Public Choice (2023) 194:369–393
https://doi.org/10.1007/s11127-023-01045-0

The impact of voter turnout on referendum outcomes: evidence from Ireland

Vincent Munley[1] · **Abian Garcia-Rodriguez**[2] · **Paul Redmond**[2]

Received: 10 December 2021 / Accepted: 23 January 2023 / Published online: 15 February 2023

Abstract
We estimate the causal effect of voter turnout on referendum outcomes in Ireland using a newly created dataset that links 25 years of constituency-level referendum results to a variety of demographic and economic characteristics, as well as daily rainfall amounts. Our instrumental variables methodology uses rainfall as an instrument for voter turnout to overcome issues of endogeneity. By exploiting Ireland's extensive experience with referendums, we are the first to explore the heterogeneous effects of turnout by referendum type (social issues versus regime-related issues). We find that a one-percentage-point increase in turnout is associated with a 1.6-percentage-point increase in support for progressively liberal social policies, which include issues such as same-sex marriage and abortion. For regime-related issues, such as EU economic treaties, we find no statistically significant effect of voter turnout on referendum outcomes. Our finding that turnout benefits socially progressive policies is consistent with a related strand of literature for general elections that indicates higher turnout benefits left-wing political parties.

Keywords Voter turnout · Referendums · Rainfall · Instrumental variables

JEL Classification D72 · D02 · K16

1 Introduction

Voter turnout varies substantially across and within countries. This has important implications, as voter turnout may affect electoral outcomes. The mechanism is illustrated in Fowler (2013), who studies the introduction of compulsory voting in Australia. Before compulsory voting, wealthy citizens were more likely to vote than working-class citizens. Following compulsory voting, turnout increased, as did the electoral success of the Labor Party, who benefitted from greater support among the new working-class voters. Similarly, for the United States, there is evidence that higher voter turnout is beneficial to the Democratic Party (Gomez et al., 2007). Voter turnout has also been shown to impact economic

✉ Paul Redmond
paul.redmond@esri.ie

[1] College of Business, Lehigh University, Bethlehem, USA

[2] Economic and Social Research Institute, Dublin, Ireland

outcomes including income inequality (Mueller & Stratmann, 2003), as individuals who vote regularly are more likely to favour right of centre policies. Therefore, the existing literature indicates that individuals who vote infrequently are systematically different to those who vote regularly, and as a result, greater voter participation can influence electoral outcomes.

In this paper, we focus on a related research question that has received less attention in the literature, namely the causal impact of voter turnout on referendum outcomes. Similar to general elections, individuals that vote in referendums may have different policy preferences compared to non-voters (Matsusaka, 2005).[1] Therefore, much like general elections, variation in voter turnout could also influence referendum outcomes.

The focus of our study is Ireland, which is well suited for this type of analysis due to its extensive experience of the referendum as a decision-making tool (Barrett, 2017). In addition to having a greater number of referendums than most western democracies, there is significant variation in the types of issues covered in referendums in Ireland. Recent referendums have covered social issues such as abortion, divorce and marriage equality, the results of which have been described as representing a major shift in previously held conservative attitudes (Elkink et al., 2020). Other recent referendums also include administrative issues (e.g., the eligibility age for the office of president) and economic issues (European Union [EU] treaties). While referendums have often been used in other European countries for EU treaties, their use is even more extensive in Ireland, which is the only country whose constitution requires a referendum to ratify every EU treaty.[2] As ratification is required by all member states, the success of previous EU treaties has hinged on the outcomes of referendums in Ireland.

As with general elections, uncovering the causal impact of voter turnout on referendum outcomes is challenging due to endogeneity concerns. The research on general elections highlights the potential for reverse causality. As the perceived probability of a close result increases, the voter's value of voting, and hence turnout, will also increase (Artés, 2014; Hansford & Gomez, 2010; Søberg & Tangerås, 2007).[3] Furthermore, an expected close outcome incentivizes parties, candidates, interest groups and party elites to mobilize voters (Cox, 1988; Cox & Munger, 1989; Matsusaka, 1993; Arnold & Freier, 2016).[4] With reverse causality, a standard ordinary least squares (OLS) regression of referendum outcomes on voter turnout could lead to biased estimates. As noted by Hansford and Gomez (2010), "this could cause high turnout to appear to cause close elections when the reverse relationship is more likely".[5]

[1] One criticism of referendums is that powerful interest groups may use their resources to generate outcomes that do not represent the majority. However, Matsusaka (2005) notes that the evidence typically shows that "direct democracy serves the many and not the few".

[2] Treaties are typically ratified by national parliaments in other EU countries.

[3] In the "calculus of voting", the decision to vote is based on the cost versus the benefit of voting (see, e.g., Riker & Ordeshook, 1968; Downs, 1957). The "value" of one's vote, and hence turnout, increases in a close election.

[4] Matsusaka (1993) finds no relationship between turnout and closeness in California ballot propositions, but suggests that the findings in other studies may be due to an increased mobilization of party elites in close races.

[5] Other election parameters that influence outcomes may also impact turnout, leading to previous work treating turnout as a dependent variable (Gong & Rogers, 2014). For example, Cebula (2008) finds that emotionally charged referendums increase turnout.

