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## The heterogeneous effects of internet voting

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## ABSTRACT

A decline in voter turnout over the last decades has prompted governments to introduce technological innovations for voting. This paper studies the heterogeneous effects of internet voting on voter turnout and vote shares in the Canton of Geneva, Switzerland. Exploiting across-time and across-municipalities variations during the introduction of internet voting between 2006 and 2013, we find that internet voting increased the turnout of individuals aged 80 and above, particularly of male voters, but did not have any effects on younger individuals. As a result, the vote share of adults aged 80+ relatively increased following the introduction of internet voting. Overall, our study shows that although internet voting does not appear to have an effect on general turnout, it has reweighted the political power of some sociodemographic groups, giving more weight to males and older adults.

## 1. Introduction

Voting turnout has seen a substantial decline in the last decades in most of the advanced democracies (Blais et al., 2004; Blais and Rubenson, 2013; Hooghe and Kern, 2017). Several explanations have been put forth, including the decline of union and labor parties, restrictive voting laws, less political competition (e.g. gerrymandering) and a sense of diminished political efficacy or public trust in the government (Gray and Caul, 2000; Cancela and Geys, 2016). Low voter turnout can threaten a healthy democracy as it may potentially allow a small group of people who are not representative of the whole, to make decisions for the entire population (Birch, 2010). The characteristics (e.g. age and socioeconomic status) and values of a few would then affect the allocation of resources in the economy and the rules of a society (e.g., laws on immigration and same-sex marriage). More generally, low turnout may erode the legitimacy of a democracy.

Given the far-reaching impact of voter turnout, several governments responded to the decline in turnout, either by passing mandatory voting laws or by decreasing the cost of voting with postal (e.g., in Switzerland) or electronic voting (e.g., in Brazil and United States).<sup>1</sup> More recently, technological change has brought a new option: online or internet voting (i-voting). This option allows citizens the freedom to vote without requiring them to travel to a specific location. They only need access to a device that connects to the internet. The implementation of i-voting has occurred on various scales in different countries such as Canada, Australia, France, Estonia and Switzerland. In many cases, i-voting was piloted but was not adopted and/or discontinued because it was deemed not secure (VerifiedVoting, 2019).

Nevertheless, i-voting remains an attractive option as it can significantly reduce the costs associated with voting, saving time and money spent commuting, as well as reducing adverse experiences such as traveling under unfavorable weather conditions.

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<sup>1</sup> Electronic voting includes all forms of voting that use some electronic means. These include electronic voting machines or computers connected to the internet (internet or online voting).

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I-voting can also alleviate constraints for citizens with disabilities or suffering from health conditions. Most importantly, proponents of online voting hope to reverse the stark decline in the turnout of young voters with user-friendly technologies that could render voting more attractive to the younger generations. Some think tanks and policymakers went as far as expecting a “youthquake” in turnout (Toby, 2017; Dawson, 2015). At the same time, i-voting also poses a threat to the democratic process; there are widespread concerns about the security of online systems, which are vulnerable to different kinds of manipulations (Zetter, 2018) or technology failures like the 2020 Iowa caucus delays in vote reporting (Epstein et al., 2020). There is a risk of hacking as well as an opportunity for governments to manipulate voting results. As a result, citizens may lose their motivation to vote if election results cannot be trusted (Birch, 2008). It is unclear whether these concerns outweigh the potential gains in voting costs generated by the internet or how different demographic groups will react to this innovation. Digital skills, technology access (“digital divide”), limited physical mobility, and awareness of the underlying risks of online manipulation are all characteristics that are very heterogeneous with respect to age, and to a lesser extent, gender.

We examine these questions in the context of Switzerland, a country with a long tradition of direct democracy and where citizens are frequently called to the polls. In this paper, we use data made available to us by the Statistical Office of the Canton of Geneva to estimate the *heterogeneous* effects of the introduction of internet voting in the Swiss Canton of Geneva on voter turnout and vote shares, i.e., the shares of total votes cast by each demographic group, at the municipality level. Vote shares are important characteristics to look at as they determine the outcome of a referendum and therefore the allocation of resources in the economy. After a short pilot in 2004, the Canton of Geneva officially introduced i-voting to some municipalities for national referendums starting in 2008. However, in 2018, the cantonal government decided to abandon i-voting amid security and budget concerns (Richard, 2018; Conseil d’Etat Genevois, 2018). Indeed, the development of a more secure online voting platform to meet the Federal Chancellery’s new security requirements would have generated additional costs that the Canton of Geneva was not willing to bear alone (Conseil d’Etat Genevois, 2018).

As detailed in the next section, internet voting was implemented in various municipalities across different referendums, providing useful variations in i-voting availability, over time and across municipalities. As a result, this allowed us to uncover the heterogeneous and causal effects of i-voting on voter turnout and vote shares in a specification that includes municipality and time fixed effects.

Consistent with the existing literature on i-voting in Switzerland, we find no effects of i-voting on overall turnout (Germann and Serdült, 2017). However, the availability of novel and more detailed data by demographic group allows us to investigate differences by demographic group, with respect to age and gender. First, we do not find significant differences by gender. The effect on males turnout is positive but not statistically significant. The effect on the share of male voters is positive but small and statistically significant only at the 10% level.

Second, we do not find that turnout for the youngest age group (18–29 years old) increases following the introduction of i-voting. In fact, the age category 80+ is the only category for which we see a positive and statistically significant effect on turnout (+1.53 percentage point,  $p$ -value = 0.024). This effect corresponds to an increase in vote share for this age category by about 0.3 percentage points, resulting in an increase in the electoral weight for this age category. The results on 80+ turnout are slightly stronger for males, in line with the gender digital divide literature, which points to a lower level of internet use and related skills for females (Hargittai, 2010). Our results are robust to various econometric specifications, and we find no differential trends in turnout among municipalities in the treated and control groups prior to the introduction of i-voting.

Overall, the expectation of a “youthquake” in turnout following the introduction of i-voting was unfounded, at least in the context of Geneva, Switzerland. We instead found a positive effect on turnout among individuals aged 80 and above. The case of Geneva is a cautionary tale for governments interested in experimenting with technologies to increase turnout. While internet voting has the potential to increase turnout, its effects are not homogeneous across age, as we found no effect on turnout for any of the age categories but for the 80+. The positive results for the oldest age group could speak to the benefits that online voting can bring to citizens with physical mobility limitations, allowing them to vote from the comfort of their home. The null results on turnout for individuals aged 18–29 could potentially be due to a decreased trust in the electoral system among young voters who are more knowledgeable and aware of the risks associated with manipulations of online platforms. This speculation seems to be supported by anecdotal evidence we discuss below. Moreover, security concerns would need to be addressed and well communicated to the public in order to reap the full benefits of new technologies such as internet voting. Clearly, the external validity of our results is limited by the presence of postal voting. At the same time, security concerns would most likely also arise in contexts where only poll voting was available.

This paper contributes to the literature on electoral turnout and in particular to the literature that estimates the causal effects of a change in voting costs. Godefroy and Henry (2016) and Meier et al. (2019) study how weather shocks affect turnout in France and Switzerland and find significant effects on the quality of the politicians elected. A more substantial number of studies looked at the effects of compulsory voting, which de facto made non-voting substantially more costly. Both Jaitman (2013) and Hoffman et al. (2017) find major increases in turnout when voting became compulsory in Argentina and Austria, while Chong and Olivera (2008) and De Leon and Rizzi (2016) find that compulsory voting has an effect on government policies and political preferences.

On the other hand, León (2017) finds that halving the fine for abstention in Peruvian elections decreased turnout by 2.6 percentage points. Finally, some papers have looked at the causal effects of information costs on turnout. There is evidence that political advertising (Baek, 2009) and information campaigns (Lassen, 2005) have substantial effects on turnout although the evidence is mixed (Dunning et al., 2019).

Our study contributes more specifically to the literature on turnout with regard to voting technology. Fujiwara (2015) finds that the introduction of electronic voting in Brazil increased turnout of the less educated and public spending on health care. In

Switzerland, [Hodler et al. \(2015\)](#) finds that the introduction of postal voting increased turnout by 5% but with larger effects for the less educated, while [Schelker and Schneiter \(2017\)](#) estimate that the inclusion of prepaid postage on the return envelope in some municipalities in the Canton of Berne induced a 4% increase in turnout. In Canada, [Goodman and Stokes \(2020\)](#) find that i-voting increased turnout by 3% in local elections.

The studies that are closest to the present study are by [Germann and Serdült \(2017\)](#) and [Petitpas et al. \(2021\)](#). [Germann and Serdült \(2017\)](#) estimated the effects of i-voting on turnout in the municipalities of Geneva and Zurich and, as mentioned above, did not find any evidence of an effect of i-voting on turnout.<sup>2</sup> However, their analysis is somewhat limited in terms of heterogeneous effects, as they look only at effects for those aged 35 or below, and those aged 65 and above. As part of their main findings, they do not observe any effects on turnout for these two age groups. Moreover, they do not consider any potential effects of the introduction of i-voting on turnout across gender. The data we have at hand, obtained from the Statistical Office of the Canton of Geneva, allowed us to estimate the heterogeneous effects of i-voting on turnout and vote share for both men and women, and for finer age categories as compared to [Germann and Serdült \(2017\)](#).

In their recent study, [Petitpas et al. \(2021\)](#) look at the heterogeneous effects of i-voting on turnout in the Canton of Geneva, as this study does. Using individual data on turnout for 30 ballots between 2008 and 2016 and Bayesian multi-level models, they find that i-voting increase turnout among individuals born before 1950 but had small and non credible effect on participation among the youngest cohort. Moreover, they find that the difference in predicted probability of participating between men and women widened following the implementation of i-voting, resulting in an increase in the gender gap in turnout.

