parameter (d), the share of drop box users delivering their ballots on Election Day, I relied again on the Declaration of Paddy McGuire along with data from Denver, Colorado and Kings County, Washington. The parameter (d) assumption is particularly important because in the State of Ohio voters are not permitted to return their ballots via a mail box on Election Day. Anyone with a ballot that has not been already put into a mailbox for a postmark of Monday-before-Election-Day or earlier has the sole option of voting absentee by delivering their absentee ballot to a county ballot drop box on Election Day. In King County, Washington in the August 2020 primary election, 63 percent of drop box ballots were deposited on Election Day; in the previous 2018 general election, the figure was 72 percent. In this analysis for Ohio I used 50 percent as a midpoint, also testing 40 percent as a low-end estimate and 55 percent as a high-end estimate.

58. The combination of the parameters above yielded a number of different possible outcomes in terms of the share of registered voters who I would estimate will attempt to deliver absentee ballots via drop box on the day of the election. The lowest share obtained by the variance in assumptions is 3.6 percent of registered voters; the middle and "baseline" share is 5.25 percent of registered voters; and the high estimate yields 10 percent of registered voters attempting to drop off their ballots at a county drop box location on Election Day.

B. Methodology: Estimating Queue Lengths and Wait Times on Election Day

59. The second step of the analysis, estimating drop box queue lengths and wait times on Election Day, consisted of an input-output analysis requiring a set of parameters about (e) how demand would be distributed over the course of the day on Election Day; (f) the number

of existing or expected drop boxes at each of the county boards of elections offices across the state; and (g) the service capacity of those drop boxes—i.e., how many ballots per hour they could receive depending on deposit speed by individuals delivering their ballots.

60. Regarding parameter (e), I inferred that demand would be distributed from 6 am through 7:30 pm, as ballots must be delivered to drop boxes by 7:30 pm (or voters must be waiting in the queue by that time). I further inferred, based on common travel patterns in the United States, that 30 percent of this travel would occur during the morning peak (8 am to 10 am) and 35 percent during the evening peak (4 pm to 7:30 pm), with the remainder distributed throughout the other hours of the day from 6 to 8 am and from 10 am to 4 pm. This parameter turns out to have very little effect overall on queue formation in the populous counties, because in those counties voter demand estimates exceed drop box service capacity by a very wide margin.

61. For parameter (e), I assumed that every county board of elections office has two drop boxes, one for walkup patrons and another for drive-up patrons (except for Cuyahoga County, as explained next). In fact, a number of counties apparently have only one drive-up ballot drop box, which means the estimates I provide could be far too small for many counties. For Cuyahoga County, I was informed that there are two walk-up drop boxes and one drive-up box, and this was taken into account in setting a higher service capacity for Cuyahoga County.

62. Parameter (g), the service capacity of each drop box, depends on the speed of individuals depositing their ballots, which varies depending on whether it is a drive-up or a walk-up box. (I assume that physical capacity of the boxes is not an issue, if elections board staff are available to empty the boxes when needed.) News footage of walk-up patrons at a ballot drop

box in King County, Washington showed about 12 ballots being dropped per minute, prior to the COVID-19 pandemic (https://www.youtube.com/watch?v=R1wzrCRxFBI). Based on the presumption of social distancing for Covid-19, I used a medium-range estimate of 8 ballots per minute (one every 7.5 seconds) for walk up traffic, also inferring that walkup traffic would be somewhat constrained by parking lot size and by friction caused by a vehicle queue in the same vicinity using a drive-up drop box. I also tested 6 and 10 ballots per minute (10 and 6 seconds per ballot respectively). For drive-up traffic, queues necessarily move more slowly because of the awkwardness of reaching for the box from a car window and because the distance between cars is greater (for an illustration, see news footage of a drive up box in Minneapolis at https://www.youtube.com/watch?v=Kg61Jr9Dm7k). I used three ballots per minute (one every 20 seconds) as a mid-range estimate, and also tested a perhaps more realistic assumption of two ballots per minute.

