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RESEARCH ARTICLE / ÉTUDE ORIGINALE

I Came, I Saw, I Voted: Distance to Polling Locations and Voter Turnout in Ontario, Canada

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Abstract
How accessible are polling locations in Canada? This article explores, for the first time in the Canadian context, the distance that voters may travel to get to their polling stations. It assembles a new set of data from the province of Ontario, mapping the distance between polling locations and a representative point in the polling division, using a variety of measures, including walking, driving and public transit times. It estimates the relationship between these distances and travel times and socio-demographic characteristics of each polling division, finding noteworthy relationships between these distances and the percentage of minority populations (both immigrant and Indigenous) in the polling division. This article also presents a potential negative, but nonlinear, relationship between distances and travel times and turnout, contributing to our understanding of how voters' rational calculus of voting may be related to the locations of polling stations.

Résumé
Dans quelle mesure les bureaux de vote sont-ils accessibles au Canada ? Cet article explore, pour la première fois dans le contexte canadien, la distance que les électeurs peuvent parcourir pour se rendre à leur bureau de vote. Il rassemble un nouvel ensemble de données provenant de la province de l'Ontario, cartographiant la distance entre les bureaux de vote et un point représentatif de la section de vote, en utilisant une variété de mesures, y compris les temps de marche, de conduite et de transport en commun. Il estime la relation entre ces distances et les temps de déplacement et les caractéristiques sociodémographiques de chaque section de vote, en trouvant des relations notables entre ces distances et le pourcentage de populations minoritaires (immigrantes et autochtones) dans la section de vote. Cet article présente également une relation négative potentielle, mais non linéaire, entre les distances et les temps de déplacement et le taux de participation, contribuant ainsi à notre compréhension de la manière dont le calcul rationnel du vote des électeurs peut être lié à l'emplacement des bureaux de vote.

Keywords: elections; voter turnout; polling locations; convenience voting; electoral management

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Mots-clés : élections; participation des électeurs; bureaux de vote; vote de proximité; administration électorale

Introduction[1]

In recent years, election administrators have sought to make the voting process easier through a variety of convenience voting measures. While Canadians have some postal and absentee voting options, most still vote at an assigned physical polling location, either in advance or on Election Day. There are some convenience voting stations at which Canadians can vote at any location (for example, at a returning office during an election campaign), but most voters are still required to attend their assigned voting location, unlike in some other jurisdictions where vote centres available to any voter regardless of their assigned polling locations are an expanding option (Stein and Vonnahme, 2008).

Despite the importance of physical polling locations in the Canadian context, there is little empirical research on this topic. There are a variety of key areas that could be studied, including accessibility measures for voters with disabilities (Cross et al., 2009; Schur et al., 2017) or the electoral officials that work the polls on Election Day (Clark and James, 2017; Hall et al., 2009).

This article, however, will look at one issue regarding polling locations that has yet to be studied in the Canadian context: the geographical locations of polling stations. It considers two major sets of questions. First, how accessible are polling locations? And are there variations in the level of accessibility? In other words, do some voters have easier access to their polling locations than others, and does this vary systematically? Second, is distance to the polling station related to turnout? This article presents preliminary research on this relationship.

To respond to these research questions, we assembled a new set of geographic data. Polling locations in one province (Ontario) were mapped in each polling division, and the distance between the representative point of a polling division and the polling location was calculated. We also estimated travel times by different means. Finally, data were assembled on turnout and socio-demographic profiles of each polling division. Using these data, we are able to summarize the distance from a representative point of a polling division to each polling station and also test for the socio-demographic correlates with these distances and whether the distance is related to turnout.

This research has important scholarly and practical implications. For scholars, it adds to the literature on the costs of voting, particularly on the issue of whether distance travelled to a polling location has an impact on voter turnout. It also speaks to literature on the accessibility of voting, especially for populations in rural locations and for those who rely on public transportation to get to the polls. This information will be important for scholars who study the relationship between socio-demographic characteristics and voter turnout.

The research will also respond to a number of key issues that election administrators must balance in their pre-election planning, including whether to have more polling locations closer to where voters live or to provide better equipped and larger polling stations, albeit more sparsely placed around the country (Stein and Vonnahme, 2011).

In the next section, we review some of the major literature regarding convenience voting measures and the location of polling stations and voter turnout,

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referring to the rational calculus of voting and the potential socio-demographic gaps between voters and non-voters. Following that, we outline our hypotheses and methodology. In the final section, we present the results and discuss the implications for scholars and practitioners.

Distance to Polling Locations and Voter Turnout

We know that a variety of factors will influence whether a voter goes to the polls (or votes absentee). These include considerations of senses of habit and duty to vote, as well as interest in and competitiveness of the contest (Blais, 2000, 2020). From Downs's rational calculus of the "costs" of voting (Downs, 1957) to more recent studies about the potential decrease in voting costs through alternative voting means and convenience measures (Brians and Grofman, 1999; Burden et al., 2009; Haspel and Knotts, 2005), scholars have considered whether the ease of voting may have an important impact on voter turnout. While the magnitude of this impact may be small (Blais, 2020), it nonetheless does appear as part of the voting calculus, and these findings do not preclude the costs associated with the ease of voting playing a role in at least some voters' decisions about whether or not to vote.

The solution offered by some, therefore, is to reduce the costs of voting by making the process easier. There is a wealth of research on means to improve the convenience of voting, many of which would reduce or even eliminate travel times to get to the polls. For example, research on postal voting has demonstrated that the reduction in time and travel costs associated with this convenience measure can improve voter turnout in some contexts. This innovation, which is used exclusively in some American states and, most notably, in Swiss elections, provides voters with ballots via the post and then provides an option to mail back ballots or hand-deliver them to a drop-off point (Funk, 2010; Garnett, 2019; Karp and Banducci, 2000; Luechinger et al., 2007).