Consistent with these results, our study complements [Petitpas et al. \(2021\)](#)'s findings by providing further evidence of the heterogeneous effects of i-voting on turnout. More specifically, while they use a cross-classified multilevel logit model to analyze the effects of i-voting on turnout, we use a standard two-way fixed effects linear model approach to estimate the causal effect of i-voting on turnout. Moreover, [Petitpas et al. \(2021\)](#) use data from June 2008 onward and i-voting became widely available in the Canton of Geneva in November 2008. This means that their study includes only one ballot prior to the implementation of i-voting. Our study, on the other hand, includes data from the beginning of 2006, thus containing a total of seven ballots prior to the implementation of i-voting. These data prior to treatment allow us to test the critical assumption underlying our identification strategy, i.e., the parallel trends assumption in our outcome variables between the treated and untreated groups. Furthermore, while [Petitpas et al. \(2021\)](#) use impressive individual-level data in their study, we use data at the aggregate level, which allows us to more directly assess the extent to which i-voting has re-weighted the political power of some socio-demographic groups as defined by their age and gender, notably by looking at the effect of vote share of one socioeconomic group relative to another.

## 2. Internet voting in Switzerland

Swiss citizens who are 18 years old are automatically registered to vote. During each referendum (approximately three to four times per year depending on the year<sup>3</sup>), registered voters receive a voting envelope no less than three weeks before the referendum end date. This allows them ample time to vote either by post mail (mail-in ballots) using the paper ballot and envelope provided within the voting envelope,<sup>4</sup> or by visiting polling booths, typically the day of the referendum (on Sundays), at the local community polling station to cast their paper ballot directly.

With the introduction of mail-in ballots in Switzerland, there was a positive impact on turnout, increasing by almost 4 percentage points over the period 1970 and 2005 ([Luechinger et al., 2007](#)). Voices were raised in political circles promoting i-voting as a means to provide an additional boost to Switzerland's relatively low average turnout rates, especially among younger citizens ([Serdült et al., 2015](#); [Blais, 2014](#)).

In 2002, with the support of the Swiss Federal Council, the Federal Act on Political Rights was amended to allow cantons to conduct internet voting pilot schemes on a limited basis, limiting the i-voting trials to federal referendums and to a maximum 10% of the electorate at the country level ([OSCE, 2011](#); [CEPP, 2013](#)). At the cantonal level, this restriction was applied to 20% of the electorate and later raised to 30% after April 2012 ([CEPP, 2013](#)). In order to comply with this limitation, the Canton of Geneva decided to restrict the availability of i-voting to referendums to a subset of its municipalities. Municipalities that participated in i-voting trials were selected in a way that citizens' socio-demographic characteristics were balanced across municipalities that could use i-voting and those that could not ([Germann and Serdült, 2017](#)). While it is unclear how exactly municipalities were selected to participate in i-voting, our fixed-effect analysis at the municipality level controls for any unobserved municipality characteristics that are constant over time, therefore estimating the change in turnout following the implementation of i-voting using within municipality variation. As described in the "Data and Methods" section, we exploit both time and municipalities variations in i-voting availability to estimate the causal effects of i-voting access on turnout.

Between 2001 and 2005, the implementation of i-voting in Switzerland was first piloted and the Canton of Geneva took a pioneering role in its application. Experimental trials of i-voting were first launched in September 2004, with only four municipalities of the Canton of Geneva (out of 45) allowed to vote online. I-voting was also allowed in the two following referendums of November 2004 and April 2005. At the end of this pilot phase, the Federal Council evaluated these trials positively, and decided in 2006 to be in favor of the sequential implementation of i-voting in Switzerland ([CEPP, 2013](#); [Federal Council, 2006](#)). However, during

<sup>2</sup> [Germann \(2020\)](#) finds that i-voting had a small effect on effective turnout as it slightly reduced the residual vote rate.

<sup>3</sup> [Stutzer et al. \(2019\)](#) show that citizens in Switzerland are unlikely to be overstrained by the frequency at which they are asked to vote.

<sup>4</sup> Note that in Geneva, which is the canton we are focusing on in this study, this envelope is pre-stamped, so that there are no direct financial costs associated with voting by post.

the interim, i-voting was suspended between April 2005 and November 2008. It was not until November 2008 that i-voting was officially reinstated in the Canton of Geneva and expanded to a more extensive set of municipalities in 2012 (from 20% to 30% of the electorate). Details on the history of how i-voting was implemented in the Canton of Geneva is discussed in further detail by Gerlach and Gasser (2009), Mendez and Serdült (2014) and Germann and Serdült (2017).

The introduction of i-voting was put in place mainly with the hope of increasing turnout, among other reasons (Serdült et al., 2015; Blais, 2014). However, the availability of i-voting in Switzerland did not seem to increase turnout in municipalities that allowed it. After exploiting both space and time variations in the implementation of i-voting in Geneva, as this study does, Germann and Serdült (2017) and Sciarini et al. (2013) found that i-voting did not have any statistically significant effect on turnout. In this study, and in line with results from Petitpas et al. (2021), we claim that the implementation of i-voting has had heterogeneous effects on turnout, which can then affect the political weight (that is the share) of a specific sub-population with respect to the overall electorate.

### 3. Theory

In this section, we discuss how the introduction of internet voting can have different effects across different demographic groups. Generally, the benefits and the costs associated with the introduction of i-voting depend on the characteristics of the voters. As discussed in more detail below, internet voting may facilitate voting for people with internet access and those with physical mobility limitations, while it may alter the confidence in the electoral system and affect the value of voting for those who are aware of the possible threats that online voting can generate.

**Costs of traditional voting options and benefits of i-voting:** Both the benefits and costs of voting affect turnout in the electoral process. The “instrumental” perspective suggests that citizens vote because of the relative benefits they derive in case their preferred vote outcome is realized (Miguet, 2008). The expressive theories of voting underline the importance of social networks and social norms in motivating voting decisions (Geys, 2006; Harder and Krosnick, 2008; Fieldhouse and Cutts, 2018). According to this theory, individuals derive benefits in the act of voting and in supporting their preferred alternative (Miguet, 2008; Frank et al., 2004).

The costs associated with voting are also a primary determinant of turnout (Riker and Ordeshook, 1968; Gomez et al., 2007; Miguet, 2008). Voting takes time and may require gathering information on the subject of the referendum or the candidates political platforms (Gant, 1983). It may also involve monetary costs (e.g., driving), be inconvenient (e.g., in the case of disabilities) and/or depend on trivial factors (e.g., in the case of bad weather, traffic or going to polling stations on Sundays) (Aldrich, 1993). Even postal voting, which increases the flexibility of voting, requires voters to travel to the nearest post box to mail their ballot. For these reasons, i-voting can represent a non-negligible gain of time for voters, even in the presence of postal voting. As the opportunity cost of voting is likely to be higher for workers, one would expect i-voting to be particularly appealing for those involved in the labor market, as they would particularly benefit from a reduction in the time cost of voting. Having access to the internet at work also represents a convenient opportunity for workers to vote online directly from their workplace (Frank et al., 2004). At the same time, internet voting can be attractive to those with physical mobility limitations: The option of voting without having to travel to a specified location, allows people with severe physical disabilities to vote more easily (Vasilogambros, 2018). As mobility decreases with age, particularly after 80 years old, internet voting can potentially provide access to voting for this subset of the population (Ferrucci et al., 2016; Fielding et al., 2011; Daley and Spinks, 2000). While the possible lack of digital skills and internet access in this specific demographic group may prevent these individuals from fully capitalizing on this opportunity, internet voting can nonetheless increase their turnout and hence their political presence.

**Cost of i-voting:** Importantly, voting online in the Canton of Geneva did not require any pre-registration and all information required to vote online, including website link and login details, is provided in the voting envelope (Serdült et al., 2015).<sup>5</sup> The possibility of saving time via the use of i-voting however relies on having an internet access and digital skills. For some voters, understanding the procedures to vote online may actually take more time than traditional voting methods, or it may be prohibitively too complicated. Although the availability of online voting does not preclude from voting using traditional means, citizens might perceive the act of voting as more daunting and complex, which could negatively impact their voting behavior and their probability of turning out to vote (Hessami, 2016; Hessami and Resnjanskij, 2019). There exists substantial evidence of a *digital divide* between users and non-users of the internet, notably across age (Loges and Jung, 2001; Niehaves and Plattfaut, 2014), and income and wealth (Agarwal et al., 2005; Bucy, 2000). In Switzerland, 90% of individuals age 14 to 19 used the internet compared to around 17% among individuals 70+ back in 2009 (Friemel, 2016). There is also evidence of a gender *digital divide* (Cooper, 2006). In Switzerland, differences still persist in 2019, with 88.4% of women using the internet versus 93.5% of men (NetMetrix, 2019). This gender *digital divide* also exists among younger generations: Hargittai (2010) found that males of the so-called “net-generation” used the internet more than their female counterparts. As reflected in our data, younger adults, especially males, are more likely to use the internet to vote relative to other socio-demographic groups. Whether or not the introduction of i-voting increases turnout and vote share for some specific socio-demographic groups, such as men and younger adults, however, remains unclear. The introduction

<sup>5</sup> More specifically, citizens living in the municipalities that belong to the control group receive their standard voting envelope as usual. This standard voting envelope allows citizens to cast their vote either by post (pre-stamped envelope is included in the voting envelope) or by going to the polling station. Citizens living in the municipalities that belong to the treatment group receive the same envelope, but this envelope also contains the required information to vote online, including website link and login details to vote online. Voting online therefore did not make voters incur any i-voting-specific costs, beyond the ones associated to having a device and an internet connection.

of i-voting could just provide voters with another method of voting, and one may therefore observe just a substitution effect from traditional voting means to i-voting without i-voting having any impact on turnout (i.e., attracting new voters).

**Trust in the electoral system:** There is growing concern about the security of internet voting (Simons and Jones, 2012; Springall et al., 2014), and several political parties have expressed concerns over i-voting in Switzerland. Perhaps more surprisingly, the most severe criticisms came from young voters and politicians, as well as from the “tech community” (Enguehard, 2009; Fenazzi, 2017; Delley, 2009b,a; Ashwanden, 2018; GULL, 2015; Rebetez and Heuberger, 2018; Ghiselli, 2019). As a result, the federal government has been extremely cautious in expanding i-voting to all of Switzerland. In fact, the Canton of Geneva decided in 2018 to discontinue i-voting after a hacking test showed the vulnerability of the online platform (Richard, 2018; Conseil d’Etat Genevois, 2018).