To overcome endogeneity concerns, we employ an instrumental variables (IV) setup, using rainfall as an instrument for voter participation.[6] Our work, therefore, contributes to filling a gap in the literature on referendums, most of which does not employ causal techniques due to many studies being carried out before the "revolution in causal inference" (Matsusaka, 2018). We find that voter turnout causes an increase in support for referendum outcomes relating to liberal social policies. A one-percentage-point increase in voter turnout leads to a 1.6-percentage-point increase in support for referendum outcomes covering social issues such as same-sex marriage and abortion liberalization. Our results indicate that individuals who are likely to vote less frequently are more likely to be ideologically predisposed to more liberal and progressive policies. However, we detect no effect of voter turnout on the outcomes of regime-related referendums.

To our knowledge, Rudolph (2020) is the only other paper that adopts this type of IV approach to study a referendum. Rainfall on the day of the Brexit referendum is used as an instrument for voter participation.[7] Rudolph (2020) finds that higher voter turnout led to an increase in the "Leave" vote, implying that occasional voters that participated in the referendum were leaning towards "Leave".[8] The main difference between our paper and Rudolph (2020) is that instead of focusing on one specific referendum, we examine 28 referendums over the period 1992–2019. Therefore, our findings may provide evidence on the effect of turnout on referendums more generally. A further contribution of our paper is that we are the first to examine whether the effect of turnout on referendum outcomes varies by referendum type (social versus regime-related issues).

A related strand of literature examines other factors that influence referendum outcomes. Older voters and regular churchgoers are more likely to vote against liberal social policies such as abortion liberalization and same-sex marriage (Elkink et al., 2020; Simon et al., 2018). Simon et al. (2018) also include voter turnout as an explanatory variable in their analysis of referendum outcomes and find that higher turnout is associated with greater support for same-sex marriage. However, due to potential endogeneity, it is difficult to ascertain the extent to which this association represents a causal relationship. Using Canadian election data, Matsusaka and Palda (1999) examine the impact of a wide range of variables on voter turnout.[9] While variables such as age and education are found to be statistically significant, the models have low explanatory power, leading the authors to conclude that turnout may be driven largely by idiosyncratic determinants, such as the weather.

Finally, the use of rainfall as an instrument for voter turnout has support in the literature on general elections. Artés (2014) and Arnold and Freier (2016) find that higher voter turnout has a negative causal effect on the vote share of conservative parties in Spain and Germany, respectively. For the United States, Hansford and Gomez (2010) find that greater voter turnout improves the vote share of Democratic candidates. Lind (2020) addresses a different question by examining the effect of parties on political outcomes, using rainfall as an instrument for the party composition of the municipal councils in Norwegian elections. By harming left-wing parties, rainfall on election day generates an exogenous boost to the

[6] Ireland is a suitable setting for this type of study from a methodological standpoint, as previous work has shown a strong relationship between rainfall and voter turnout in Ireland (Garcia-Rodriguez & Redmond, 2020).

[7] Brexit is another example of a referendum with far-reaching consequences, with early studies indicating adverse economic effects (Bloom et al., 2019).

[8] In related work, Leslie and Ari (2018) find that rain on the day of the Brexit vote was associated with lower turnout, especially among "Leave" voters.

[9] Over three dozen explanatory variables are included in their models.

right-wing vote share, leading to a shift in expenditure towards education but a reduction in total spending. Fujiwara et al. (2016) use rainfall as an instrument for voter turnout to examine habit formation in voting; they find that a one-percentage-point reduction in past turnout reduces current turnout by 0.6 to 1 percentage points.[10]

The rest of the paper is structured as follows. In Sect. 2, we discuss the institutional setting, providing an overview of the referendum process in Ireland. Section 3 describes the various sources we used to construct our dataset and explains each of the variables used in the analysis. We then discuss the empirical strategy in Sect. 4 before presenting the results in Sect. 5. We conclude in Sect. 6 with a brief overview of the main results and how they fit into the existing literature on voter turnout.

2 The referendum process in Ireland

Under procedures defined by the Irish Constitution, proposed amendments must originate with legislation by Dáil Éireann (Ireland's Parliament) and not, for instance, by a public petition originating within the general citizenry. Specific amendments proposed for referendum approval therefore move from informed political debate and discourse at the level of representative democracy to decision at the level of general plebiscite. The key outcome that we analyse in this paper is the percentage of votes that are cast in favour of the proposed constitutional amendment, which we term the "percent approval" or "% Yes" as it will be referred to later in the text. We examine this for all referendums, as well as separately for different "types" of referendums. Therefore, it is important to have a clear understanding of how we categorize referendums by "type", and what "percent approval" represents in the context of Irish referendums.

We categorize referendums into two types—those that deal with social issues and those that deal with administrative and legal issues. We label the latter group "regime-related" referendums, and the former "social" referendums. Our categorizations derive from an earlier taxonomy by Sinnott (1995), who categorizes referendums into two groups: (1) regime-related issues that "have to do with the basic rules and principles of the political system" (p. 220), and (2) religious-moral issues arising over time in response to the "imprint of the conservative Catholic social and political philosophy that was prevalent at the time (the 1937 Constitution) was written" (p. 226).

Table 1 shows the classification of referendums. Our analysis focuses on the 12th through the 38th proposed amendments to the Constitution of Ireland. The *social issues* include referendums relating to, for example, marriage equality, divorce, abortion and blasphemy. The *regime-related* category includes, for example, the salaries of Irish Judges, eligibility age for becoming president, the disclosure of information from confidential cabinet meetings, the ability of a court to refuse bail to a defendant, and EU treaties. There are a total of six referendums relating to EU treaties. In two instances, the 1998 Amsterdam Treaty and the 2012 Treaty on Stability, Coordination and Governance in the Economic and Monetary Union (EMU), the proposed amendment was approved in its initial referendum. In the other two instances, the Nice and Lisbon treaties, the initial proposal failed to receive referendum approval but was approved in a subsequent second referendum. The requirement in Ireland to have a referendum to approve an EU treaty is based on a Supreme

[10] In related work, Kurrild-Klitgaard (2013) shows that weather is an important determinant of participation in collective political action, as rainfall reduces participation in political demonstrations.