63. I modeled the ballot drop box locations at each county board of elections office as a simple D/D/s queueing system with a constant hourly capacity as explained above, and deterministic arrival times that varied by the hour as explained in the paragraph prior. In this model, queues form whenever the demand exceeds the capacity, and the queue length at a given hour is simply the excess demand in that hour plus the queue length at the end of the previous hour, as given in the following equation:

$$Q(t) = Q(t-1) + D(t) - C(t)$$

where $Q(t)$ is the queue length at hour t, $Q(t-1)$ is the queue length at hour *t-1*, $D(t)$ is the demand at hour t, and $C(t)$ is the capacity at hour t.

64. Given the queues at a given hour, the average delay in that hour is given by the following equation

$$W_{average}(t) = \frac{Q_{average}(t)}{C(t)}$$

where $W_{average}(t)$ is the average expected wait time for a voter arriving at hour t, $Q_{average}(t)$ is the average queue length at hour t, and $C(t)$ is the capacity at hour t.

65. For a concise overview of the input-output method for analyzing queueing, see Daganzo (1983). A more thorough explanation is set forth in a textbook by the same author (Daganzo, 1997).

C. <u>Results: Estimates of Election Day Queue Lengths and Wait Times, By County</u>

66. I generated outputs by county for three different scenarios: low queuing (low demand, higher end of service capacity), "baseline" queuing (my best estimate of actual demand for drop boxes on Election Day), and high queuing (high demand, lower end of service capacity).

67. The baseline scenario is shown in Tables 4 and 5, found after the references at the end of this Declaration. Table 4 shows projected Election Day queue lengths for each county throughout the course of the day, and Table 5 shows projected wait times for people who arrive during those hours of the day. Only those counties for which queues in fact exist, according to the baseline scenario, are shown in the tables, because with 88 counties it is not possible to fit all on a page.

68. In the baseline scenario (in which 5.25 percent of registered voters attempt to drop off their ballots on Election Day), eight counties have queues exceeding two thousand vehicles and ranging up to 35,000 vehicles (Table 4); with wait times exceeding five hours and ranging up to 53 hours (Table 5).

69. The impacts in more populous counties are much more severe than in less populous counties. The wait at the end of a day to drop off a ballot over the course of a day in the nine most populous counties in the state is estimated at baseline to average 21 hours, with a range from

three to 53 hours. The 75 least populous counties in the state are not projected to have any wait time in the baseline scenario. A total of about 120,000 voters are potentially affected by an inability to cast a ballot in this scenario.

70. I also calculated the low queueing and high queueing results, creating output tables similar to Tables 4 and 5. I describe the results here, without displaying the detailed results in tables.

71. For the low queuing scenario (in which 3.6 percent of registered voters attempt to drop off their ballots on Election Day), the six most populous counties in the state have significant queues and waiting times. Excess queues at the end of the day range from about 400 in Lucas County to more than 20,000 in Franklin County, and average wait times per voter range from 2 to 28 hours at the end of the day in those counties. A total of about 54,000 voters are potentially affected by an inability to cast a ballot in this scenario.

72. In the high queueing scenario, in which about 10 percent of registered voters plan to deliver their absentee ballots to a drop box on Election Day, the 25 most populous counties are affected. End-of-day queues range from 460 to 78,000 vehicles, and wait times for the ten most populous counties range from 19 hours to 157 hours. The total number of voters affected statewide in this scenario is more than 400,000.

73. The range of potential outcomes based on variance in the input inferences can be shown as I do here for three of the most affected counties: Cuyahoga, Franklin and Hamilton. Figures 6 to 11 (below) visualize the variance in possible incomes for queue lengths and wait times for those three counties.