Because of this deficiency in security, internet voting could very well erode trust in the electoral system, especially among those who have the knowledge and are aware of the possible security threats (Enguehard, 2009; Fenazzi, 2017; Delley, 2009b,a; Ashwanden, 2018; GULL, 2015; Rebetez and Heuberger, 2018; Ghiselli, 2019). Some voters may therefore see less benefit in i-voting, and perhaps voting more generally, if they do not trust the integrity of the election or referendum results, believing that their votes would not be counted accurately as it should be or that their privacy would be violated. If that were the case, one would observe a decrease in turnout when i-voting is available due to the mistrust against tampering of votes. This could be particularly the case among young individuals who are more aware of digital security issues associated with internet voting. Several studies also show that young adults are more afraid to lose control over their information and therefore more likely to take measures to protect their privacy online (Rainie, 2016; Hargittai and Marwick, 2016).

All in all, the effects of the introduction of i-voting on turnout can be heterogeneous across gender and age. The direction and magnitude of these effects depend on which mechanisms described above dominates. Ultimately, this is an empirical question and given its exploratory nature, we refrain from explicitly stating any hypotheses.

#### 4. Data and methods

Our study aims to assess the heterogeneous effects of the introduction of i-voting on turnout and vote shares. We exploit space-at-the-municipality-level- and time variations during the introduction of i-voting in order to estimate its causal effects on turnout and vote shares using a two-way fixed effects linear regression model. As discussed above, i-voting was first introduced in the Canton of Geneva at three occasions in September 2004, November 2004 and April 2005, as part of a trial period. From April 2005 to November 2008, i-voting was suspended and thus unavailable before it was officially implemented in the Canton of Geneva in November 2008. Our study period extends from May 2006 to November 2013, allowing for the observation of seven different referendum dates before internet voting was implemented in November 2008, and 17 referendum dates after its first implementation (24 referendum dates in total).<sup>6</sup> Table 1 summarizes the dates and municipalities where i-voting was available for the time period under consideration. As evidenced in the table, not only is there variation in i-voting availability over time, there is also substantial variation across municipalities, variations that we exploit to estimate the causal effects of i-voting on turnout and vote shares. As detailed earlier, the Federal Council imposed on the Canton of Geneva a 20% quota rule for all referendums that contained subjects at the federal level, restricting i-voting to maximum 20% of the population that could vote online within the canton. After May 2012, the threshold rose to 30%, which increased within and across municipality variations in our analysis. This can be seen in Table 1, where municipalities that could use i-voting in March 2012 (date 17 in the table) is a subset of those in June 2012 (date 18). The last row of Table 1 represents the control group, which includes the 25 other municipalities in the Canton of Geneva.<sup>7</sup>

##### 4.1. Data

We obtained gender- and age category-specific data on voting participation in national referendums at the municipality level from the Statistical Office of the Canton in Geneva.<sup>8</sup> Our data details the voting participation count by the three different voting methods (i.e., mail-in ballots, voting booth, and i-voting when available) and the number of registered voters, covering the period from the beginning of 2006 (about two years before i-voting was officially implemented in the Canton of Geneva) until the end of 2013. Our analysis includes voting information for all 45 municipalities in the Canton of Geneva over 24 referendum dates, leaving us with a sample size of 1080 observations. The data was disaggregated by gender and age categories, in 10 years bin, starting from 18–29, all the way up to 70–79 and 80+.<sup>9</sup> Using voting participation count and information on the number of registered individuals who can vote by gender and age category, we compute voter turnout (number of votes over number of registered voters) and vote share (number of votes for a subcategory of the population over the total number of votes) for subgroups of the population defined by their gender and age category.

<sup>6</sup> During that period, there were four referendums in which i-voting was available in all municipalities of the Canton of Geneva (May 2011, November 2011, October 2012 and November 2012). There were no federal subjects to vote on those dates. Given that the restriction of a maximum of 20% of the electorate, and then 30% after April 2012, that could use i-voting was applied only to federal referendums, the Canton of Geneva was free to offer i-voting to all its registered citizens. Given the lack of valid counterfactual, we do not use the information on turnout for these four dates in our analysis.

<sup>7</sup> The 25 other municipalities are the following: Avully, Bellevue, Cartigny, Celigny, Chancy, Choulex, Collex-Bossy, Corsier, Daardagny, Genthod, Geneva, Gy, Hermance, Jussy, Laconnex, Lancy, Meinier, Pregny-Chambesey, Presinge, Puplinge, Russin, Satigny, Soral, Vernier and Veyrier.

<sup>8</sup> Note that i-voting was principally available for referendums and not for elections.

<sup>9</sup> Information about the votes of expatriates and individuals living abroad was not available in the dataset we obtained from the Statistical Office of the Canton in Geneva.

**Table 1**  
Availability of i-voting by municipalities in the Canton of Geneva over time.

Municipalities	Dates																							
	1 to 7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24						
Aire-la-Ville								x	x	x	x	x	x	x	x									
Anieres		x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x					
Avusy							x	x	x	x	x	x	x	x	x	x	x	x	x					
Bardonnex												x	x	x	x	x	x	x	x					
Bernex				x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x					
Carouge		x										x	x	x	x	x	x	x	x					
Chene-Bougeries						x		x	x	x	x	x	x	x	x	x	x	x	x					
Chene-Bourg		x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x					
Collonge-Bellerive		x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x					
Cologny		x		x		x	x	x	x	x	x	x	x	x	x	x	x	x	x					
Confignon												x	x	x	x	x	x	x	x					
Grand-Saconnex				x	x		x	x	x	x	x	x	x	x	x	x	x	x	x					
Meyrin		x										x	x	x	x	x	x	x	x					
Onex				x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x					
Perly-Certoux				x	x	x		x		x	x	x	x	x	x	x	x	x	x					
Plan-les-Ouates				x	x		x	x	x	x	x	x	x	x	x	x	x	x	x					
Thoney		x		x	x	x	x																	
Troinex									x															
Vandoeuvres		x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x					
Versoix		x																						
<i>Control group (25 other municipalities)</i>																								

Note: Information retrieved from the official report written by [Sciarini et al. \(2013\)](#) for the External Commission on Public Policy Evaluation in the Canton of Geneva and from [Germann and Serdült \(2017\)](#). There were 7 referendums dates between May 2006 and June 2008 (dates 1 to 7) that contained national level topics: during this period, i-voting was unavailable for all the municipalities. Date 1 corresponds to May 2006 and date 24 to November 2013. Small “x” represents referendum dates in municipalities where i-voting was available. There are 25 municipalities in the control group: Avully, Bellevue, Cartigny, Celigny, Chancy, Choulex, Collex-Bossy, Corsier, Daardagny, Genthod, Geneve, Gy, Hermance, Jussy, Laconnex, Lancy, Meinier, Pregny-Chambesey, Presinge, Puplinge, Russin, Satigny, Soral, Vernier and Veyrier.

We merged the data with the data made publicly available by [Germann and Serdült \(2017\)](#). The data contains municipality-level yearly information on the population (in log), the share of foreigners, the share of the population below 35 and above 65, unemployment rate and the share of the population who voted for the SP and GPS in the last national election, the socialist and green party, respectively. This dataset also included a measure of individual income; however, that measure contained many missing values for the period considered in our study. We therefore replaced this variable with a proxy for individual income, namely the average individual income tax received by municipalities each year.<sup>10</sup> As in [Germann and Serdült \(2017\)](#), we include these variables in our econometric specification.

[Fig. 1](#) shows the rate of individuals who voted using the internet by gender for each given date. While the use of internet vote ranges from 10 to about 22%, there is a clear gender difference in i-voting, which is consistent with the literature ([Serdült et al., 2015](#); [Sciarini et al., 2013](#); [CEPP, 2013](#)). Males (solid line) consistently used i-voting more often than females (dashed line), with a parallel shift upward of about 5% points.

[Fig. 2](#) presents similar descriptive statistics, differentiating this time by age. Again, there exist significant differences by age. However, i-voting does not appear to monotonically decrease with age, as one could expect. In fact, the 18–29 age category is not the group that uses internet voting the most. Instead, those who are age 30–39 appear to use the internet to vote the most, with a rate ranging from roughly 16% to 28%, depending on the referendum dates under consideration. I-voting decreased with age for all other age categories, reaching the lowest rate for the age category 80+ (between 3% and 5%). It is interesting to note that while the older age categories tend to use the internet to vote less frequently than others, the 60–69 and above age categories increase the use of i-voting over time, whereas this is not the case for younger age categories. Finally, [Fig. A.1](#) in the Online Appendix shows that the difference in i-voting shares between males and females is not constant over time and varies by age group. While the gender gap in i-voting between 18–29 years old and 80+ appears relatively low, the gender gap is the highest for middle-aged individuals, particularly those aged between 30 and 49 years old.

Overall, our descriptive analysis presents some important heterogeneity in the use of i-voting, which is consistent with the literature ([Serdült et al., 2015](#); [Sciarini et al., 2013](#); [CEPP, 2013](#)). The next section describes how we can use the data at hand to estimate the causal effects of i-voting on turnout and vote share and explore whether these are heterogeneous across age and gender.

#### 4.2. Empirical specification

Our identification strategy relies on across-time and across-municipalities variations during the introduction of internet voting to estimate the heterogeneous effects of internet voting using a two-way fixed effects linear regression model. Our main interest is

<sup>10</sup> This data is publicly available from the Statistical Office of the Canton in Geneva's website.

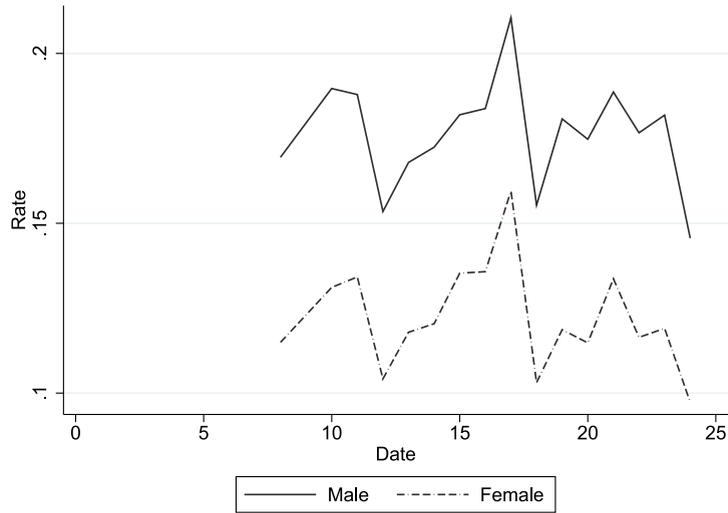


Fig. 1. Share of i-voting by gender over time.