Court decision at the time of the 1987 Single European Union Act, one that Barrett (2017) notes "has compelled successive Irish governments to hold referendums which they plainly would not otherwise have held".

As previous work on general elections has shown that greater voter turnout can lead to increased support for left-leaning parties, for social issue referendums we define our outcome variable "% Yes" in a manner that is consistent with a left/right political spectrum to facilitate interpretation of the results. In most referendums on social issues, the "% Yes" vote represents support for progressively liberal social policies such as divorce or abortion liberalization or marriage equality. There are, however, two exceptions. These are the 12th and the 25th proposed amendments that comprised "two successive efforts to strengthen the constitutional prohibition on abortion in 1992 and 2002" (Barrett, 2017). Thus, for these two proposed amendments, the "% Yes" vote represents the degree of socially conservative endorsement. To align these two proposed amendments within the context of the other social referendums for which the '% Yes' vote represents endorsement for progressively liberal social policies, we use the complement of the percent yes vote (1 − % Yes) for the 12th and 25th proposed amendments.

No obvious left/right, or liberal/conservative, interpretation exists for the regime-related grouping. Many of these proposals arguably comprise issues that Barrett (2017) refers to as purely technical amendments to the constitution, with little political salience. Because every proposed amendment originates within Dáil Éireann, before being put out for plebiscite approval, a reasonable interpretation of the "% Yes" vote for proposals in this grouping is that it represents a measure of the public's affirmation, in many instances absent a lack of particular interest in the issue itself, for judgments already made by their elected representatives.

3 Data

We use multiple data sources to create a unique dataset that links referendum-day rainfall to voter turnout and referendum results, all at the constituency level, as well as a wide range of socio-economic control variables. The "Referendum Results 1937–2019, Constitution of Ireland", published by the Department of Housing, Planning and Local Government, is the primary data source for details about referendums in Ireland.[11] It provides the official tallies for the percent of eligible voters participating in the referendum, which is our measure of voter turnout, and the percentage of votes in favour of the proposed amendment, which is our outcome variable. Our analysis begins with the 12th, 13th and 14th referendums held concurrently on 25 November 1992, as these were the first referendums for which it was possible to map the Census of Small Area Population Statistics (SAPS) electoral district demographic data directly to constituency boundaries—a process which is described below.

Constituencies are the subnational political units for which voting results are reported for both general elections to Dáil Éireann and referendums to amend the Constitution. A census of the population is conducted in Ireland every fifth year ending in 1 or 6.[12] To adjust for population changes associated with each census, Dáil Éireann passed an Electoral

[11] See {https://www.gov.ie/en/publication/32ea7-1937-2019-referendum-results/}.

[12] For example, in the 1990s, a census was conducted in 1991 and 1996. An exception to this rule is the 2002 Census of the Population that was delayed 1 year due to an outbreak of foot and mouth disease in the United Kingdom, and so precautions were taken in Ireland to mitigate any spread of the disease.

Table 1 Referendum categories

Regime-related ($n = 17$)	
Ref 16 (1996)—Allow courts to refuse bail in certain circumstances	Yes (74.8%)
Ref 17 (1997)—High court can order the disclosure of information from cabinet meetings if it is in the public interest	Yes (52.6%)
Ref 18 (1998)—Ratification of the Treaty of Amsterdam	Yes (61.7%)
Ref 19 (1998)—Ratification of the British-Irish Agreement	Yes (94.4%)
Ref 20 (1999)—Constitutional recognition of local government	Yes (77.8%)
Ref 23 (2001)—Ireland to become a party to International Criminal Court	Yes (64.2%)
Ref 24 (2001)—Ratification of the Treaty of Nice	Yes (46.1%)
Ref 26 (2002)—Ratification of the Treaty of Nice (2nd Nice referendum)	Yes (62.9%)
Ref 27 (2004)—Limit the right to Irish citizenship of individuals born in Ireland to children of Irish citizens	Yes (79.2%)
Ref 28F (2008)—Ratification of the Treaty of Lisbon	Yes (46.6%)
Ref 28P (2009)—Ratification of the Treaty of Lisbon (2nd Lisbon referendum)	Yes (67.1%)
Ref 29 (2011)—To allow for reduction of the salaries of Irish judges	Yes (79.7%)
Ref 30F (2011)—Allow Houses of the Oireachtas powers to conduct full enquiries into matters of public importance	Yes (46.7%)
Ref 30P (2012)—Ratification of the European Fiscal Compact	Yes (60.4%)
Ref 32 (2013)—Abolish Ireland's upper house of parliament (Seanad Éireann)	Yes (48.3%)
Ref 33 (2013)—To establish a Court of Appeal	Yes (65.2%)
Ref 35 (2015)—Reduce minimum age of candidacy for President of Ireland from 35 to 21	Yes (26.9%)
Social change ($n = 11$)	
Ref 12 (1992)—Restrict abortion by excluding suicide risk as a reason to allow a legal abortion	Yes (34.7%)
Ref 13 (1992)—Remove limits on freedom of travel for abortion	Yes (62.4%)
Ref 14 (1992)—Allow distribution of information on foreign abortion services	Yes (59.9%)
Ref 15 (1995)—Remove constitutional prohibition on divorce	Yes (50.3%)
Ref 21 (2001)—Introduce constitutional ban on death penalty	Yes (62.1%)
Ref 25 (2001)—Second attempt to exclude risk of suicide as grounds for abortion	Yes (49.6%)
Ref 31 (2012)—Strengthen rights of children/counterbalance the rights of the child versus the rights of the *married* family	Yes (58.0%)
Ref 34 (2015)—Permit same-sex marriage	Yes (62.1%)
Ref 36 (2018)—Allow for legislation to legalize abortion	Yes (66.4%)
Ref 37 (2018)—Remove blasphemy as criminal offense	Yes (64.9%)
Ref 38 (2019)—Relax requirements for getting a divorce	Yes (82.1%)