Similarly, advances in internet voting eliminate the need for travel altogether by allowing voters to complete the entire voting process from a computer in any location. This innovation is used in some Canadian municipal elections (and more recently in a territorial election) (Essex and Goodman, 2020) and in some European countries, most notably Estonia (Alvarez et al., 2009; Alvarez and Nagler, 2001; Bochsler, 2010; Germann and Serdült, 2017), though there is limited evidence so far about its effectiveness in improving turnout.

These types of convenience-voting innovations are thought to reduce costs, time and energy and thus improve the chances of a voter casting their ballot. However, we also know that these innovations rarely reduce costs in a uniform manner. Some convenience measures, such as postal voting or advance voting, have been found to increase voter turnout only among those who were already likely to vote and thus may not improve access for population groups under-represented at the polls (Garnett, 2019). Other research has suggested that removing the voting process from Election Day may decrease the civic significance of Election Day (Burden et al., 2014).

While some voting now occurs remotely, most voting around the world still occurs on Election Day at physical polling locations. Some recent interesting research has considered whether the type of location can impact a voter's choice (Rutchick,

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2010). But the bulk of research on polling places considers three major issues: staffing, accessibility, and (the focus of this article) travel distance for voters.

Recruiting, training and compensating the (often short-term) employees who manage polling stations is a huge undertaking for election-management bodies. Research into this task by Clark and James (2017) has included surveys of poll workers to better ascertain their motivations for this type of work and whether they feel they have the appropriate skills and training to do the job. Talking to poll workers can also provide a sense of whether the polling locations were appropriate for the activity and what sorts of issues arose on Election Day. Furthermore, the considerable leeway poll workers have as "street-level bureaucrats" may have a significant impact on the fair implementation of election law (Atkeson et al., 2010, 2014).

Another key area of study regarding polling locations is the issue of accessibility, particularly for voters with disabilities (Bundy, 2003; Cross et al., 2009; Schur, 2013; Schur et al., 2002, 2015, 2017). Survey data have demonstrated that many voters with disabilities have difficulties in voting (Schur et al., 2017). These challenges may include inaccessibility via public transport or pick-up and drop-off points, as well as issues entering or exiting the building where voting is taking place (Schur et al., 2015; Weiss, 1988). Furthermore, difficulties in accessing polling places can repress turnout and influence feelings of efficacy for voters with disabilities (Schur et al., 2017).

The final major issue studied regarding polling locations is geographical placement. Research on Election Day vote centres in the United States—for example, Colorado's experience prior to moving to all-mail elections—shows that increasing the convenience of polling stations can increase voter turnout, especially among those less likely to turn out to vote (Stein and Vonnahme, 2008). Other research has demonstrated that the density of early voting polling places can increase voter turnout (Fullmer, 2015).

Finally, a body of work has considered the distance voters have to travel to get to polling locations and the likelihood of turning out to vote. Taking advantage of individual turnout data available in the United States, Dyck and Gimpel (2005) calculated the distance in Manhattan-blocks between voters' residences and their precinct and early voting sites during the 2002 midterm election in Clark County, Nevada. They then analyzed the relationship between these distances and a voter's likelihood of not voting, voting at the precinct or voting through various nontraditional means (mail or early voting). They find a nonlinear relationship between distance to polling location and turnout: turnout decreases as distance to polling location increases, until it reaches 10 miles (16 kilometres), at which point the relationship begins to reverse.

This nonlinear finding is also supported in the French case, where increases at short distances have a larger impact on turnout than do increases at longer distances, since these more rural individuals may be used to driving long distances and thus will not find the inconvenience of driving further to their polling station a barrier to turning out to vote (Fauvelle-Aymar and François, 2018).

Because Dyck and Gimpel (2005) also test alternative ways of voting, they are able to further note that greater distances to election-day polling places encourage voters to vote by mail. They also suggest that early voting sites are most likely used

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by those who would vote on Election Day anyway, rather than by non-voters. There are some limitations to the external validity of their findings, however, since Clark County provides some of the widest array of alternative voting measures and does not include many rural locations.[2]

Other studies innovate in their means of measuring distance to better estimate the time or monetary cost associated with travelling this distance. For example, Haspel and Knotts (2005) examine the relationship between polling location distance and turnout in Atlanta municipal elections. They use individual-level data from the Atlanta voter file to determine voters' road distances along city streets to polling locations, a more accurate measure of the actual distance a voter must travel to a polling station. In line with other studies, they find that distance does have a statistically significance effect on individual turnout.

Gibson et al. (2013) take this line of inquiry a step further in a study in New Zealand that considers actual time costs, as measured by wages that would be lost due to the time it takes to vote. They measure both distance and travel time by road and find that the costs of voting can reduce turnout.

In a similar vein, Bhatti (2012) considers the relationship between distance and turnout and finds that it is conditional on the household's availability of a car. This result suggests that an important area of inquiry remains the accessibility of means of accessing polling for those who do not drive.