Figure 6: Range of Possible Election Day Queue Lengths in Hamilton County

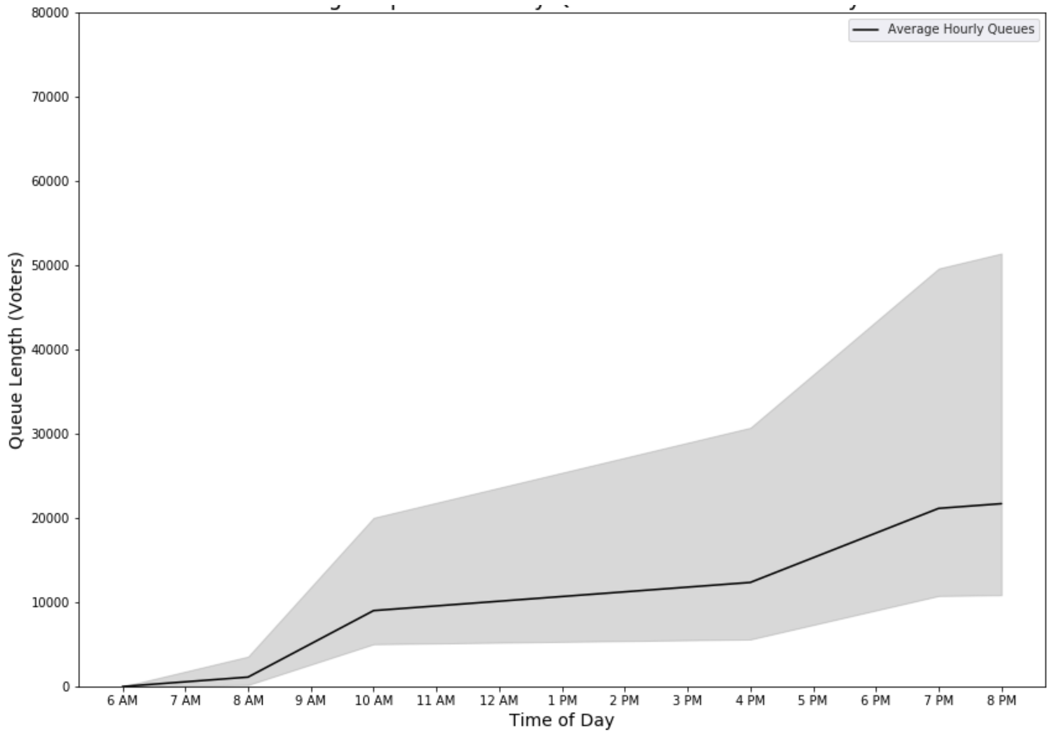


Figure 7: Range of Possible Hourly Delay Per Capita in Hamilton County

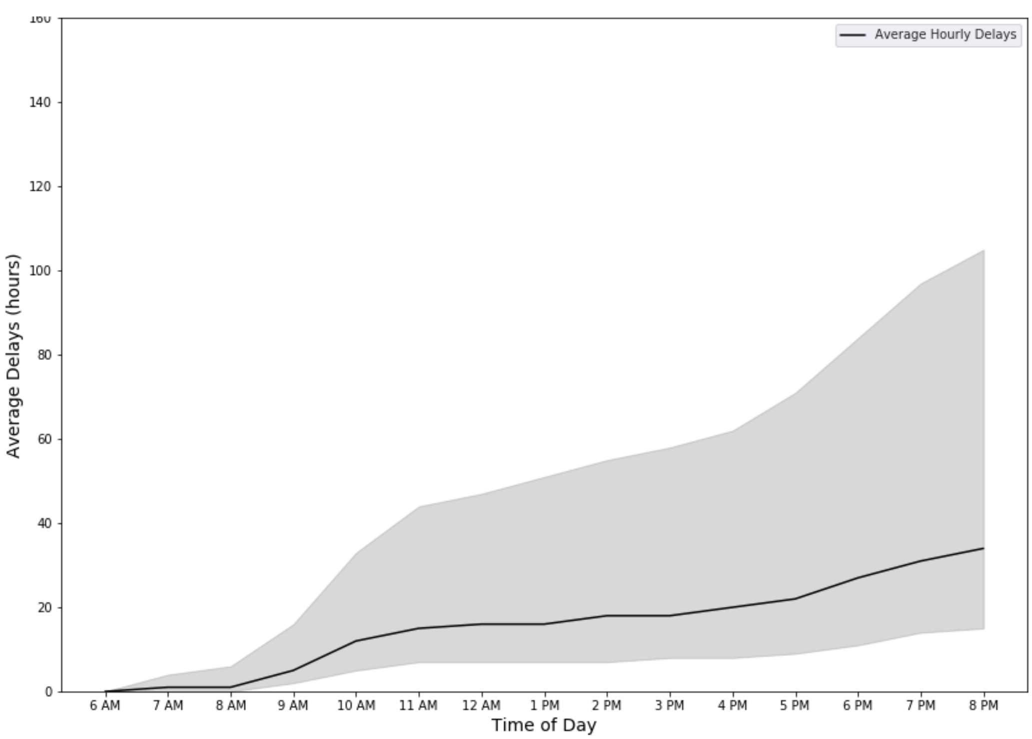


Figure 8: Range of Possible Election Day Queue Lengths in Franklin County

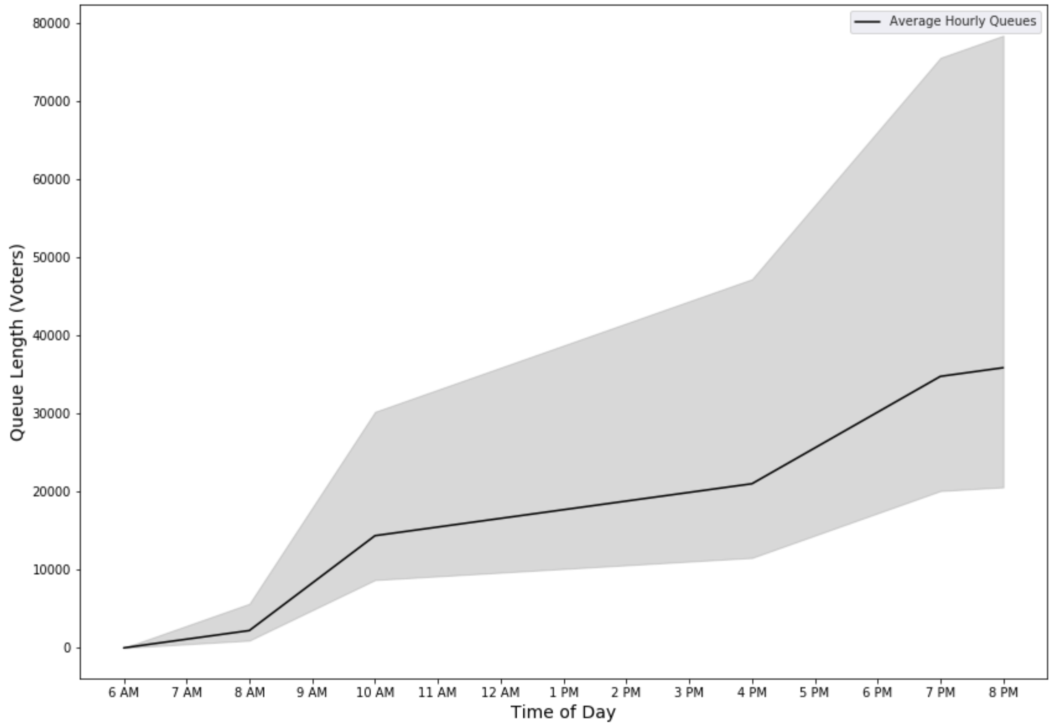


Figure 9: Range of Possible Hourly Delay Per Capita in Franklin County