(Amendment) Act that defines constituencies as aggregations of electoral districts (EDs), the most basic electoral/political division in Ireland. Constituencies defined on the basis of the most recent census of the population take effect with the next general election following passage of an Electoral (Amendment) Act. Constituencies vary in population size proportional to whether they elect three, four or five members to Dáil Éireann. Because constituencies comprise geographic units, they may be contiguous with, and share the same name as, a county, part of a county or a combination of counties. In order to maintain population proportionality, a constituency bearing the same name as a county may contain

a small number of electoral districts from a neighbouring county, or a county may lose a small number of EDs to a neighbouring constituency.

Ireland's Central Statistics Office (CSO) Census of the Population Small Area Population Statistics (SAPS) are the data source for population demographic characteristics that we include in our analysis. From the 1996 Census of the Population onward, the CSO has included constituencies among the subnational political divisions for which it publishes SAPS data. For the 1991 Census of the Population, we manually compiled constituency-level measures of included population demographic characteristics by aggregating CSO-published electoral district (ED) SAPS data using the definitions of constituencies established in the Electoral (Amendment) Act 1990.

The choice of what population demographic characteristics to include in our dataset, and hence our analysis, rests in part on the availability of census enumerated measures whose definition remained consistent over the 25-year census period (from 1991 to 2016) that spans our analysis. The following demographic characteristics satisfy this criterion, and also represent population demographic characteristics that are likely to influence voter turnout and the percentage of the population voting in favour of a referendum:

- % Retired—percentage of voting age population that are retired
- % Farmers—percentage of all socioeconomic groups classified as farmers
- % Post-2nd-Level Educ—percentage of adult population with post-secondary education
- Electorate Size—the number of eligible voters in the constituency
- HRDL Soceco—Herfindahl Index for population socioeconomic classifications

While the first four variables are self-explanatory, the Herfindahl Index requires some explanation. It is defined as the sum of the squared value of the percentage of the population within each socioeconomic classification. A higher value, therefore, indicates a greater degree of homogeneity of socioeconomic status, and a lower value indicates a greater degree of heterogeneity of socioeconomic status within the constituency population.[13] Therefore, the Herfindahl Index is included in the analysis to capture the potential impact of population diversity.[14]

We also include two constituency-based measures of economic activity. The first is household income per person (Income real) measured in real terms with 1 July 2000 the base reference. The second is the unemployment rate (Unem rate). Ireland's Central Statistics Office (CSO) publishes household income per person at the county level annually.[15] These data are the basis of the constituency-level measures used here. In instances where a constituency is coterminous with a county or is contained entirely within a county, the income measure for this county comprises the constituency income measure. In instances where a constituency spans more than one county, the real income measure is based on a

[13] The Irish Census of the Population over the time period studied here enumerates respondents according to the following 11 socioeconomic classifications: employers and managers, higher professional, lower professional, non-manual, manual skilled, semi-skilled, unskilled, own account workers, farmers, agricultural workers, and all others gainfully occupied and unknown.

[14] Kaniovski and Mueller (2006) suggest that constituencies with larger voting populations may be more heterogeneous than smaller ones, and that community heterogeneity may be inversely related to voter turnout.

[15] CSO Statbank publication "County Incomes and Regional Accounts" series CIA02. Because these data are available with a 3-year lag, we use 2018 data as the Income Real measure for the 38th Amendment held 24 May 2019.

population-based weighted average for each county or partial county that jointly comprise the constituency.

Ireland's CSO also publishes regional unemployment rate data. These data are available on an annual basis for the years 1992–1998 and on a quarterly basis from 1999 onward.[16] The European Union Classification of Territorial Units for Statistics (NUTS) changed between 2011 and 2012. As a result, the definitions of regions in Ireland changed slightly, causing a few counties to realign into a different region before and after that time. The number of counties in a NUTS 3-defined region in Ireland ranges from one, in the case of Dublin, to as many as six in the pre-2012 Border Region. In many instances over the entire period, constituencies were defined geographically solely within a single region, and the unemployment rate for this region comprises the constituency's unemployment rate measure. In some instances, though, a constituency spanned more than one NUTS region so that the unemployment rate is calculated as a NUTS region weighted average, based on the population share contained within each region.

We collect rainfall data from the archives of Met Éireann, Ireland's national meteorological service. Met Éireann provides historical daily data from its 511 meteorological stations, in some cases dating back as far as 1941. The network of meteorological stations provides wide coverage of the whole country, as can be seen in Fig. 2 in the Appendix. To quantify the amount of rain collected in a given constituency on a referendum day, we first map each meteorological station to an electoral division, the smallest administrative unit in Ireland, according to the station's geographic coordinates, as provided by Met Éireann. In the small number of cases where several stations belong to the same electoral division, we take the average of all stations. We then assign each electoral division to its corresponding constituency following its definition in the appropriate Electoral (Amendment) Act. Finally, we compute the average of the rain collected across every electoral division within a given constituency to obtain our measure of rain on referendum day for that constituency.