When exact turnout data are not available, alternative methods must be used to calculate typical distances between voters' residences and polling locations. These alternative methods are necessary in Canada, where individual voter turnout data are not available. This situation is not unprecedented. For example, Gimpel and Schuknecht (2003) use the county as the unit of analysis. They estimate the relationship between distance to polling location and turnout by measuring the distance from the centroid of each voting district or precinct to the polling location in 300 suburban Maryland counties. To ensure that the measure takes into consideration the true population centre, they adjust precinct boundaries for uninhabited natural areas (for example, bodies of water or parks). They find a nonlinear relationship between distance to polling location and turnout: turnout is lowest in suburban districts with middle-range distances to polling locations (2–5 miles) but higher in rural regions with higher distances to polling locations (6–10 miles). Gimpel and Schuknecht suggest that this is because the route for rural voters is relatively straight and free of traffic compared to the route for suburban voters.

Research Questions and Hypotheses

Building on these previous studies, this article extends the research on the geographical location of polling stations to the Canadian context. The first goal is to present a description of the variations in distances and travel times (via driving, walking or public transport) to polling locations in Ontario, Canada. It then tests four main hypotheses.

First, does accessibility vary by the size of the polling division, both in terms of geography and population? Polling divisions are delineated by both population and geographic size. However, since there are vast differences in population density in

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different areas of Canada, it is likely that the size of polling divisions, and consequently the time it takes to travel to a polling location, will vary. As a result, we suspect that larger polling divisions (by geographic size) will have greater travel distances and times than smaller polling divisions [H1].

Second, does the socio-demographic profile of the polling division influence polling-place accessibility in terms of distance and travel times? There are few Canadian studies to draw on, so US literature is relied upon to consider three major variables. Research from the US context has suggested that areas with lower incomes and larger minority communities may not have adequate facilities for polling locations close by (Barreto et al., 2009; McClendon et al., 2019). Elections Canada has several accessibility requirements for facilities that are used to determine which buildings are possible polling locations. Some lower-income areas may not have these types of accessible locations readily available; thus voters may require further travel to get to an appropriate voting location. This research may extend to the Canadian context regarding the types of facilities available to use as polling places, though we acknowledge that the US example is a difficult comparison. Thus, we hypothesize that the distance to polling stations will increase as income level decreases [H2]. Additionally, we predict that areas with large immigrant and Indigenous populations will also have longer distances to the polling location [H3].

The second part of this article is concerned with the relationship between distance to polling locations and voter turnout. We expect to see a negative relationship, in general, between distance to polling location and turnout, as previous studies have suggested. However, we also expect that this relationship may be nonlinear, as has been found in some of these studies (Fauvelle-Aymar and François, 2018). There should be a decline in voter turnout as distance to the polling station increases at first; however, we expect any increased negative impact will become negligible at some point [H4].

Methods

Canada is, in many ways, an ideal place in which to study distances to polls. Most Canadians continue to vote at physical polling locations, whether on Election Day or at advance polls, since mail-in voting is relatively uncommon (in 2015, it represented only about 4 per cent of all ballots cast[3]). Thus the distance to polling location should make a difference for most Canadian voters since few are voting using alternative means. In this article, data are collected on polling locations and distances to the polls in Ontario for the 2015 general election. Ontario provides a good case study since it includes both large urban centres and rural areas and has population characteristics similar to Canada as whole.[4]

Data

Because voter turnout data are not available at the individual level in Canada, the polling division is used as the unit of analysis. The polling division in Canada is the smallest unit in which turnout data are recorded. Polling locations were provided as addresses from Elections Canada. It is important to note that multiple polling

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divisions may share a single polling location. We converted the addresses to geospatial coordinates (that is, latitude and longitude) via the ArcGIS World Geocoding Service.

The representative point of the polling division was determined by the mean centre of the population. If you imagine the polling division as a weightless plate, and each person weighs an identical amount, this point is where the plate will balance. Mathematically, it is computed by taking the mean of the coordinates of the dissemination blocks within a polling division, weighted by population. This technique is often used when demonstrating the centre of the population, as it is quick to compute and easy to understand. See Appendix A for more details on this process, including maps illustrating these points and the process of manual correction of locations.

In this project, we use several distance metrics. To ensure continuity with the previous literature, we calculated the Euclidian[5] distance between the points and the Manhattan distance oriented with north (following the Statistics Canada Lambert coordinate reference system)[6] and the maximum Manhattan distance, which can be viewed as the maximum possible distance between two points following city block routing. These distance metrics are visually represented in Figure 1.

In addition to the three computed distance metrics, we utilized Google Maps to retrieve the following: walking distance and walking time, driving distance and driving time, and (if applicable) public transit time. The idea behind incorporating Google's routing information into the analysis is that (1) it is potentially a better representation of reality in the explicit distance one must travel when going from point A to point B; (2) it can account for differences in transportation methods by looking at travel time; and (3) when planning a trip, people often account for the time it takes to get from point A to point B, rather than a distance metric—that is, they consider a trip to a destination (say, various stores) by travel time rather than by physical distance. Historical public transit times were not available, and public transit options for the distant future (beyond approximately two weeks) were limited. For this article, we determined public transit options for Monday, December 16, 2019, for various times throughout the day.[7]

For socio-demographic data, polling divisions' demographic data were matched to census data. The smallest geospatial unit in which Statistics Canada publishes their demographic information from the census is the dissemination area (DA) (see Appendix B for more details). The DA is a geospatial boundary comprising 400–700 people.[8] While these units are useful for planning cities and allocating government resources, they do not align with polling divisions, and many polling divisions cross over multiple DAs. Statistics Canada has one smaller geospatial unit, known as the dissemination block (DB); however, only population and dwelling count is released at this level. DBs are often drawn around the road network and can have as few as five people. Therefore, demographic data are not released for this level in order to protect people's privacy. In addition, if values or regions are sufficiently small, Statistics Canada will often randomly round the total number of people (and/or demographic data) to a multiple of five people in order to further protect the privacy of the people living there.[9]