Note: Data coming from the Statistical Office of the Canton of Geneva. Solid and dashed lines represent the shares of male and female voters, respectively, who have used i-voting over time. These statistics are weighted by the number of registered voters in each municipality at date 1.

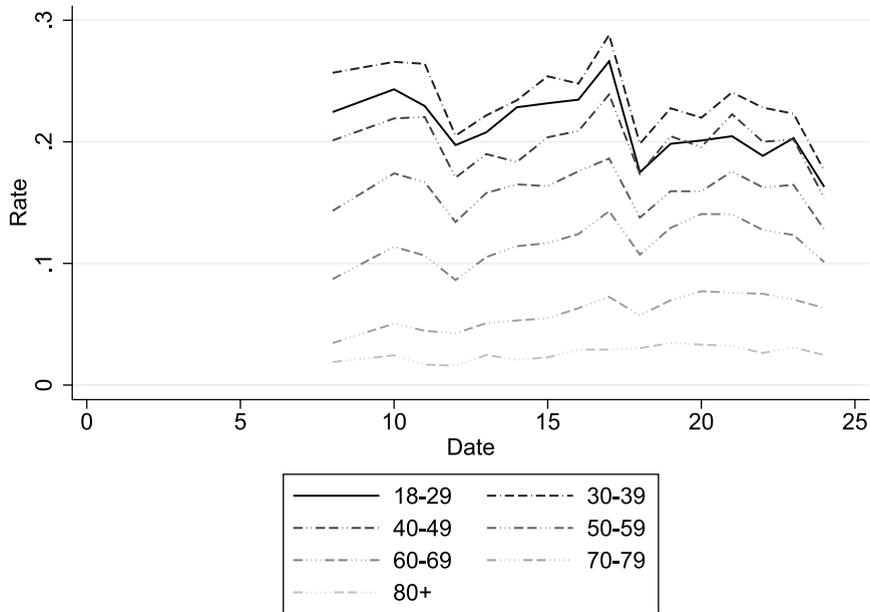


Fig. 2. Share of i-voting by age category over time.

Note: Data coming from the Statistical Office of the Canton of Geneva. Solid line represents the share of voters aged 18–29 who have used the internet to vote. Dashed lines represent corresponding shares for older age categories. Note the shades of the dashed lines get lighter as the age category under consideration increases. These statistics are weighted by the number of registered voters in each municipality at date 1.

to understand the extent to which internet voting has affected the turnout and vote share of socio-demographic groups (defined by gender and age), the latter being critical to determine (and change) the political outcomes of referendums.

We perform linear regressions to estimate the heterogeneous effects of the introduction of i-voting on overall, male, female, and age-category-specific turnouts. More specifically, we estimate the following econometric model:

$$Y_{it} = \alpha + \beta E_{it} + X'_{it}\gamma + \lambda_t + \mu_i + \epsilon_{it} \quad (1)$$

where the unit of observation is a municipality-referendum day.  $Y_{it}$  represents turnout in municipality  $i$  for referendum date  $t$ .  $\beta$  is the coefficient of interest and represents the effect of the introduction of i-voting,  $E_{it}$ , on  $Y_{it}$ . The vector of municipality characteristics  $X$  includes the population count in the municipality (in log), the share of foreign residents, the share of the population below 35

**Table 2**  
Effects of the introduction of i-voting on turnout and vote share.

	Overall turnout (1)	Male turnout (2)	Female turnout (3)	Male share (4)
I-voting available	-0.099 (0.294)	0.032 (0.314)	-0.210 (0.296)	0.120* (0.070)
Observations	1080	1080	1080	1080

Note: Cluster robust standard errors at the municipality level are reported in parentheses with \*  $p < 0.1$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$ . Effects of i-voting on overall turnout (column 1), male turnout (column 2), female turnout (column 3) and male vote share (column 4). All specifications include referendum dates and municipality fixed-effects, population level (in log), share of foreign resident, share of individuals below 35, share of individuals above 65, unemployment rate, the share of the population who voted for SP and GPS in the last national election, the socialist and green party, respectively, as well as the average individual income tax received by municipalities each year. These effects are estimated using model (1). Our specification in column 4 also includes the share of registered males. We weight our regressions using the number of registered voters (columns 1 and 4), registered males (column 2) and registered females (column 3) in each municipality at date = 1.

and above 65, unemployment rate, the share of the population voting for SP and GPS in the last national election, the socialist and green party, respectively, and average individual income tax received by municipalities each year. This set of control variables is the same as the one used in [Germann and Serdült \(2017\)](#). In addition, we include municipality  $\mu_i$  and date  $\lambda_t$  fixed-effects to capture any unobserved municipality characteristics and time factors that could confound our estimates. Moreover, we cluster our standard errors at the municipality level in all our model specifications as within-municipality errors are likely not independent of each other (serially correlated). Finally, we use the number of registered voters as weights in our estimation to correct for heteroscedastic error terms and therefore obtain more precise estimates. This is appropriate in our case, as the number of registered voters is highly variable across municipalities and relatively small in some of them ([Solon et al., 2015](#)).

We also estimate the effects of i-voting on vote share by gender, age category, and by gender×age-category. Because our analysis on shares by age group contains more than two categories, we restrict the vote shares to sum up to one by estimating our model using a fractional multinomial logit specification.<sup>11</sup> Formally, we can define the vote share of group  $g$ ,  $s_g$ , with  $g = 1 \dots G$ , such that  $\sum_g s_g = 1$ . Specifying the conditional means of the shares to have a multinomial logit functional form in linear indexes, the expected share of vote for group  $g$ , conditional on i-voting being available ( $E_{it}$ ) and observable characteristics  $X_{it}$  take the following form:

$$E(s_g | E_{it}, X_{it}) = f_g(E_{it}, X_{it} : \beta, \gamma, \lambda_t, \mu_i) = \frac{\exp(\beta_g E_{itg} + X'_{itg} \gamma_g + \lambda_{tg} + \mu_{ig})}{\sum_g \exp(\beta_g E_{itg} + X'_{itg} \gamma_g + \lambda_{tg} + \mu_{ig})} \quad (2)$$

for  $g = 1 \dots G$  such that  $\sum_g E(s_g | E_{it}, X_{it}) = 1$ ,  $Pr(s_g = 1 | E_{it}, X_{it}) \geq 0$  and  $Pr(s_g = 0 | E_{it}, X_{it}) \geq 0$  for  $g = 1 \dots G$  as well.  $E_{it}$  is a dummy variable that takes the value one if i-voting was available in municipality  $i$  at date  $t$ . We estimate this model by quasi-maximum likelihood and report marginal effects with respect to  $E_{it}$ .<sup>12</sup> Similar to our analysis on turnout, we use the number of registered voters as weights and cluster standard errors at the municipality level. We report unweighted estimates in the Online Appendix.

## 5. Results

Consistent with [Germann and Serdült \(2017\)](#), the first column of [Table 2](#) shows that the introduction of i-voting had no effect on overall turnout.<sup>13</sup> It did not have any statistically significant effects on male and female turnouts either (columns 2 and 3), although these effects have different signs, resulting in a positive effect on male vote share by about 0.12% point (column 4). The effect is small and statistically significant only at 90% confidence, and should be taken with caution, although it is in line with [Petitpas et al. \(2021\)](#) who find that the introduction of i-voting increases the gender gap in turnout. The effect on male vote share we find is not driven by trends in registered voters as we control for the share of male registered voters in that specification.

Plots in [Fig. 3](#) show the effects of the introduction of i-voting on turnout ([Plot 3\(a\)](#)) and vote shares ([Plot 3\(b\)](#)) for each age category, including 95% confidence intervals. We find no statistically significant effect on turnout for the youngest age group (18 to 29 years) and for the other age groups, except for the oldest age group (80 years and above). The magnitude of the effect on turnout for the oldest age group turnout is rather large. The introduction of i-voting increased turnout of individuals aged 80+ by about 1.53% points ( $p$ -value = 0.024). Consistent with our results pertaining to turnout, [Plot 3\(b\)](#) shows that the share of votes

<sup>11</sup> Note that because our heterogeneous analysis on vote share by gender contains only two categories (male and female) and these two effects mirrors each other, we use model (1) to estimate the effect of the introduction of i-voting on male vote share.

<sup>12</sup> In specifications where the outcome variable is a vote share, we include as a control variable the respective share of registered voters for the corresponding category. Note also that the marginal effects will sum up to zero, i.e., the effects on shares across the various categories under consideration will cancel out.

<sup>13</sup> The coefficients associated to the other explanatory variables are presented in the Online Appendix (Table A.1).

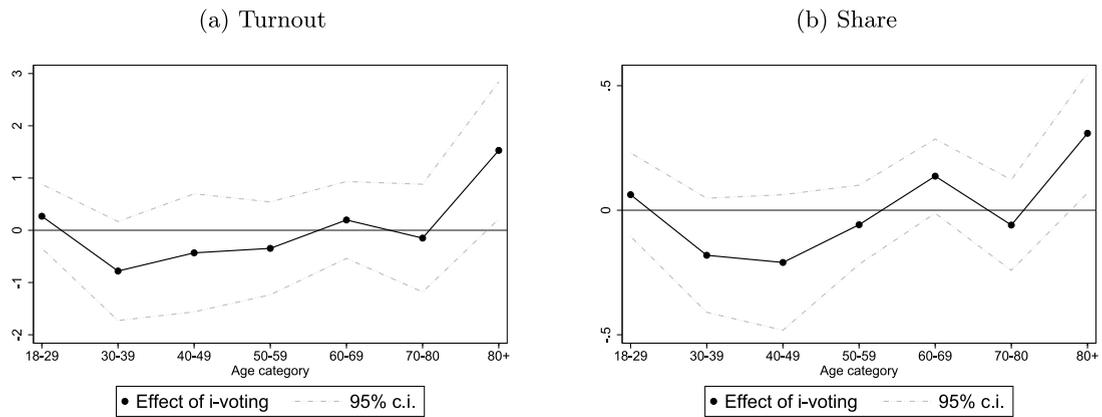


Fig. 3. Effects of the introduction of i-voting on (a) turnout and (b) vote share by age category.