In this paper, we analyse 28 referendums that took place over 20 different days. Figure 1 shows a box plot of rain collected in millimetres for each referendum day, representing the distribution of rain across the different constituencies. Of all referendums, 12 (43%) can be considered to have happened on "dry" days, with the maximum amount of rain collected in any constituency below 5 mm. On the other extreme, three referendums (11%) occurred on wet days, with one constituency receiving at least 20 mm of rain. Importantly, in referendum days when some rain was collected, there are significant differences among constituencies. For example, on 24 November 1995, the day of the referendum to ratify the 15th Amendment to the Constitution of Ireland, rain collected on the day was as low as 3.7 mm in the Dublin South-East Constituency to as high as 37.9 mm in Kerry South. The geographical variation of the treatment, rain in this case, enhances its usefulness as an instrument.

Table 2 presents summary statistics for all of the variables in our dataset. For each variable, we show the average across all referendums, as well as separately for the regime-related referendums and the social referendums. The average support (percentage of yes votes) across referendums is approximately 61%. Average voter turnout is 51%. However, this varies by referendum type. For regime-related elections, average turnout is just 49%, compared to 54% for referendums on social issues. Average referendum-day rainfall is approximately 2 to 3 mm. The percentage retired, percentage of farmers and the unemployment rate across referendums are all approximately 10%. Approximately 26% of

[16] CSO Statbank series LFCA4 and QLF15.

individuals are educated to the third level. There is a large difference between the minimum value (10%) and maximum value (63%) for this variable, which reflects significant changes that have occurred over time. For example, in 1991, approximately 14% of individuals nationally had third-level education compared to over 40% in 2016.[17]

4 Empirical strategy

To address the issue of endogeneity, we employ an instrumental variables (IV) approach, whereby constituency-level rainfall on the day of the referendum is used as an instrument for voter turnout. Certain necessary conditions are required for this to be a valid approach. First, rainfall must be correlated with voter turnout. Previous work by Garcia-Rodriguez and Redmond (2020) shows that this is true for general elections to Dáil Éireann. We validate this for our analysis by showing that rainfall is also a strong predictor of voter turnout in referendums. It is also important that the instrument (rainfall) affects the referendum outcome only through its effect on voter turnout; that is, the instrument must satisfy the exclusion restriction. This is a plausible assumption and has support in the literature on general elections (Arnold & Freier, 2016; Artés, 2014; Hansford & Gomez, 2010).

We implement our strategy using two-stage least squares (2SLS). The first stage involves estimating the following regression:

$$\text{Turnout}_{i,r} = \alpha + \beta \text{Rain}_{i,r} + X'_{i,r}\theta_x + \sum_{\rho=r_2}^{R} \delta_\rho I_\rho + \sum_{\tau=2}^{4} \lambda_\tau P_\tau + \varepsilon_{i,r} \quad (1)$$

where the dependent variable $Turnout_{i,r}$ is voter turnout (in percent) in constituency i in referendum r. The variable $Rain_{i,r}$ is the average daily rainfall in millimetres for constituency i on the day of voting in referendum r. We include a vector of additional control variables, $X_{i,r}$, which were described in Sect. 3 and include the percentage of voting age population that are retired (% Retired); the percentage of all socioeconomic groups that are farmers (% Farmers); the size of the constituency electorate (Electorate); the percentage of adult population with post-secondary level education (% Post-2nd-Level Educ); the Herfindahl Index (HRDL Soceco); constituency-level real household income per person (Income real); and constituency-level unemployment rate (Unem rate). A full set of dummy variables for each of the R referendums are included, denoted by I_ρ, to capture potential fixed effects associated with individual referendums. We also include regional dummy variables for each of the four provinces in Ireland, denoted by $\sum_{\tau=2}^{4} \lambda_\tau P_\tau$.[18]

The second stage involves taking the predicted outcomes from the first stage [Eq. (1)] and regressing the percentage of yes votes cast for the referendum in constituency i (% $Yes_{i,r}$) on these predicted values of voter turnout, denoted $\widehat{T}_{i,r}$. In doing so, we are using the exogenous variation in turnout that is predicted by (or instrumented by) rainfall. The vector of other exogenous explanatory variables from Eq. (1) ($X'_{i,r}$) together with the referendum and province fixed effects are also included in the second stage. Specifically, the second stage involves estimating the following regression,

[17] See https://www.cso.ie/en/releasesandpublications/ep/p-cp10esil/p10esil/tl/.

[18] As Ireland is geographically small, these four provincial fixed effects should be detailed enough to capture region-specific variation in turnout and rainfall.