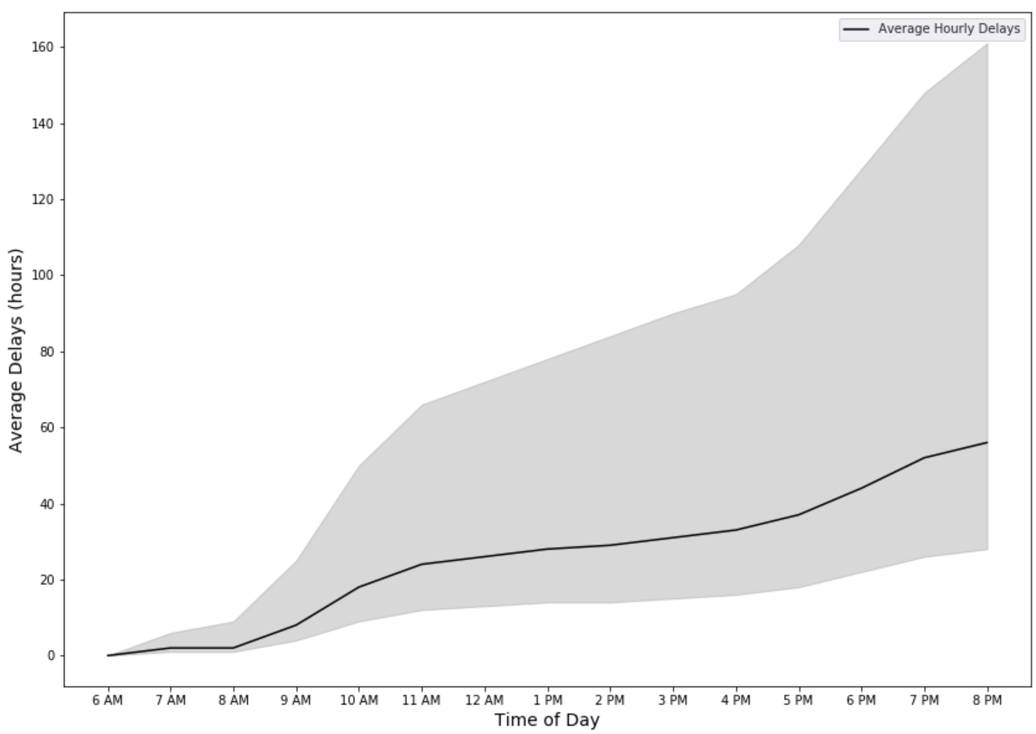


Figure 10: Range of Possible Election Day Queue Lengths in Cuyahoga County

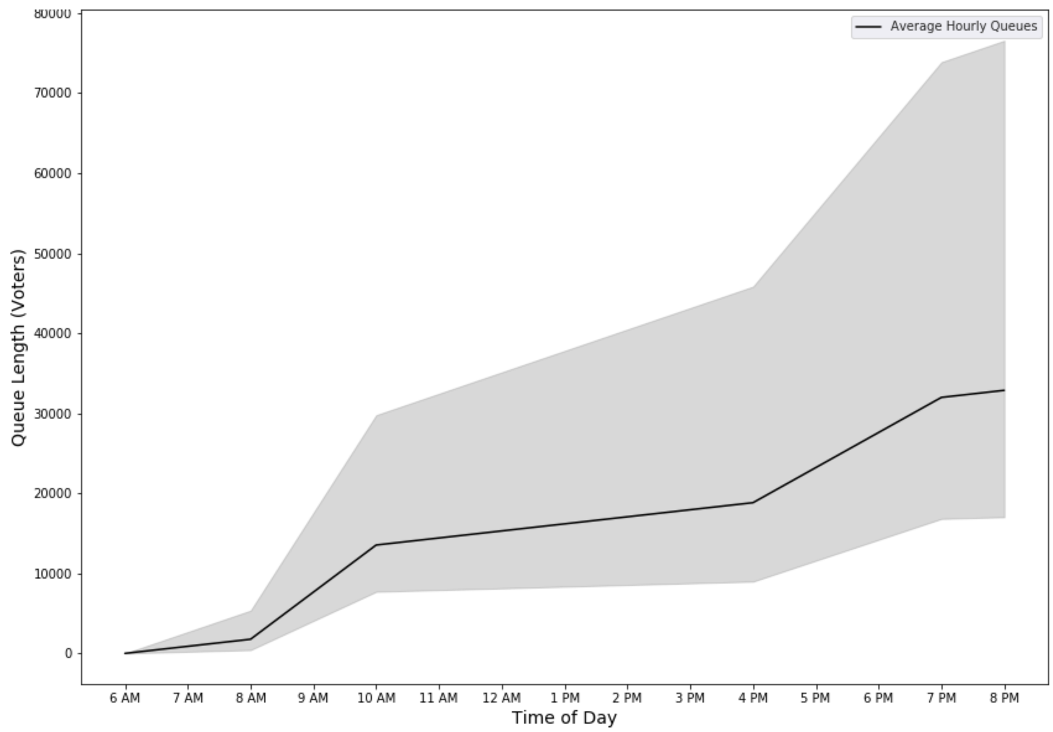
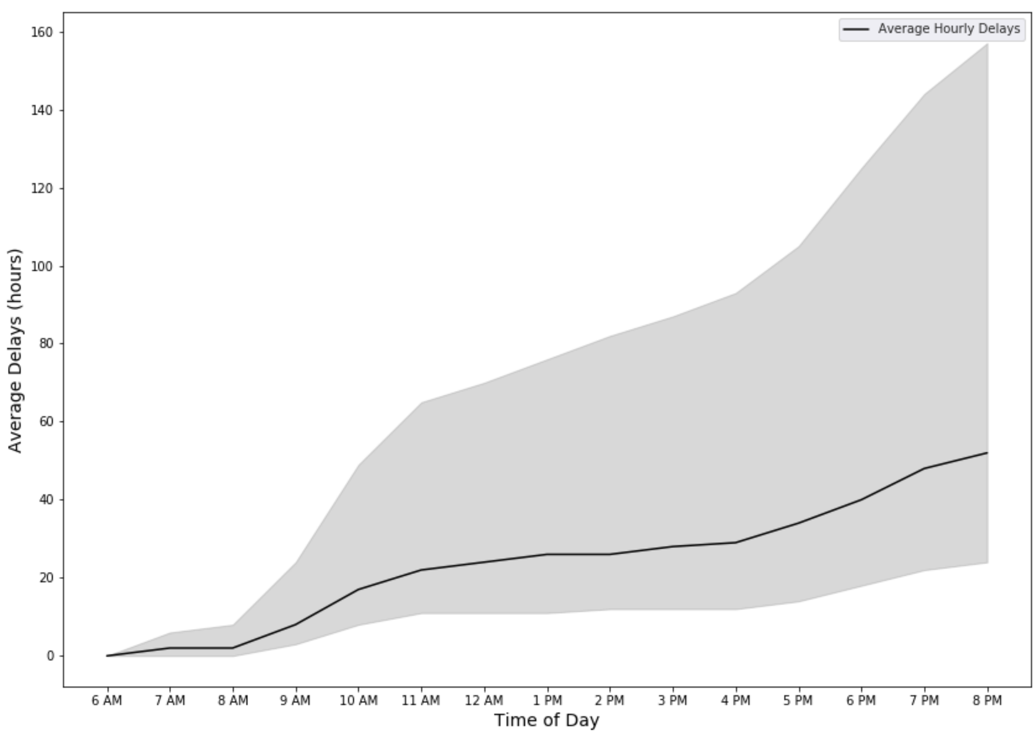


Figure 11: Range of Possible Hourly Delay Per Capita in Cuyahoga County



D. Results: Impacts on Voters

74. The figures discussed above, shown in Tables 4 and 5, and displayed for three counties in Figures 6 to 11, show projected scenarios that help estimate the magnitude of the impact of not allowing more than one location for ballot drop boxes in each county. Plainly, it is unlikely that the massive queues and wait times shown by these analyses would occur, because once the queues and wait times become long, voters are likely to either abandon the queue; arrive at their county drop box site and be deterred from joining the queue; or hear about the long wait times on the news or from friends and not even begin a trip to the county elections office. In other words, queues of much shorter than the projected lengths would likely dissuade voters from attempting to deliver their ballots long before the queues achieve the length demonstrated by demand. For example, a queue of 30,000 vehicles would stretch for about 150 miles; and one has difficulty imagining a voter willing to tolerate a wait of more than 8 hours.