To the best of our knowledge, and for privacy reasons, there is no literature trying to reverse-engineer the demographics of larger census discretizations to their

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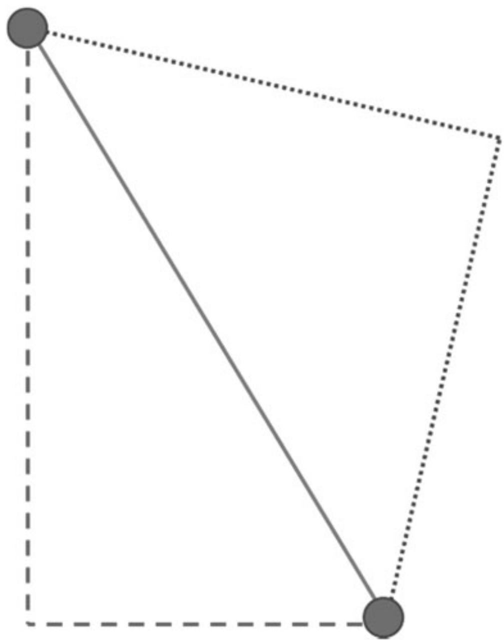

Figure 1 Understanding Distance Calculations
Euclidian line (solid), Manhattan distance (dashed), maximum Manhattan (dotted). Note that Euclidian ≤ Manhattan distance ≤ maximum Manhattan.

smaller counterparts.[10] Because of the nesting nature of DAs and DBs, we chose to infer demographics as a proportion of the population of the DA and apply it to the DB. We use the nesting nature of these geospatial objects and have applied a naive procedure that is outlined here. We take the demographic data from the DA and apply it proportionally to the DB (that is, $\frac{P_{DB}}{P_{DA}}$ where P_{DB} is the population of the DB and P_{DA} is the population if the DA). Likewise, for data recorded as an average or a median, we take the weighted average of the data point to the sum of the P_{db} (that is, $\frac{P^i_{DB} \times Data}{\sum_{i \in \text{Relevant DBs}} P^i_{DB}}$). For example, if there are 1,000 people in a given DA, and if the DA has 700 people older than 18 and 300 people younger than 18, and if the DB we are inspecting has 100 people in it, we would assume that there are 70 people older than 18 and that there are 30 people younger than 18 in the DB.

There are, of course, some exceptions. Recall that there may be multiple DBs in a polling division. Therefore, to compute the demographic data of the polling division, we identify what DBs are associated with each polling division. This is done by geospatially aligning what DBs are inside each ordinary polling division. Once the associations are made, we then compute the demographic data by adding[11] together the relevant DBs' demographic data.

Mobile polling divisions also exist, often at locations that have people who require additional assistance in order to vote. In these cases, the polling division is smaller than any DB, and here we choose the closest DB to the representative point of the polling division. Likewise, there are some ordinary polling divisions

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that administer to a single address (such as a retirement home or large apartment building); these are computed like mobile polling divisions.

Method

In the results that follow, we first present summaries of polling locations and distances. Next, we use ordinary least squares (OLS) regression to calculate the predictors of distances, including variables at the polling-division level: geographic size, population (as a control variable), average value of dwellings (as a measure of wealth or income), percentage Indigenous, percentage immigrant, and average age (as a control variable). Note that in these models, there were issues with multicollinearity between the percentage of each minority group (immigrant and Indigenous); thus they are included in separate models.

Next, the relationship between distances to polling stations and turnout are considered, again using OLS regression. In addition to the main independent variable of distance and of distance-squared (to account for a potential nonlinear relationship), several control variables known to influence voter turnout are included (Blais and Dobrzynska, 1998; Blais et al., 2003; Smets and van Ham, 2013). These are average age, average value of dwellings (as a measure of wealth or income), percentage Indigenous, and percentage immigrant. Additionally, population and geographic size of the polling division are included. Finally, to take into account differences in the competitiveness of the races in different ridings, a fixed effect variable for riding is included (but not reported in the tables).

Recognizing the extreme outliers of distance (which will be discussed below), only the bottom 75 per cent of data are included in the models. These data are more normally distributed (see Appendix C). However, a robustness check with the full set of data, available in Appendix D, does not report notably different results.

Results

Distance to polling location

The first question this article addresses is, how accessible are polling locations from a representative residential point in the polling division? To assess this, a variety of distances from the representative point to the polling locations were calculated, including maximum Manhattan, Manhattan and Euclidean metre. Full summary statistics are presented in Appendix E.

There is considerable spread in these data. Distances ranged from close to 0 metres to nearly 85 kilometres (maximum Manhattan). An example of the former would be a polling division made up of one building, such as an apartment building or seniors residence. An example of the latter would be the polling location at the Pikangikum Community Centre in northwestern Ontario. For a further example (with map) of an extreme distance, see Appendix F. However very few polling divisions were at this extreme end of the data.[12] In fact, 75 per cent of distances fell within about 1.05 kilometres.