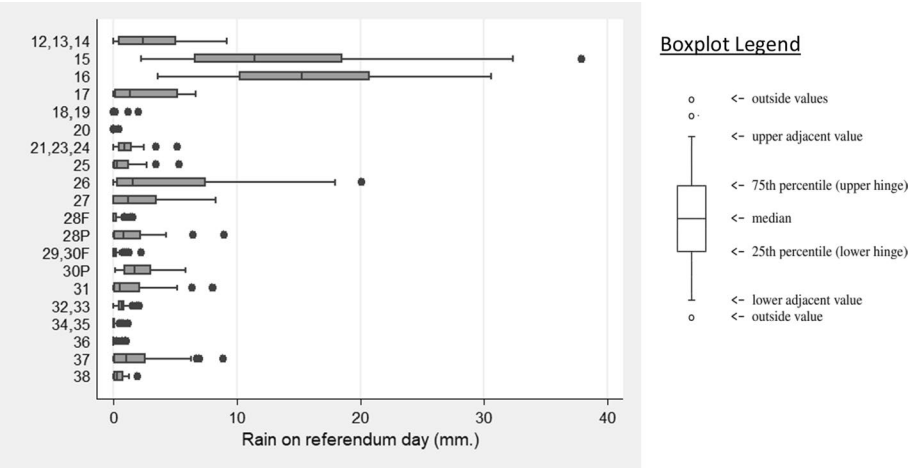

Fig. 1 Box plot of rain on referendum day (in mm) by constituency. (*Notes:* The box marks the 25th and 75th percentiles, with the middle line showing the median. The whiskers represent the lower and upper adjacent values, defined as the values in the data that are furthest from the median, but within a distance of 1.5 times the interquartile range. The dots represent outside values, which are defined as values that are smaller (larger) than the lower (upper) quartile minus (plus) 1.5 times the interquartile range. Data source: Met Éireann Data, authors' calculations)

$$\%\text{Yes}_{i,r} = \alpha + \beta \hat{T}_{i,r} + X'_{i,r}\theta_x + \sum_{\rho=r_2}^{R} \delta_\rho I_\rho + \sum_{\tau=2}^{4} \lambda_\tau P_\tau + \varepsilon_{i,r} \tag{2}$$

where the coefficient β is our estimate of the causal impact of voter turnout on the percentage of yes votes.[19] One can manually implement the estimator using two separate stages, as explained above. However, it is necessary to correct the standard errors to account for the fact that the second stage uses an estimated regressor (the predicted turnout).[20] We implement the estimator using Stata's *ivregress* command, which conveniently reports the 2SLS estimates and the correct standard errors.

Note that, while we include region-specific fixed effects, in the form of provincial dummy variables, our specification does not include constituency-level fixed effects. This is due to how constituencies are constructed, and how they constantly change over time (as mentioned in Sect. 3). Following each census of the population every 5 years, an independent constituency commission may adjust constituencies to account for population changes. As a result, from one referendum to the next, a constituency may gain, or lose, EDs to a neighbouring constituency. Some changes are small, resulting in the re-allocation of a small number of EDs from contiguous constituencies. These changes may, or may not, be accompanied by a change to the constituency name. Some changes are substantial. For example, in 1997, the Kildare constituency was abolished and replaced by two new constituencies: Kildare North and Kildare South. While approximately 40 constituencies exist

[19] We cluster standard errors using 26 constituency-based clusters. We also verify the significance of our estimates using the method for bootstrapping standard errors in IV outlined by Wang (2021), using Stata's *boottest* command.

[20] As explained here: https://www.stata.com/statalist/archive/2010-02/msg00307.html.

Table 2 Summary statistics. [*Source*: Authors' calculations based on Irish Census data (from the Central Statistics Office), meteorological data (from Met Éireann) and election data (from the Department of Housing, Planning and Local Government)]

	Mean	Std. Dev.	Min.	Max.
All referendums (N = 1145)				
% Yes votes	61.27	14.67	21.97	96.34
% Voter turnout	51.24	12.33	17.97	75.70
Rainfall (daily, mm)	2.22	4.55	0.00	37.90
Real income (in 000s euros)	17.85	4.21	9.25	27.80
Unemployment rate	9.84	4.42	3.30	22.40
% Retired	11.19	2.97	3.26	19.50
% Farmers	8.93	8.72	0.04	37.11
Socioeconomic group homogeneity	13.39	2.15	10.43	20.94
% Post-2nd-level education	26.03	10.98	10.00	63.08
Size of electorate (in 000s)	72.64	25.83	21.23	354.45
Regime-related (N = 702)				
% Yes votes	61.39	16.59	21.97	96.34
% Voter turnout	49.21	10.82	17.97	75.70
Rainfall (daily, mm)	1.98	4.46	0.00	30.70
Real income (in 000s euros)	18.24	3.28	11.18	27.80
Unemployment rate	9.81	4.24	3.30	22.40
% Retired	11.06	2.77	3.26	18.67
% Farmers	8.42	8.03	0.04	37.11
Socioeconomic group homogeneity	12.90	1.75	10.43	20.94
% Post-2nd-level education	26.00	10.27	10.00	61.12
Size of electorate (in 000s)	72.01	25.18	21.23	351.19
Social (N = 443)				
% Yes votes	61.09	11.00	29.41	86.70
% Voter turnout	54.47	13.82	23.81	75.40
Rainfall (daily, mm)	2.61	4.68	0.00	37.90
Real income (in 000s euros)	17.22	5.30	9.25	27.80
Unemployment rate	9.91	4.69	3.30	20.30
% Retired	11.38	3.25	3.26	19.50
% Farmers	9.75	9.66	0.04	37.11
Socioeconomic group homogeneity	14.16	2.49	10.43	20.94
% Post-2nd-level education	26.09	12.03	10.00	63.08
Size of electorate (in 000s)	73.64	26.82	26.34	354.45

for any one referendum, the changing nature of Irish constituencies results in 84 distinct units over the period of our study, many of which appear only once.[21]

When implementing IV, it is necessary to have sufficient variation in the instrument. If we try to exploit within-constituency variation, we will lose the observations that appear

[21] In three instances there were "special constituency definitions"—the 20th, 27th and 30th referendums—that were held on the same date as European Union and local elections in Ireland. These special constituency definitions represent combinations of county and city municipalities that differ slightly in the case of each of the three referendums. The number of constituency data observational units ranges between 31

just once. Moreover, many appear just twice or even three times, and basing identification on within constituency variation with such a limited number of repeated observations is not suitable. In addition, even when a constituency name appears over several time periods, it does not stay constant with respect to its geographic make-up due to boundary changes.