Note: The dashed lines represent the 95% confidence intervals (cluster robust standard errors at the municipality level). Effects of i-voting on (a) turnout and (b) vote share by age category. All specifications include referendum dates and municipality fixed-effects, population level (in log), share of foreign resident, share of individuals below 35, share of individuals above 65, unemployment rate, the share of the population who voted for SP and GPS in the last national election, the socialist and green party, respectively as well as the average individual income tax received by municipalities each year. We also include the share of registered voters for the different age categories in the results for (b). The marginal effects on vote shares sum up to zero. We weight our regressions using the number of registered voters (overall in (b) and age category-specific in (a)) in each municipality at date = 1.

from voters 18 to 29 years old did not change while the share of voters who are 80 years or above increased by 0.31% points.<sup>14,15</sup> This effect is statistically significant at the 95% confidence level ( $p$ -values = 0.012). The effects for the other age groups are not precisely estimated. Overall, our results suggest that the introduction of i-voting increased the electoral power of the 80+ voters.

The fact that we find an effect for the oldest age group may be a consequence of the relatively small size of this age category, although this estimated result appears robust to various econometrics specifications and sample selections, as outlined in the robustness section. Moreover, this age pattern is consistent with [Petitpas et al. \(2021\)](#) who using individual-level data find that the effects of i-voting on turnout are the highest among older voters and that the availability of i-voting increases the age gap in turnout.

We can also estimate the effects of i-voting on turnout and vote share across gender and age. [Figs. 4\(a\) and 4\(b\)](#) show that the age patterns in the effects of the introduction of i-voting on turnout appear fairly similar across gender with only slightly higher effects for males but no significant effects on turnout except for the oldest group.<sup>16</sup> The effect on 80+ turnout is slightly higher for men and is significant only for men ( $p$ -values = 0.063).

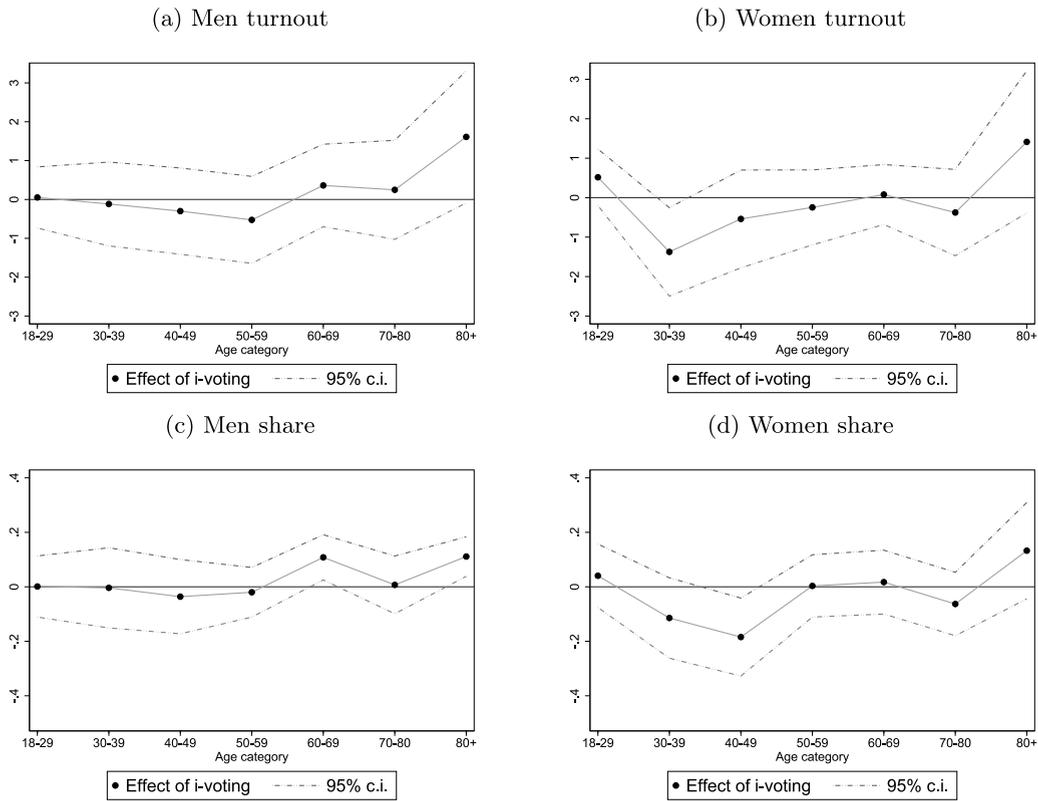
[Figs. 4\(c\) and 4\(d\)](#) present corresponding results on vote shares. In this model, the denominator of the dependent variables is the total number of votes. The 14 marginal effects estimated (one for each age group  $\times$  gender) on vote shares therefore sum up to zero. Overall the pattern in vote share changes by age group across gender appears similar to the pattern when men and women votes were combined ([Plot 3\(b\)](#)).

We also investigate the substitution effects that take place between other voting means and internet voting and whether these effects are heterogeneous across gender and age categories. In this analysis, we explore the heterogeneous effects (by gender and age category) of the introduction of i-voting on turnout for those who cast their vote either by mailing their ballot or by going to the polling station on voting dates. Plots in [Fig. 5](#) show that the introduction of i-voting reduced voting either by mailing or by going to the polling station by approximately 7 and 5% points for males and females aged 18–29, respectively. Across the different age categories, the decrease in voting by other means displays a U-shape pattern, with inflection points between 40–49 years old for males and 30–39 for females. The fact that i-voting has had larger substitution effects on males relative to females is consistent with the digital divide that exists across gender and the patterns displayed in [Fig. 1](#). It is interesting to note, however, that the effects appear to be zero for both males and females of age 80+. Although not verifiable with the data at hand, this suggests that the introduction of i-voting did not change the voting behavior of voters who are 80+. But given the positive impact of the introduction of i-voting on turnout for this age category, our results suggest that i-voting has attracted new voters that were unable to vote before the availability of this new voting means, due for instance to physical limitations. On the other hand, the fact that we do not observe any increase on overall turnout for younger age categories suggests that the introduction of i-voting simply offered individuals below 80 a new means to vote without attracting new voters (substitution effect).

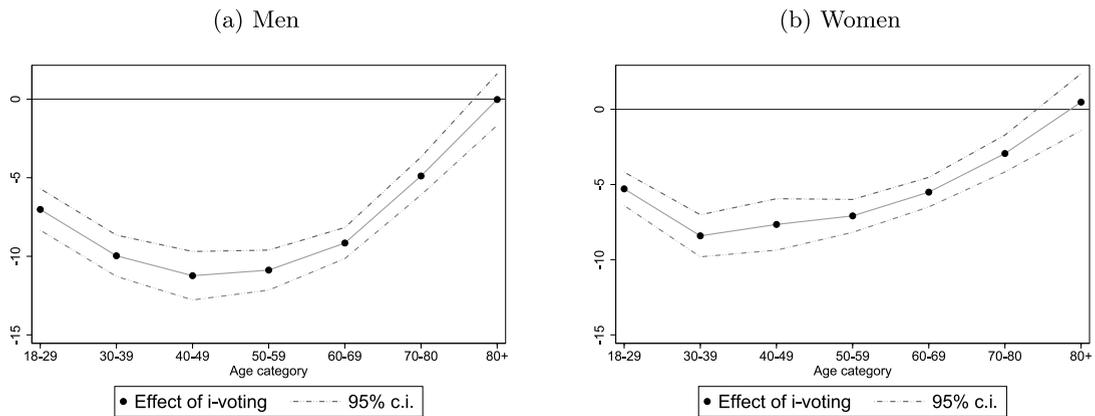
<sup>14</sup> The average share over the period under consideration for individuals aged 18–29 and 80+ is equal to 11.9 and 18.7, respectively.

<sup>15</sup> The sum of the marginal effects reported in [Plot 3\(b\)](#) is equal to 0. The fractional multinomial logit model restricts its marginal effects to cancel each other out. A marginal effect of 0.31% points for the age category 80+ means that that on average the availability of i-voting has increased the vote share of those who are 80+ by 0.31% points relative to municipalities in which i-voting was not available. The political weights of those who are 80+ has thus increased in municipalities that allowed i-voting: their votes constituted a larger share of the overall turnout in these municipalities.

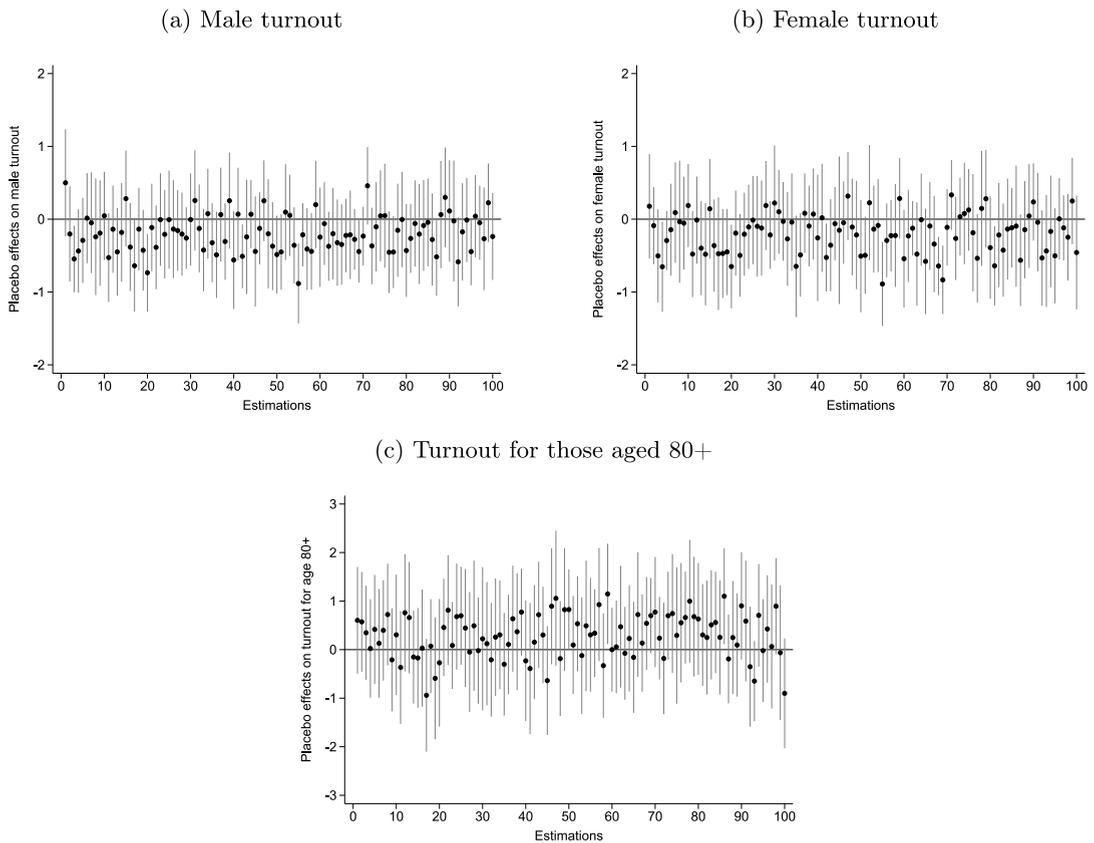
<sup>16</sup> Surprisingly, we find a negative effect for women aged between 30 and 39 which is hard to explain. However, this result is not robust to other specifications – as detailed below – and disappears for instance in the case where the econometric specification is unweighted.