To better approximate the voters' experience getting to the polls, walking and driving distance were also calculated. Mean and median distances (across all polling

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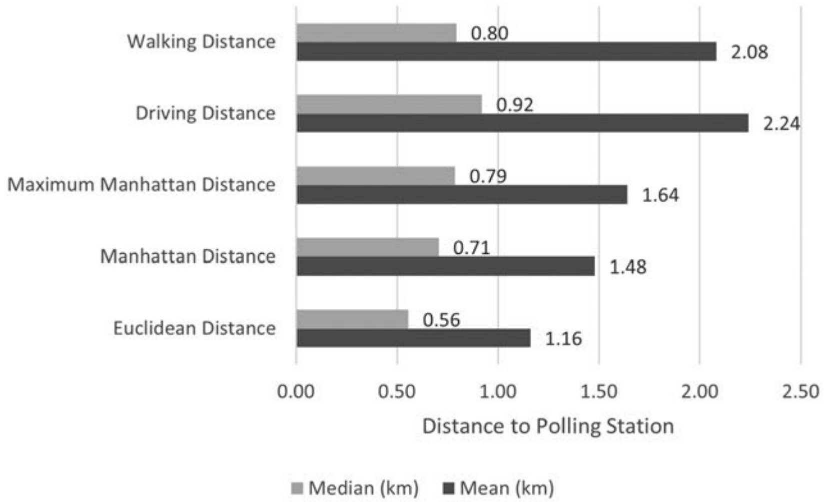

Figure 2 Mean and Median Distances from Representative Point to Polling Location

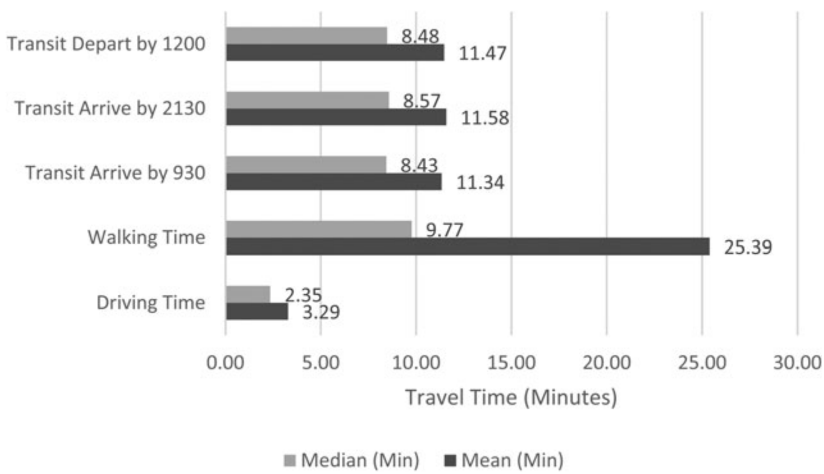

Figure 3 Mean and Median Travel Time to the Polls by Method of Travel

divisions) are depicted in Figure 2 (alongside other distance measures). The median walking and driving distances are both less than a kilometre. The mean is much larger, again due to the data points at the extreme end.

However, even walking and driving distances may not best represent the costs associated with getting to the polls for most voters, since walking and driving would take very different lengths of time. Thus, further analysis calculated the walking and driving times from the representative point to the polling location (Figure 3). The walking travel time median was less than 10 minutes; the driving travel time median was just over 2 minutes.

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Additionally, we considered the time it would take on public transport to get to the polling location. We calculated times on public transport at the polling location by three times—arriving by 9:30 a.m., departing at 12 noon and arriving by 9:30 p.m.—to account for different opening and closing times of polling places and the traffic conditions that may influence the travel time. We queried Google Maps for public transit directions. Public transport options were available for a little over 90 per cent of polling divisions,[13] so note that all results with transit are not including those places where transit options are not available. The mean travel time on public transport is about 11.5 minutes and median time about 8.5 minutes, regardless of the time departing or arriving. Again, most of the data tends to be concentrated at the shorter end of the spectrum.

Predictors of distance and travel time

What might predict these distances to the polling locations and travel times? We hypothesized earlier that predictors might be related to geographic size of the polling division and to socio-demographic variables, including income (here measured by average value of dwellings) and minority status (here measured both by percentage immigrants and percentage Indigenous).[14]

Table 1 presents the results of an OLS regression model with the dependent variable as the distance or travel time and the independent variables from census or Elections Canada data sources. The impact of geographic size of the polling division is significant for the Manhattan distance, but not driving or transit times. The magnitude is also exceptionally small. An additional 100,000 square kilometres in the polling division does not even increase the distance a metre (Table 1, Model 1).

Additionally, we notice that as the number of electors in a polling division increases, so too does the distance (Manhattan) to the polling station, as does the travel time for walking or driving, even when controlling for the land area size of the polling division. For each additional 100 electors in a polling division, the distance to the polls increases by approximately 0.04 kilometres or 40 metres (Table 1, Model 1). This is a modest increase, since nearly all polling divisions have less than 1,000 electors.

Thus, what may be more relevant is the relationship between distance and the socio-demographic profile of the polling division. First, the control variable of age has a negative relationship with distance. In other words, as the average age in the polling division increases, distance to the polling station decreases. However, again, we see a small magnitude: for each additional year in the average age of the population in the polling division, the distance (in Manhattan) decreases only about 3 metres (Table 1, Model 1).

There is also a small magnitude for income (measured by average value of dwellings). Even if the average value of dwellings in the polling division increases by $100,000, the distance (in Manhattan) decreases only approximately 2 metres (Table 1, Model 1). So these results are not substantively noteworthy.