Despite the inclusion of referendum fixed effects and provincial fixed effects, along with the other explanatory variables listed above, concerns may still exist relating to regional variation in rainfall levels. If constituencies that are more susceptible to higher levels of rainfall are also different with respect to other characteristics that could impact the outcome variable, then this could violate the exclusion restriction.[22] We address this by constructing an alternative version of the instrument that captures local deviations from average rainfall amounts. This is defined as rainfall in millimetres collected on the day of the referendum *minus* the average daily rainfall for the month of the referendum *within the constituency*. We show that estimates from both outcome measures are similar, which corroborates the causal mechanism that voter turnout impacts referendum outcomes. As a final check on the validity of the instrument, we test for systematic relationships between rainfall amounts and observed constituency characteristics by regressing rainfall (in deviations from the average) on constituency-level covariates. Except for the percentage of farmers, there is no strong systematic relationship between rainfall and the constituency-level characteristics. We show the effect for the percentage of farmers is driven by a small number of outliers, consisting of farming-intensive constituencies that experienced very high rainfall in some referendums. We show that our results are robust to the exclusion of these outliers.

As we are using 2SLS to estimate the effect of turnout on referendum outcomes, it is necessary to discuss what β is capturing. To do so, consider the different types of voters in the population. Firstly, there are people who always vote, irrespective of the weather. For such people, the instrument will not impact their voting decision. Likewise, there will be people who never vote, irrespective of the weather. Again, the instrument (rainfall) will have no bearing on their voting decision. There will be others whose decision to vote will be impacted by the weather, that is, they may be less likely to vote if there is heavy rainfall. Our estimate of β will capture the average effect of increased turnout on the referendum outcome among constituencies containing individuals whose voting decision is affected by rainfall (referred to as *compliers* in the literature). More formally, this is referred to as the local average treatment effect (LATE).[23]

5 Results

5.1 First-stage results

The results of the first-stage equation [Eq. (1)] are shown in Table 3. Columns (1)–(3) show results using our baseline measure of rainfall, while columns (4)–(6) show results for

Footnote 21 (continued)

and 36 for these three referendums and ranges between 40 and 43 for the remaining 25 referendums. See {https://www.gov.ie/en/publication/32ea7-1937-2019-referendum-results/}.

[22] For a review of the IV literature utilizing weather, with a particular focus on the exclusion restriction, see Mellon (2021).

[23] The seminal paper on local average treatment effects (LATE) is Imbens and Angrist (1994). They define LATE as "the average treatment effect for individuals whose treatment status is influenced by changing an exogenous regressor that satisfies an exclusion restriction".

Table 3 2SLS First-stage results

Variables	(1) All referendums	(2) Social	(3) Regime	(4) All referendums	(5) Social	(6) Regime
Rainfall (daily, mm)	−0.191***	−0.155**	−0.212***	−0.179***	−0.153**	−0.195***
	(0.052)	(0.074)	(0.050)	(0.050)	(0.068)	(0.056)
Real income (in 000s euros)	0.302	−0.007	0.637**	0.315	−0.001	0.658**
	(0.190)	(0.142)	(0.310)	(0.195)	(0.144)	(0.319)
Unemployment rate	−0.109	−0.372***	0.080	−0.103	−0.373***	0.089
	(0.124)	(0.119)	(0.171)	(0.127)	(0.124)	(0.174)
% Retired	0.341***	0.202	0.440***	0.339***	0.201	0.438***
	(0.114)	(0.126)	(0.132)	(0.117)	(0.127)	(0.136)
% Farmers	0.141**	0.070	0.208***	0.138**	0.069	0.205***
	(0.063)	(0.071)	(0.071)	(0.063)	(0.070)	(0.072)
Electorate (in 000s)	−0.036**	−0.029**	−0.039**	−0.036**	−0.029**	−0.038**
	(0.016)	(0.014)	(0.017)	(0.016)	(0.014)	(0.017)
Socioeconomic group homogeneity	−0.095	−0.041	−0.227	−0.083	−0.031	−0.215
	(0.224)	(0.247)	(0.251)	(0.222)	(0.247)	(0.250)
% Post-2nd-level education	0.098*	0.058	0.129***	0.095*	0.057	0.124***
	(0.055)	(0.068)	(0.048)	(0.055)	(0.068)	(0.047)
Constant	41.966***	52.215***	40.106***	41.090***	51.592***	38.973***
	(4.779)	(5.241)	(6.544)	(4.962)	(5.404)	(6.749)
Referendum fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Province fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,145	443	702	1,145	443	702
R-squared	0.894	0.919	0.864	0.894	0.919	0.864
First-stage *F*	14	5	18	13	5	12

Columns (1)–(3) show results from our baseline rainfall measure (mm in 24 h). Columns (4)–(6) show results using the alternative rainfall measure (deviations from constituency average). Robust standard errors in parentheses, clustered using 26 constituency-based clusters. ***$p<0.01$, **$p<0.05$, *$p<0.1$

our alternative rainfall measure (deviations, in millimetres, from monthly average). Note firstly that the estimated coefficient for our instrument, daily rainfall, is negative and statistically significant across all specifications, with a similar impact for both the regime-related and social change categories; a 1-mm increase in rainfall is associated with a reduction of 0.16–0.21 percentage points in voter turnout.