**Fig. 4.** Effects of the introduction of i-voting on turnout (Plots a and b) and vote share (Plots c and d) by gender and age category.  
*Note:* The dashed lines represent the 95% confidence intervals (cluster robust standard errors at the municipality level). Effects of i-voting on turnout (plots a and b) and vote share (plots c and d) by gender and age category. All specifications include referendum dates and municipality fixed-effects, population level (in log), share of foreign resident, share of individuals below 35, share of individuals above 65, unemployment rate, the share of the population who voted for SP and GPS in the last national election, the socialist and green party, respectively as well as the average individual income tax received by municipalities each year. We also include the share of registered voters (gender-specific) for the different age categories in (c) and (d). When computing gender and age-specific vote shares, we use total number of votes as denominator, irrespective of gender, so that the marginal effects on vote shares for males and females sum up to zero. We weight our regressions using the number of registered voters (overall in plots (c) and (d), and gender and age category-specific in plots (a) and (b)) in each municipality at date = 1.



**Fig. 5.** Effects of the introduction of i-voting on turnout using other voting means, by gender and age.  
*Note:* The dashed lines represent the 95% confidence intervals (cluster robust standard errors at the municipality level). Effects of i-voting on turnout using other voting means (mail-in ballots and polling booths) by gender and age category. All specifications include referendum dates and municipality fixed-effects, population level (in log), share of foreign resident, share of individuals below 35, share of individuals above 65, unemployment rate, the share of the population who voted for SP and GPS in the last national election, the socialist and green party, respectively as well as the average individual income tax received by municipalities each year. We weight our regressions using the number of registered voters (gender and age category-specific) in each municipality at date = 1.



**Fig. 6.** Effects of placebo treatments on male turnout (a), female turnout (b), and turnout for those aged 80+ (c).

*Note:* Dots represent the effects of 100 placebo treatments on male turnout (a), female turnout (b), and the turnout for those aged 80+ (c). Gray vertical bars represent 95% confidence intervals derived using cluster robust standard errors at the municipality level. All specifications include referendum dates and municipality fixed-effects, population level (in log), share of foreign resident, share of individuals below 35, share of individuals above 65, unemployment rate, the share of the population who voted for SP and GPS in the last national election, the socialist and green party, respectively as well as the average individual income tax received by municipalities each year. We weight our regressions using the number of registered voters (gender-specific in (a) and (b), and age category-specific in (c)) in each municipality at date = 1. 6 out of 100 placebo effects are statistically significant when considering male turnout as outcome variable. Corresponding number for female turnout and for turnout of those 80+ are 7 and 2.

### 5.1. Parallel trends and placebo tests

The critical assumption underlying our identification strategy is the one of parallel trends, that is, the differences in our outcome variables between the treated and untreated municipalities would have been constant over time if the treatment would not have occurred. While [Germann and Serdült \(2017\)](#) already provided strong evidence that this assumption holds using similar data to ours, we explored the assumption of parallel trends on key outcome variables we used in our study. Figs. B.1a and B.1b of the Online Appendix reveal very similar and parallel trends in male and female turnouts between municipalities in the control group (municipalities where i-voting was not possible) and those in the treatment group, i.e., municipalities in which i-voting was available at any point after date 7. The same holds when assessing the presence of parallel trends on the turnout of voters aged 80+ in Fig. B.1c.

Additionally, following [Germann and Serdült \(2017\)](#), we run placebo tests to provide empirical evidence in support of the parallel trends assumption. In particular, we randomly shift the introduction of i-voting ahead of its actual introduction and estimate the effects of these placebo treatments on our key outcome variables of interest, restricting the analysis to time periods before i-voting was officially introduced in the Canton (date 8).<sup>17</sup> We repeat this exercise one hundred times.

Figs. 6(a) and 6(b) report the coefficients of the treatment effect of these 100 placebo tests, along with their 95% confidence intervals. Our results indicate that 6 out of 100 and 7 out of 100 of these estimates are statistically significant at 95% confidence level when considering male (Panel a) and female (Panel b) turnouts as outcome variable, respectively. Fig. 6(c) shows corresponding

<sup>17</sup> Again, municipalities in the treatment group are all municipalities that have had access to i-voting after date 7. Municipalities in the control group are all those where i-voting was not possible. We created placebo treatments only for municipalities in the treatment group.

estimates but looking at turnout for those aged 80+ instead (Panel c). 2 out of 100 of these estimates are statistically significant at 95% confidence level, respectively. One would expect on average 5 out of 100 of these placebo effects to be statistically significant at 5% if the null hypothesis of parallel trends in these four outcome variables were to hold. Our results are in line with that expectation.

Moreover, we present in Fig. C.1 of the Online Appendix an extension of this analysis in which the sample is not restricted to time periods prior to date 8. Instead, we randomly shift the introduction of i-voting ahead of its actual implementation anytime before the first time it was introduced in a specific treated municipality. Results using this unbalanced panel again suggest that trends are parallel prior to the implementation of i-voting. More specifically, Fig. C.1 shows that 5, 8 and 0 out of 100 placebo effects are significant at 5% when we consider the turnout of males, females, individuals aged 80+, respectively.

Finally, Fig. C.2 shows coefficients from an event study where we again define a municipality as treated if i-voting was ever available during the study period.<sup>18</sup> As expected, none of the coefficients for periods prior to the introduction of i-voting (date 8) are statistically different from zero.

Overall, in conjunction with results from [Germann and Serdült \(2017\)](#), our analysis shows that the parallel trend assumption holds in our setting.

## 5.2. Robustness checks

We present in the Online Appendix results when registered voters weights are not applied and when we restrict our analysis to municipalities with more than one thousand registered voters (measured at date 1) to account for the heterogeneity in the size of registered voters across municipalities. Unweighted regression results are very similar to the weighted ones, with somewhat lower precision in the results corresponding to male vote share and turnout for the oldest age category (see Online Appendix Table D.1 and Figs. D.1 and D.2). Results derived using municipalities with more than one thousand registered voters present an alternative to the use of weights to deal with the small denominator issue that arises when computing turnouts by subgroup. This comes at the cost of losing statistical power due to smaller sample size ( $N = 696$ ). But results using this restricted sample are overall in line with our benchmark results, albeit somewhat less precise (see Online Appendix Table E.1 and Figs. E.1 and E.2).

## 6. Discussion and conclusions

Internet voting has the potential to increase voter turnout by reducing the cost of voting, particularly for digitally skilled young voters and those with physical mobility limitations. However, barriers to digital inclusion and security concerns over the manipulability of online systems may undermine these benefits. In this paper, we estimated the effects of the introduction of internet voting in the Swiss Canton of Geneva on turnout and vote share by demographic groups. We found that the introduction of i-voting increased turnout of individuals aged 80 and above, particularly of male voters, but did not have any corresponding effects on younger individuals. Our analysis therefore suggests that the introduction of i-voting has reduced the costs of voting for some individuals who are 80+ as it seems to have attracted new voters. Our results however show that the reduction in voting costs thanks to online voting did not decrease as much as to convince *abstainers* aged below 80 to vote, although it did reduce the voting costs of some young voters, as illustrated by the large substitution effects we report. This is in line with [Petitpas et al. \(2021\)](#) who show that i-voting did not have any effects on turnout among frequent voters but merely offered them an additional channel to vote.

Interestingly, the effect on turnout for those 80+ appears to materialize only after some time (see Figs. B.1c and C.2c).<sup>19</sup> We cannot directly investigate why such effects are taking place only gradually. It is possible that the composition of the 80+ cohort has changed over time and that recent 80+ cohorts are more digitally included and more experienced internet users than previous 80+ cohorts. It is also possible that trust in internet voting might take time to build, especially for individuals who are skeptical about the internet and less likely to use it in general, as it is the case for older cohorts ([Kämpfen and Maurer, 2018](#); [Smith, 2014](#)). Differences by gender are less clear: there is a small positive effect on male vote share but the effect is not statistically significant at the conventional levels (95%).

Overall, our results are consistent with and support prior evidence on the heterogeneous effects of i-voting on turnout ([Petitpas et al., 2021](#)). In terms of magnitude, the effects we find on vote shares by age category are rather large and could have potentially changed the results of referendums, especially for referendums that were barely accepted or refused by the population. For instance,

<sup>18</sup> The empirical specification is

$$Y_{it} = \alpha + \sum_{\tau=T-7}^{T+7} \beta_{\tau} E_{i\tau} + X'_{it} \gamma + \lambda_t + \mu_i + \epsilon_{it}$$

where  $T$  is the first date when i-voting was introduced (date 8) and  $E$  is a dichotomous variable for being in the treatment group. The sample is restricted symmetrically to 7 periods before and after  $T$ . We remove the coefficient corresponding to the period just before  $T$  to avoid multicollinearity (i.e. coefficient is normalized to zero). These types of event studies are the usual way to test for the presence of differences in trends prior to treatment. However, in our case, treatment is not permanent after the initial introduction of i-voting, which renders the standard event study-type specification less interpretable. For this reason, we use the placebo exercise above as our main way to test the parallel trends assumption.