More notable are the results for the minority communities, though not in the predicted direction. For each additional percentage of the polling division that is immigrant, the distance to the polls decreases by about 0.27 kilometres, or

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Table 1 Predictors of Distance and Travel Times

	(1) Manhattan (km)	(2) Walking time (min.)	(3) Driving time (min.)	(4) Transit time (min.)	(5) Manhattan (km)	(6) Walking time (min.)	(7) Driving time (min.)	(8) Transit time (min.)
Land area (100,000s sq. km)	>0.00**	>0.00**	< 0.00	>0.00	>0.00*	>0.00**	>0.00	>0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Number of electors	>0.00**	0.01**	>0.00*	>0.00**	>0.00**	0.01**	>0.00	>0.00**
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Average age	<0.00**	−0.01	−0.01**	−0.02**	<0.00**	0.04**	−0.01**	−0.01**
	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.00
Percentage immigrant	−0.27**	−8.21**	0.24**	−1.91**				
	0.01	0.25	0.04	0.13				
Percentage Indigenous					0.31**	8.09**	−0.82**	1.54*
					0.06	0.97	0.18	0.64
Average value of dwellings (1,000s of CAD)	<0.00**	<0.00**	>0.00	<0.00	<0.00**	<0.00**	>0.00	<0.00**
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Constant	0.64**	9.80**	2.33**	7.17**	0.48**	5.11**	2.48**	6.08**
	0.02	0.45	0.08	0.24	0.02	0.44	0.07	0.23
N (polling divisions)	18,203	18,178	18,201	16,668	18,203	18,178	18,201	16,668
R^2	0.04	0.07	0.01	0.02	0.04	0.02	0.01	0.01

Note: OLS regression models. Standard errors in second row. Per cent Indigenous and per cent immigrant not included in the same model due to collinearity. Data at the polling division level. Case of Ontario is used only. Distances are from a representative point to the polling station. Bottom 75 per cent of data used only. See robustness checks with full set of data in Appendix D.
* $p < .05$; ** $p < .01$

270 metres (Table 1, Model 1). This finding may be related to immigrant communities living in denser urban areas where there are more people, and so more frequent polling stations, but we are unable to say for certain based on the data we have, since the land area of the polling division and population were also taken as control variables. The notable exception to the relationship between distance to the polls and percentage of immigrant and Indigenous population is driving time, where the direction is flipped between the two groups. At this point, as the percentage of the population who are immigrants increases, so does driving time. We speculate this may be due to heavy traffic in high-density urban environments where immigrants may live (Gimpel and Schukenecht, 2003).

Conversely, as the percentage of the Indigenous population increases one percentage point, the distance increases about 0.31 kilometres or 310 metres (Table 1, Model 5). This finding is likely related to the statistic that most Indigenous people live in smaller towns or reserves, and thus they may be in more rural areas where distances to the polling station are greater.[15] However, we also note that as the percentage of the Indigenous population increases, driving time decreases, perhaps since more rural or small towns have straighter highway access to these locations, rather than stop-and-go traffic. This finding echoes similar ones by Gimpel and Schukenecht (2003), who originally demonstrated that drivers outside of suburban areas may have more straightforward (and therefore shorter) driving routes to the polls. While population and land area are taken into

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Table 2 Distance to the Polling Station and Turnout

	(1) Turnout	(2) Turnout	(3) Turnout	(4) Turnout
Land area (100,000s sq. km)	>0.00*	>0.00*	>0.00	>0.00
	0.00	0.00	0.00	0.00
Number of electors	−0.02**	−0.03**	−0.03**	−0.03**
	0.00	0.00	0.00	0.00
Average age	0.18**	0.19**	0.19**	0.20**
	0.01	0.01	0.01	0.01
Percentage with post-secondary education	22.56**	22.65**	22.47**	21.84**
	0.85	0.86	0.86	0.91
Percentage Indigenous	−10.31**	−6.75**	−4.01*	−14.62**
	2.22	2.08	1.80	2.61
Percentage immigrant	−9.58**	−9.16**	−7.95**	−9.07**
	0.79	0.79	0.79	0.83
Average value of dwellings (1,000s of CAD)	<0.00	<0.00	<0.00**	<0.00
	0.00	0.00	0.00	0.00
Manhattan (km)	−13.84**			
	0.89			
Squared term—Manhattan (km)	6.16**			
	0.65			
Walking time (minutes)		−0.84**		
		0.06		
Squared term—walking time (minutes)		0.02**		
		0.00		
Driving time (minutes)			−2.38**	
			0.34	
Squared term—driving time (minutes)			0.20*	
			0.09	
Transit—depart by 1200 (minutes)				−0.87**
				0.10
Squared term—transit—depart by 1200 (minutes)				0.02**
				0.01
Constant	54.05**	53.64**	51.92**	53.53**
	1.16	1.17	1.17	1.22
N	18098	18095	18082	16568
R^2	0.26	0.25	0.24	0.25

Note: OLS regression models. Standard errors in second row. Data at the polling division level. Case of Ontario is used only. Distances are from a representative point to the polling station. Bottom 75 per cent of data used only. See robustness checks with full set of data in Appendix D. Riding fixed effects included but not reported here.
* $p < .05$; ** $p < .01$

consideration, the unique living situations of Indigenous Canadians, whether on or off reserves, may lead to a unique pattern of distances to polling locations.

Distance and turnout

The final question we can begin to answer with these data is whether representative distance or travel time to polling locations is related to turnout. We may expect to see lower turnout in polling divisions with a greater distance to polling stations, even when controlling for the factors that traditionally influence turnout, such as age, education and affluence.