75. This analysis may underestimate queues and wait times in less populous counties. In his Declaration, Auditor Paddy McGuire of Washington State states that he believes his board of elections office in Mason County, Washington would not have been able to handle the 7,650 ballots that were delivered to the several county drop box locations on Election Day in the most recent election. Given that my estimation procedure assumes that a single county location can handle more than 9,000 drop offs without forming queues, these may well be substantial underestimates of actual queues and wait times in the smaller counties for the levels of demand described in the previous section of the report.

76. The estimated queue lengths at the end of Election Day are a good estimate of the number of voters who could be dissuaded from dropping off their ballots by the intense traffic that would be associated with county drop box locations once only a few hundred vehicles are

lined up, in addition to the prospect of intolerably long vehicle queues and wait times. Thus, one estimate of the number of voters who might forgo casting their ballots due to the small numbers of drop box locations in populous counties would be the surplus demand in the remaining queues at the end of Election Day. Statewide, this would be about 120,000 ballots in the baseline scenario, with a range as low as 54,000 ballots in the lowest-impact scenario and as high as 415,000 ballots in the high-impact scenario.

CONCLUSION

77. I have analyzed two potential impacts of the Ohio Secretary of State's decision not to allow counties to provide multiple satellite ballot drop off locations for voters in the November general election. The first is the travel burden for those individuals who have a long distance to travel on public transportation and/or on foot due to their not having access to a personal vehicle in their household. The second is the queue lengths associated with large potential demand for access to ballot drop boxes due to the circumstances of this election and based on comparisons with other locations that have implemented drop boxes as a ballot delivery option.

78. I find that about 70 percent of the 679,000 car-less citizens of voting age in the state would have a round trip to access a county ballot drop box location exceeding 90 minutes, which is substantially longer than the average amount of travel undertaken in an entire day in the State of Ohio, under conditions that are typically much more difficult than driving in a personal vehicle. Overall, about 5.8 percent of the population of the state is affected, and seven counties account for more than half of those individuals. The share of the population with a travel burden is particularly high in two cities, Cleveland and Cincinnati, where about 14.5 percent of the population is estimated to have a round trip of more than 90 minutes to access the board of elections ballot drop box, and some other of the more populous cities in the state

also have shares much higher than the state average. Poor households are much more likely to be affected by this burden, across the state as a whole, because they are less likely to have access to a personal vehicle in their household. Such long travel durations under uncomfortable conditions are likely to dissuade affected voters from delivering their absentee ballots to drop boxes, and may consequently discourage voting altogether, given reasonable fears of Covid-19 infection at in-person polling places, and skepticism that the postal service will deliver ballots on time if they are put in a mailbox.

79. I estimate that the demand for drop boxes would generate extraordinarily lengthy queues in the nine most populous counties in the state, ranging up to more than 30,000 vehicles in Cuyahoga and Franklin Counties, with waits exceeding 24 hours to drop off a ballot. It appears likely that in those counties more than 100,000 people could be turned away from drop box locations, or could be dissuaded from attempting to drop off their ballots on Election Day by reports of long lines or by encountering intense traffic on the way to or upon arriving at the drop box, if the state does not permit affected counties to provide additional drop box locations in order to mitigate queuing delays.

I declare under penalty of perjury that the information set forth in this declaration is true and correct to the best of my knowledge.