<sup>19</sup> We thank one of the reviewers for pointing this out.

in March 2015 (i-voting was available on that referendum date), voters in Geneva were asked to decide whether they wanted to have a new law that changed the structure of various law enforcement entities, including the creation of a community/neighborhood police service which was meant to increase the local police presence. This topic is presumably a topic with important difference in opinion by age, with possibly older age categories being more in favor of it. In Geneva, the population decided to approve that law, with 50.02% of the voters accepting it, and 49.98% refusing it. According to our estimates, the availability of i-voting led to a decrease (increase) of about 0.32% in the vote shares of individuals aged 18–59 (aged 60+). To the extent that large differences in the preferences over police-related issues and security concerns exist across these two age groups, it is possible that that law would have been rejected by the population if i-voting would have not been available in Geneva for that specific referendum date.

Given that the introduction of new technologies is not neutral and that its costs and benefits vary across subpopulations, our results stress the importance of looking at *heterogeneous* effects when analyzing the introduction of new voting technologies on turnout. Differences in the familiarity with new technologies and also their potential benefits and costs are likely to be key elements to consider when predicting which group will gain a political advantage following the introduction of new voting tools.

We believe the age-specific patterns we find in our results underline the importance of physical mobility limitations and the security concerns that arose following the introduction of i-voting in Geneva. We investigate in Online Appendix F whether the introduction of internet voting has had different effects on turnout across municipalities depending on (a) the quality of the internet connection that is available, (b) the surface area within a municipality that is dedicated to transport, (c) population density, (d) area size of municipality, and (e) wealth levels. The estimated effects do not appear to be heterogeneous across these dimensions. An important limitation of this heterogeneous analysis is that it is based on municipality-level data and future research using individual-level data should investigate the mechanisms that take place to better understand why we do not observe an increase in turnout for the overall population except for those aged 80 and above.

Finally, the canton of Geneva in Switzerland presents a compelling case study due to its extensive and noteworthy use of i-voting, making it one of the most notable examples worldwide. At the same time, the external validity of our findings to other contexts can be challenging for several reasons. First, the availability of a very reliable and effective postal system in Switzerland makes postal voting very convenient and is thus likely to lower the attractiveness of i-voting. While our study shows that the introduction of i-voting did not have any effect on overall turnout, one should expect a positive and much larger effect of the introduction of i-voting on turnout in countries where the only option to vote is to go to the polling stations or in contexts where postal system is not as efficient and trustworthy as the one in Switzerland. In fact, our results combined with existing evidence suggest that, in countries where polling station voting is the sole option, the implementation of a robust and reliable postal voting system should take precedence over internet voting to increase turnout. Second, turnout in Switzerland is generally very low relative to other countries with established democracies (Blais, 2014). Mechanically, one should expect the introduction of i-voting to have larger effects in settings where turnout is low, other things being equal. Given that we do not find any effect on overall turnout in our data, this could imply that the introduction of i-voting in countries with higher turnout might not have any effect on voting participation either. Third, internet access and use among older individuals in Switzerland is among the highest in the world (König et al., 2018; OECD, 2023). It is possible that the positive effect on turnout for those 80+ we estimate in our study might not extrapolate to other older populations characterized by lower online connectivity and internet utilization. Therefore, the generalizability of our findings should be tested to other contexts, not only in Switzerland, where other cantons also made internet voting available to its citizens, but especially in other countries where postal voting is not an option or is less effective, or in contexts where turnout is higher than in Switzerland.

Security concerns however are likely to be the same regardless of the contexts, as they are a key issue for any country that is considering implementing internet voting as a way to get more of their citizens to vote.

### Declaration of competing interest

The authors hereby declare that they have no conflict of interests.

### Data availability

Data will be made available on request.

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### Appendix A. Supplementary data

Supplementary material related to this article can be found online at <https://doi.org/10.1016/j.ejpoleco.2023.102444>.

## References

- Agarwal, R., Animesh, A., Prasad, K., 2005. Social interactions and the digital divide: Explaining regional variations in internet use. In: Robert H. Smith School Research Paper No. RHS. pp. 06–024.
- Aldrich, J.H., 1993. Rational choice and turnout. *Am. J. Political Sci.* 246–278.
- Aschwanden, E., 2018. Gegner wollen E-Voting mit einer Volksinitiative verbieten. NZZ, <https://www.nzz.ch/schweiz/gegner-wollen-e-voting-mit-einer-volksinitiative-verbieten-ld.1360619>. (Accessed 7 November 2019).
- Baek, M., 2009. A comparative analysis of political communication systems and voter turnout. *Am. J. Political Sci.* 53 (2), 376–393.
- Birch, S., 2008. Electoral institutions and popular confidence in electoral processes: A cross-national analysis. *Elect. Stud.* 27 (2), 305–320.
- Birch, S., 2010. Perceptions of electoral fairness and voter turnout. *Comp. Political Stud.* 43 (12), 1601–1622.
- Blais, A., 2014. Why is turnout so low in Switzerland? Comparing the attitudes of Swiss and German citizens towards electoral democracy. *Swiss Political Sci. Rev.* 20 (4), 520–528.
- Blais, A., Gidengil, E., Nevitte, N., 2004. Where does turnout decline come from? *Eur. J. Political Res.* 43 (2), 221–236.
- Blais, A., Rubenson, D., 2013. The source of turnout decline: New values or new contexts? *Comp. Political Stud.* 46 (1), 95–117.
- Bucy, E.P., 2000. Social access to the internet. *Harv. Int. J. Press/Politics* 5 (1), 50–61.
- Cancela, J., Geys, B., 2016. Explaining voter turnout: A meta-analysis of national and subnational elections. *Elect. Stud.* 42, 264–275.
- CEPP, 2013. Voter par internet: évaluation des effets du vote électronique à Genève. mandat du Conseil d'Etat, Sur.
- Chong, A., Olivera, M., 2008. Does compulsory voting help equalize incomes? *Econ. Politics* 20 (3), 391–415.
- Conseil d'Etat Genevois, 2018. Genève met un terme au développement de sa plateforme de vote électronique CHVote. Point presse du Conseil d'Etat - République et canton de Genève, <https://www.ge.ch/document/point-presse-du-conseil-etat-du-28-novembre-2018#extrait-12897>. (Accessed 7 November 2019).
- Cooper, J., 2006. The digital divide: The special case of gender. *J. Comput. Assist. Learn.* 22 (5), 320–334.
- Daley, M.J., Spinks, W.L., 2000. Exercise, mobility and aging. *Sports Med.* 29 (1), 1–12.
- Dawson, G., 2015. Would online voting help engage more young people in politics? BBC Newsbeat, <http://www.bbc.co.uk/newsbeat/article/30882818/would-online-voting-help-engage-more-young-people-in-politics>. (Accessed 6 November 2019).
- De Leon, F.L.L., Rizzi, R., 2016. Does forced voting result in political polarization? *Public Choice* 166 (1–2), 143–160.
- Delley, J.-D., 2009a. Cyberdémocratie: Le clic ne remplacera pas le vote par correspondance. *Domaine Public* <https://www.domainepublic.ch/articles/2484>. (Accessed 7 November 2019).
- Delley, J.-D., 2009b. Vote électronique: un usage risqué pour un avantage démocratique restreint. *Domaine Public* <https://www.domainepublic.ch/articles/10033>. (Accessed 7 November 2019).
- Dunning, T., Grossman, G., Humphreys, M., Hyde, S.D., McIntosh, C., Nellis, G., Adida, C.L., Arias, E., Bicalho, C., Boas, T.C., et al., 2019. Voter information campaigns and political accountability: Cumulative findings from a preregistered meta-analysis of coordinated trials. *Sci. Adv.* 5 (7), eaaw2612.
- Enguehard, C., 2009. Vote par internet: faillies techniques et recul démocratique. *Jus Politicum* 2.
- Epstein, R.J., Ember, S.E., Gabriel, T., Baker, B., 2020. How the iowa caucuses became an epic fiasco for democrats. *N.Y. Times* <https://www.nytimes.com/2020/02/09/us/politics/iowa-democratic-caucuses.html>. (Accessed 03 March 2020).
- Federal Council, 2006. Rapport sur les projets pilotes en matière de vote électronique. *Swiss Fed. Chancell.* 06.056.
- Fenazzi, S., 2017. Le canton de Genève renonce à sa plate-forme de vote électronique. *SwissInfo.ch*, [https://www.swissinfo.ch/fre/democratiedirecte/e-voting\\_les-jeunes-politiciens-mettent-des-b^atons-dans-les-roues/43749172](https://www.swissinfo.ch/fre/democratiedirecte/e-voting_les-jeunes-politiciens-mettent-des-b^atons-dans-les-roues/43749172). (Accessed 6 November 2019).
- Ferrucci, L., Cooper, R., Shardell, M., Simonsick, E.M., Schrack, J.A., Kuh, D., 2016. Age-related change in mobility: perspectives from life course epidemiology and geroscience. *J. Gerontol. Ser. Biomed. Sci. Med. Sci.* 71 (9), 1184–1194.
- Fieldhouse, E., Cutts, D., 2018. Shared partisanship, household norms and turnout: Testing a relational theory of electoral participation. *Br. J. Political Sci.* 48 (3), 807–823.
- Fielding, R.A., Vellas, B., Evans, W.J., Bhasin, S., Morley, J.E., Newman, A.B., van Kan, G.A., Andrieu, S., Bauer, J., Breuille, D., et al., 2011. Sarcopenia: an undiagnosed condition in older adults. Current consensus definition: prevalence, etiology, and consequences. *International working group on sarcopenia. J. Am. Med. Dir. Assoc.* 12 (4), 249–256.
- Frank, B., Pitlik, H., Wirth, S., 2004. Expert opinion leaders' impact on voter turnout: the case of the Internet Chess Match Kasparov vs. World. *Eur. J. Political Econ.* 20 (3), 619–635.
- Friemel, T.N., 2016. The digital divide has grown old: Determinants of a digital divide among seniors. *New Media Soc.* 18 (2), 313–331.
- Fujiwara, T., 2015. Voting technology, political responsiveness, and infant health: Evidence from Brazil. *Econometrica* 83 (2), 423–464.
- Gant, M.M., 1983. Citizen uncertainty and turnout in the 1980 presidential campaign. *Political Behav.* 5 (3), 257–275.
- Gerlach, J., Gasser, U., 2009. Three case studies from Switzerland: E-voting. *Berkman Cent. Res. Publ.* No 3, 2009.
- Germann, M., 2020. Making votes count with internet voting. *Political Behav.* 1–23.
- Germann, M., Serdült, U., 2017. Internet voting and turnout: Evidence from Switzerland. *Elect. Stud.* 47, 1–12.
- Geys, B., 2006. 'Rational' theories of voter turnout: a review. *Political Stud. Rev.* 4 (1), 16–35.
- Ghiselli, L., 2019. St.Galler Jungparteien von links bis rechts wollen E-Voting auf Eis legen. *Tagblatt*, <https://www.tagblatt.ch/ostschweiz/stgallen/stgaller-jungparteien-von-links-bis-rechts-wollen-e-voting-auf-eis-legen-ld.1092890>. (Accessed 7 November 2019).
- Godefroy, R., Henry, E., 2016. Voter turnout and fiscal policy. *Eur. Econ. Rev.* 89, 389–406.
- Gomez, B.T., Hansford, T.G., Krause, G.A., 2007. The Republicans should pray for rain: Weather, turnout, and voting in US presidential elections. *J. Politics* 69 (3), 649–663.
- Goodman, N., Stokes, L.C., 2020. Reducing the cost of voting: an evaluation of internet voting's effect on turnout. *Br. J. Political Sci.* 50 (3), 1155–1167.
- Gray, M., Caul, M., 2000. Declining voter turnout in advanced industrial democracies, 1950 to 1997: The effects of declining group mobilization. *Comp. Political Stud.* 33 (9), 1091–1122.
- GULL, 2015. Vote électronique. GULL, <https://www.linux-gull.ch/DossierEVoting.html>. (Accessed 7 November 2019).
- Harder, J., Krosnick, J.A., 2008. Why do people vote? A psychological analysis of the causes of voter turnout. *J. Soc. Issues* 64 (3), 525–549.
- Hargittai, E., 2010. Digital na (t) ives? Variation in internet skills and uses among members of the "net generation". *Sociol. Inq.* 80 (1), 92–113.
- Hargittai, E., Marwick, A., 2016. "What can I really do?" explaining the privacy paradox with online apathy. *Int. J. Commun.* 10, 21.
- Hessami, Z., 2016. How do voters react to complex choices in a direct democracy? Evidence from Switzerland. *Kyklos* 69 (2), 263–293.
- Hessami, Z., Resnjanskij, S., 2019. Complex ballot propositions, individual voting behavior, and status quo bias. *Eur. J. Political Econ.* 58, 82–101.
- Hodler, R., Luechinger, S., Stutzer, A., 2015. The effects of voting costs on the democratic process and public finances. *Am. Econ. J. Econ. Policy* 7 (1), 141–171.
- Hoffman, M., León, G., Lombardi, M., 2017. Compulsory voting, turnout, and government spending: Evidence from Austria. *J. Public Econ.* 145, 103–115.
- Hooghe, M., Kern, A., 2017. The tipping point between stability and decline: Trends in voter turnout, 1950–1980–2012. *Eur. Political Sci.* 16, 535–552.
- Jaitman, L., 2013. The causal effect of compulsory voting laws on turnout: Does skill matter? *J. Econ. Behav. Organ.* 92, 79–93.
- Kämpfen, F., Maurer, J., 2018. Does education help "old dogs" learn "new tricks"? The lasting impact of early-life education on technology use among older adults. *Res. Policy* 47 (6), 1125–1132.
- König, R., Seifert, A., Doh, M., 2018. Internet use among older Europeans: an analysis based on SHARE data. *Univers. Access Inf. Soc.* 17 (3), 621–633.
- Lassen, D.D., 2005. The effect of information on voter turnout: Evidence from a natural experiment. *Am. J. Political Sci.* 49 (1), 103–118.