Recall that the lowest level of turnout data provided in official reports in Canada is at the polling division level.[16] However, when embarking on these analyses, we

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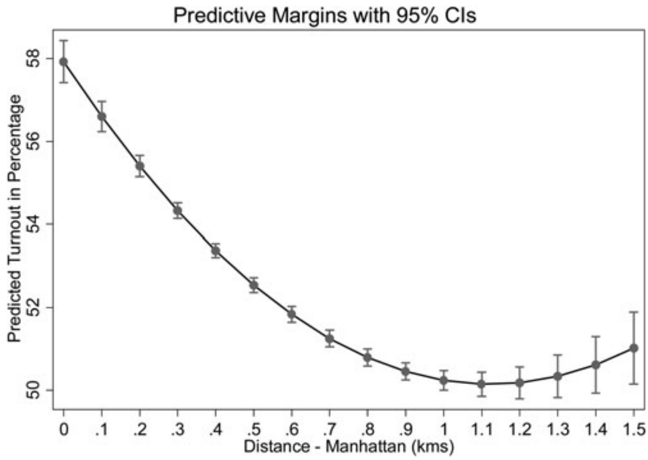

Figure 4 Distance (Manhattan km) and Turnout (Predictive Margins)
Predictive margins with 95 per cent confidence intervals (CIs), from results in Table 2. Distance in km (Manhattan metric used). Bottom 75 per cent of data only.

soon realized that turnout data by polling division must be used with care. Since Canadians can register at the polls, turnout as a percentage of eligible electors is not an entirely accurate measure. Other measures of turnout, such as percentage of Canadian citizens over the age of 18 in the polling division, were also not, strictly speaking, available, since polling divisions do not match directly to census dissemination areas; thus our data that linked census data with polling divisions are estimates. Additionally, this analysis does not take into consideration advance polling usage, which would not be a problem were it not that previous research has demonstrated advance poll usage is not necessarily consistent across the entire population (Garnett, 2019).[17]

Thus, with all these limitations in mind, Table 2 presents the results of OLS regression models, with the main independent variable of interest being the representative distance or travel time to the polls. The models include a squared term, to take into consideration previous research that has suggested that the relationship between distance to polling stations and turnout is not linear (Dyck and Gimpel, 2005).

Overall, the results do show that, in general, the relationship between distance and turnout is negative. This relationship is depicted with predictive margins in Figure 4 (using distance in Manhattan metres).[18] Consistent with previous findings, this relationship is not linear, but instead, as depicted in Figure 4, there is a decrease up to 1 kilometre of distance, after which it levels out. In general, we find that turnout in the polling division goes down about approximately 0.7 percentage points for each additional 100 metres distance between the representative point of the polling division and the polling station. This finding could mean that were distances to polling stations an additional kilometre, other things being equal, turnout in that polling division could drop as much as 8 percentage points.

We note a similar pattern of turnout dropping as travel times increase. We find that turnout decreases about 0.4 percentage points for each additional minute of

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walking required, that it decreases about 1.5 percentage points for each additional minute of driving required, and that it decreases about 0.5 percentage points for each additional minute of travel time on public transport.

Thus we can conclude that for the bulk of observations, there is a general trend of decreasing turnout when distance to polling stations increases. This finding suggests that distance to polling station could play some part in an individual's decision whether to vote or not. If the polling station is further away from the representative point in the polling division—meaning that more people are likely going to be further away from that polling station—then people may take that into consideration when choosing to vote. This result provides support for previous findings, largely from the US context, and supports the theory that voters will take into consideration the various associated costs when deciding whether or not to vote.

However, we also note the important caveats that those who reside further away from polling stations may take advantage of alternative voting measures. Additionally, the polling stations furthest away from population centres may not benefit from increased turnout due to Election Day registrations, so these results must be taken with caution.

Conclusion

This article explored, for the first time in the Canadian context, the distance that voters may travel to get to their polling stations. It first presented a new set of data, which mapped the distance between polling locations and a representative point in the polling division to estimate the potential distance that would need to be travelled and the time it would take using a variety of means of transportation—walking, driving or public transit—for a voter to go between their residence and their polling station.

It then estimated the socio-demographic profile of each polling division, to respond to the first question: What are the predictors of distances to the polling station from a representative point in the polling division? We find that, in general, as the number of electors in the polling division and the percentage of those electors who are Indigenous increase, the distances to the polling station increase. At the same time, as age, percentage immigrants and average value of dwellings in the polling division increase, the distance to the polling station decreases. This suggests that there are systematic differences in distances and travel times to polling stations between population groups.

Next, this article matched these data with turnout rates for each polling division. Because individual-level turnout data are not available in Canada, this is the smallest unit for which turnout can be measured using official sources. We find that, in general, turnout decreases as the distance to the polling location from the representative point increases. We cautiously conclude that there may be some negative relationship between how far a voter must go to get to the polls and the likelihood of that voter turning out to vote on Election Day. However, we also caution that these results could be influenced by decisions to attend advance polls or Election Day registration at more convenient, centrally located polling places.

This article used the case of Ontario, which provides a good variety of both urban and rural areas and large and small cities. We have no reason to believe

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that these findings would be especially different in other provinces. Furthermore, since elections are centrally managed in Canada, there is no expectation that the procedures for deciding on polling stations would be any different in other provinces. However, further research should expand this study to other areas of the country.

These findings shed new light on our understanding of the rational calculus of voting in the Canadian context, as it pertains to the actual distances a voter may travel to get to the polls. However, the limitations of this study also present some interesting avenues for future research. First, we did not take into account advance polling, which has been increasing in the Canadian context. With fewer advance-polling locations, it would be safe to assume that the distance between a voter's residence and polling station would be even greater. However, previous research has also shown that those who are most likely to vote in advance polls are those population groups with higher turnout to begin with (for example, older Canadians). Thus, this research is especially pertinent to the population groups with lower turnout who would need to rely on Election Day voting to cast their ballot, since they would be less likely to take advantage of alternative voting measures. Nonetheless, advance polling stations remain an interesting future extension to this project. We recognize that while our research considers physical distances to polling locations, another key area of study is what the consequences are of decreases in travel time in general, through means like postal and remote internet voting. These remain key areas of further study and may provide additional insight into the themes studied here. Additionally, research linking individual survey data with representative travel distances in polling divisions may be possible in the future, though we recognize that this may be difficult while protecting the anonymity of respondents at the polling division level.