Daniel G. Chatman

Dated: September 4, 2020

Dr. Daniel G. Chatman

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Table 4: Hourly Election Day Queues, Baseline Scenario, For Counties with Queues

County Nam	6 AM	7 AM	8 AM	9 AM	10 AM	11 AM	12 PM	1 PM	2 PM	3 PM	4 PM	5 PM	6 PM	7 PM
Clark	0	0	25	50	0	0	0	0	0	0	0	0	0	0
Wood	0	0	57	114	0	0	0	0	0	0	0	0	0	0
Fairfield	0	0	156	311	0	0	0	0	0	0	0	0	0	0
Portage	0	0	168	335	0	0	0	0	0	0	0	0	0	0
Greene	0	0	241	481	55	0	0	0	0	0	41	81	122	0
Licking	0	0	275	550	133	0	0	0	0	0	67	135	202	0
Medina	0	0	310	620	211	0	0	0	0	0	94	189	283	0
Trumbull	0	0	375	749	357	0	0	0	0	0	145	289	434	42
Clermont	0	0	429	857	479	101	0	0	0	0	187	373	560	182
Delaware	0	0	468	937	569	202	0	0	0	0	218	435	653	285
Lake	0	0	562	1124	781	438	94	0	0	0	290	581	871	528
Warren	0	0	593	1186	851	516	181	0	0	0	315	629	944	608
Mahoning	0	0	608	1217	885	554	223	0	0	0	326	653	979	648
Lorain	0	0	980	1961	1726	1491	1256	1022	787	552	1168	1784	2399	2165
Stark	0	0	1257	2513	2350	2187	2024	1861	1698	1535	2366	3196	4027	3864
Butler	0	0	1286	2571	2415	2260	2104	1949	1793	1637	2491	3344	4197	4041
Lucas	0	0	1627	3254	3187	3119	3052	2985	2918	2851	3970	5088	6207	6140
Montgomery	75	151	2327	4503	4578	4653	4729	4804	4879	4954	6500	8046	9592	9667
Summit	82	164	2367	4569	4651	4734	4816	4898	4980	5062	6629	8195	9761	9844
Hamilton	527	1055	4975	8895	9423	9950	10478	11005	11533	12060	14963	17865	20768	21295
Franklin	1079	2158	8206	14255	15334	16413	17492	18571	19650	20730	25287	29844	34402	35481
Cuyahoga	852	1704	7561	13418	14270	15121	15973	16825	17677	18529	22884	27240	31595	32447

Table 5: Hourly Delays (in hours), Baseline Scenario, for Counties with Delays

County Nam	6 AM	7 AM	8 AM	9 AM	10 AM	11 AM	12 PM	1 PM	2 PM	3 PM	4 PM	5 PM	6 PM	7 PM
Greene	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Licking	0	0	0	1	1	0	0	0	0	0	0	0	0	0
Medina	0	0	0	1	1	0	0	0	0	0	0	0	0	0
Trumbull	0	0	0	1	1	0	0	0	0	0	0	0	1	0
Clermont	0	0	0	1	1	0	0	0	0	0	0	0	1	1
Delaware	0	0	0	1	1	1	0	0	0	0	0	0	1	1
Lake	0	0	0	1	1	1	0	0	0	0	0	1	1	1
Warren	0	0	0	1	2	1	1	0	0	0	0	1	1	1
Mahoning	0	0	0	1	2	1	1	0	0	0	0	1	1	1
Lorain	0	0	1	2	3	2	2	2	1	1	1	2	3	3
Stark	0	0	1	3	4	3	3	3	3	2	3	4	5	6
Butler	0	0	1	3	4	4	3	3	3	3	3	4	6	6
Lucas	0	0	1	4	5	5	5	5	4	4	5	7	9	9
Montgomery	0	0	2	5	7	7	7	7	7	7	9	11	13	15
Summit	0	0	2	5	7	7	7	7	7	8	9	11	14	15
Hamilton	1	1	5	11	14	15	15	16	17	18	20	25	29	32
Franklin	2	2	8	17	22	24	26	27	29	31	35	42	49	53
Cuyahoga	1	2	7	16	21	22	24	25	26	27	31	38	45	49