- León, G., 2017. Turnout, political preferences and information: Experimental evidence from peru. *J. Dev. Econ.* 127, 56–71.
- Loges, W.E., Jung, J.-Y., 2001. Exploring the digital divide: Internet connectedness and age. *Commun. Res.* 28 (4), 536–562.
- Luechinger, S., Rosinger, M., Stutzer, A., 2007. The impact of postal voting on participation: Evidence for Switzerland. *Swiss Political Sci. Rev.* 13 (2), 167–202.
- Meier, A.N., Schmid, L., Stutzer, A., 2019. Rain, emotions and voting for the status quo. *Eur. Econ. Rev.*
- Mendez, F., Serdült, U., 2014. From initial idea to piecemeal implementation: Switzerland's first decade of Internet voting reviewed. In: *Design, Development, and Use of Secure Electronic Voting Systems*. IGI Global, pp. 115–127.
- Miguet, F., 2008. Voting about immigration policy: What does the Swiss experience tell us? *Eur. J. Political Econ.* 24 (3), 628–641.
- NetMetrix, 2019. Net Metrix Base - Publication. <https://www.net-metrix.ch/produkte/net-metrix-base/publikation>. (Accessed 06 November 2019).
- Niehaves, B., Plattfaut, R., 2014. Internet adoption by the elderly: employing IS technology acceptance theories for understanding the age-related digital divide. *Eur. J. Inf. Syst.* 23 (6), 708–726.
- OECD, 2023. ICT access and usage by households and individuals: Individuals aged 55-74. [https://stats.oecd.org/Index.aspx?DataSetCode=ICT\\_HH2](https://stats.oecd.org/Index.aspx?DataSetCode=ICT_HH2). (Online accessed 17 July 2023).
- OSCE, 2011. Swiss confederation federal assembly elections - 23 October 2011. In: *OSCE/ODIHR Election Assessment Mission Report*. Organization for Security and Co-operation in Europe, pp. 1–25.
- Petitpas, A., Jaquet, J.M., Sciarini, P., 2021. Does E-voting matter for turnout, and to whom? *Elect. Stud.* 71, 102245.
- Rainie, L., 2016. The state of privacy in post-Snowden America. *Pew Res. Cent.* 21.
- Rebetez, J., Heuberger, J.-M., 2018. Le scepticisme s'amplifie autour du vote électronique en Suisse. RTS, <https://www.rts.ch/info/suisse/9380495-le-scepticisme-s-amplifie-autour-du-vote-electronique-en-suisse.html>. (Accessed 7 November 2019).
- Richard, A., 2018. Le canton de Genève renonce à sa plate-forme de vote électronique. RTS, <https://www.rts.ch/info/regions/geneve/10028542-le-canton-de-geneve-renonce-a-sa-plate-forme-de-vote-electronique.html>. (Accessed 6 November 2019).
- Riker, W.H., Ordeshook, P.C., 1968. A theory of the calculus of voting. *Am. Political Sci. Rev.* 62 (1), 25–42.
- Schelker, M., Schneider, M., 2017. The elasticity of voter turnout: Investing 85 cents per voter to increase voter turnout by 4 percent. *Elect. Stud.* 49, 65–74.
- Sciarini, P., Cappelletti, F., Goldberg, A., Nai, A., Tawfik, A., 2013. Etude du vote par Internet dans le canton de Genève. In: *Rapport final à l'intention de la Commission externe d'évaluation des politiques publiques*. [http://ge.ch/vote-electronique/media/site\\_vote-electronique/files/imce/doc\\_rapports/rapport-final-sciarini-vote-par-internet.pdf](http://ge.ch/vote-electronique/media/site_vote-electronique/files/imce/doc_rapports/rapport-final-sciarini-vote-par-internet.pdf).
- Serdült, U., Germann, M., Harris, M., Mendez, F., Portenier, A., 2015. Who are the internet voters? *Innov. Public Sect.* 27, 27–41.
- Serdült, U., Germann, M., Mendez, F., Portenier, A., Wellig, C., 2015. Fifteen years of internet voting in Switzerland [history, governance and use]. In: *2015 Second International Conference on EDemocracy & EGovernment*. ICEDEG, IEEE, pp. 126–132.
- Simons, B., Jones, D.W., 2012. Internet voting in the US. *Commun. ACM* 55 (10), 68–77.
- Smith, A., 2014. Older adults and technology use. Data retrieved from OCSTAT, Table "T 02.02.1.03" <https://www.pewresearch.org/internet/2014/04/03/older-adults-and-technology-use/>,
- Solon, G., Haider, S.J., Wooldridge, J.M., 2015. What are we weighting for? *J. Hum. Resour.* 50 (2), 301–316.
- Springall, D., Finkenauer, T., Durumeric, Z., Kitcat, J., Hursti, H., MacAlpine, M., Halderman, J.A., 2014. Security analysis of the estonian internet voting system. In: *Proceedings of the 2014 ACM SIGSAC Conference on Computer and Communications Security*. ACM, pp. 703–715.
- Stutzer, A., Baltensperger, M., Meier, A.N., 2019. Overstrained citizens? The number of ballot propositions and the quality of the decision process in direct democracy. *Eur. J. Political Econ.* 59, 483–500.
- Toby, J., 2017. Scotland eyes a youthquake with online voting: here are some tips from past pilots. *The Conversation*, <https://theconversation.com/scotland-eyes-a-youthquake-with-online-voting-here-are-some-tips-from-past-pilots-89468>. (Accessed 6 November 2019).
- Vasilogambros, M., 2018. How voters with disabilities are blocked from the ballot box. PEW, <https://www.pewtrusts.org/en/research-and-analysis/blogs/stateline/2018/02/01/how-voters-with-disabilities-are-blocked-from-the-ballot-box>. (Accessed 6 November 2019).
- VerifiedVoting, 2019. Internet voting outside the United States. <https://www.verifiedvoting.org/resources/internet-voting/internet-voting-outside-the-united-states/>. (Accessed 06 November 2019).
- Zetter, K., 2018. The crisis of election security. *New York Times Mag.* <https://www.nytimes.com/2018/09/26/magazine/election-security-crisis-midterms.html>. (Accessed 6 November 2019).