What are the implications of this research for scholars and for election administrators? This article demonstrates that the distances between polling stations and a representative point in the polling division are related to the socio-demographic characteristics of that polling division. These characteristics tend to mirror some of the types of people who are already more likely to vote. The distances were greater in general for polling divisions with younger, more Indigenous and less wealthy electors. This finding is important to take into consideration when deciding where to put polling stations.

Finally, this research demonstrates that the location of polling stations may matter for turnout. In the preliminary findings for the relationship between distances to polling stations and turnout, there is a negative relationship. Thus it is important to consider where we place these stations and how far they are from where most voters are living. This information may be important when considering, for example, reductions in the number of polling stations close to electors' residences, in favour of larger vote centres, as has been done in some cases in the United States. There may be some trade-offs that need to be considered when making these decisions.

Supplementary material. To view supplementary material for this article, please https://doi.org/10.1017/S0008423921000196

Data availability statement. The code and data location for our paper can be found on a public GitHub here: https://github.com/canada-poll-location-analysis.

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Notes

1 Credit for the article title goes to student Mark Keir at the Royal Military College.
2 Dyck and Gimpel (2005) calculate the distance in Manhattan-blocks between voters' residences and their precinct and early voting sites during the 2002 midterm election in Clark County, Nevada. Clark County is home to Las Vegas, the largest city in Nevada.
3 Note that this 4 per cent includes overseas voters who likely are unable to vote in-person at a polling location. See data from Elections Canada's "Report on the 42nd General Election of October 19, 2015," https://www.elections.ca/content.aspx?section=res&dir=rep/off/sta_2015&document=p5&lang=e#T7.
4 Census demographic data for Ontario, as a proportion of population, tracks with the entirety of Canada, except for languages; specifically, more people know or speak French than English in the entirety of Canada. See, for example, Statistics Canada, "Census Profile, 2016 Census" at https://www12.statcan.gc.ca/census-recensement/2016/dp-pd/prof/details/page.cfm?Lang=E&Geo1=PR&Code1=35&Geo2=PR&Code2=01&SearchText=Ontario&SearchType=Begins&SearchPR=01&B1=All&TABID=1&type=1.
5 Although *geodesic* is the more appropriate term when referring to distances on a sphere, using the Canadian Lambert projection (which uses coordinates in metres north and metres east) and the Euclidian distance formula, we can expect a maximum error ranging between 1:400 at northernmost latitudes (the high Arctic) to 1:1,000 closer to the equator (that is, 1 metre of error per 400 metres to 1,000 metres). We choose to refer to the metric as *Euclidian*, as it is an accurate name of the method and formula used to calculate the distances.
6 For more information, see NAD83/Statistics Canada Lambert (EPSG:3347), at ESPG.io, https://epsg.io/3347.
7 Google Maps (as well as Bing Maps) does not provide historical public transit data (that is, for a date prior to the present request date). Furthermore, when requesting transit data for a future transit that is more than approximately two weeks in the future, it will not provide any transit options, just a walking option. For example, if we were to make a request on Google Maps APIs for a public transit route on December 10, we would not get a public transit option for dates past December 24 of the same calendar year. We selected Monday, December 16, because it was the first Monday following our request date (December 10). Canadian Election Day typically occurs on a Monday, so the hope was to request a day that would reflect a typical Monday or weekday public transit schedule (versus a public transit schedule for a holiday or weekend).
8 See Statistics Canada, "Dictionary, Census of Population, 2016, Dissemination Area" at https://www12.statcan.gc.ca/census-recensement/2016/ref/dict/geo021-eng.cfm.
9 See Statistics Canada, "About the Data, Census Profile, 2016 Census" at https://www12.statcan.gc.ca/census-recensement/2016/dp-pd/prof/about-apropos/about-apropos.cfm?Lang=E.
10 For more information on how Statistics Canada obfuscates the data, see "About the Data, Census Profile, 2016 Census" at https://www12.statcan.gc.ca/census-recensement/2016/dp-pd/prof/about-apropos/about-apropos.cfm—specifically the sections "Area and Data Suppression" and "Random Rounding."
11 In some special cases, the weighted average is used. One such case is median income.
12 See histograms in Appendix C.
13 Approximately 2,000 less observations for transit. Note that some transit options encouraged the user to walk as the quickest route, rather than taking a bus or metro.
14 We want to note here that we absolutely do not suggest there is any deliberate attempt by Elections Canada to create polling divisions with shorter or longer commutes to the polls based on socio-demographic variables. Instead, we suspect that certain population groups may, by virtue of their housing situations, work or other broad demographic trends, reside further from polling stations.
15 For more on where Indigenous Canadians live, see Statistics Canada, "Focus on Geography Series, 2016 Census" at https://www12.statcan.gc.ca/census-recensement/2016/as-sa/fogs-spg/Facts-CAN-eng.cfm?Lang=Eng&GK=CAN&GC=01&TOPIC=9.
16 Unlike in some other countries, researchers do not have access to individual turnout records in Canada.
17 Advance polling was excluded from this analysis because the locations are different from (or at least not consistent with) regular polling locations.
18 See Appendix G for predictive margins for travel times using various means of transportation.

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