When implementing two-stage least squares, it is important that the relationship between the instrument and the endogenous variable is strong.[24] While the coefficients associated with rainfall in Table 3 indicate a high degree of statistical significance, it is conventional to also report the *F*-statistics from the first-stage regression. A general rule of thumb is that if the *F*-statistic is greater than 10, we can be reasonably satisfied that we do not have a weak instrument. We can see from column (1) in Table 3 that the first-stage *F*-statistic is 14. As we implement our IV estimator on subsets of the main sample, we also report the *F*-statistics for these subsamples in Table 3. The regime-related *F*-statistic equals 18, while the *F*-statistic for the social referendums subsample, which has fewer observations than the regime-related subsample, is 5.[25] While presenting results based on two separate specifications for social and regime-related referendums produces results that are easily interpretable, an alternative option is to estimate one single pooled model with a full set of interactions between referendum type and all other explanatory variables.[26] This yields the same estimated effect of rainfall on turnout, along with a first-stage *F*-statistic of 18. Therefore, our first-stage relationship between the instrument and endogenous regressor is strong.

With regard to the demographic and economic explanatory variables, there is some evidence that real income, the percentage of highly educated people, the percentage of retired individuals and the percentage of farmers in a constituency are positively related to voter turnout, while the unemployment rate is negatively related to turnout.[27] However, the coefficients are not consistently significant across all specifications. The strongest evidence relates to the size of the electorate. Across all specifications and referendum types, the size of the electorate has a negative and statistically significant impact on voter turnout.

Table 3 also shows that the magnitude of the coefficients in the regime-related specification are typically larger than the social referendums. One potential explanation is that a wider spectrum of voters are inherently more interested with the issues under consideration in social referendums, and therefore variation in demographic characteristics matters less when it comes to explaining turnout in social referendums.

[24] There is a well-developed strand of literature on the consequences of weak instruments (see, e.g., Staiger & Stock, 1997; Bound et al., 1995).

[25] The bias of 2SLS is centred on the OLS bias (Bound et al., 1995). The 2SLS bias can be written as a function of the OLS bias and the first-stage *F*-statistic, $bias_{2SLS} = bias_{OLS}(1/F + 1)$. While an *F*-statistic above 10 is a rule of thumb, this is not always satisfied in practice. Andrews et al. (2019) surveyed papers published in the American Economic Review from 2014 to 2018 that use instrumental variables, and reported that in approximately 10 out of 72 specifications, the first-stage *F*-statistic is below 5.

[26] The pooled model with interactions is analogous to estimating two separate models. In Tables 3 and 4 we present the results from the separate specifications as they are easier to interpret, compared to the pooled model which produces a table consisting of a full set of interaction variables between referendum type and all other covariates. We discuss the results of the pooled sample estimation for Eq. (2) (Table 4), presented in Appendix Table 7, below.

[27] The finding relating to the percentage of farmers is in line with Kavanagh et al. (2004), who find that turnout is generally higher in rural areas. This may be due to rural voters having a stronger sense of civic duty (Knack, 1994).

Table 4 2SLS Second-stage results by referendum type (social vs regime)

Variable	(1) All referendums	(2) Social	(3) Regime	(4) All referendums	(5) Social	(6) Regime
Voter turnout (%)	1.560***	1.559**	0.391	1.565***	1.762***	0.164
	(0.468)	(0.730)	(0.291)	(0.460)	(0.586)	(0.331)
Real income (in 000s euros)	−0.047	0. 460	0.066	−0.048	0.461	0.210
	(0.336)	(0.280)	(0.218)	(0.361)	(0.300)	(0.196)
Unemployment rate	0.604***	0. 787*	0.220*	0.605***	0.851**	0.240**
	(0.228)	(0. 423)	(0.126)	(0.221)	(0.400)	(0.109)
% Retired	−0.637**	−0.511**	−0.262*	−0.639**	−0.551**	−0.164
	(0.291)	(0.246)	(0.154)	(0.278)	(0.254)	(0.160)
% Farmers	−0.207**	−0.353***	0.186***	−0.207**	−0.364***	0.231***
	(0.092)	(0.089)	(0.062)	(0.098)	(0.101)	(0.0606)
Electorate (in 000s)	0.0643*	0.053*	0.023	0.065*	0.058**	0.0140
	(0.0333)	(0.029)	(0.014)	(0.033)	(0.029)	(0.0149)
Socioeconomic group homogeneity	0.197	0.495	−0.043	0.197	0.501	−0.0879
	(0.349)	(0.384)	(0.174)	(0.352)	(0.430)	(0.155)
% Post-2nd-level education	0.062	0.195**	0.157***	0.062	0.184*	0.185***
	(0.069)	(0.089)	(0.042)	(0.072)	(0.104)	(0.0489)
Constant	−3.540	−23.19	−4.876	−3.773	−33.71	4.133
	(21.37)	(41.19)	(11.13)	(20.79)	(35.48)	(13.55)
Referendum fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Province fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1145	443	702	1145	443	702
R-squared	0.754	0.621	0.947	0.753	0.552	0.950

Columns (1)–(3) show results from our baseline rainfall measure (mm in 24 h). Columns (4)–(6) show results using the alternative rainfall measure (deviations from constituency average). Robust standard errors in parentheses, clustered using 26 constituency-based clusters. ***$p<0.01$, **$p<0.05$, *$p<0.1$

5.2 Two-stage least squares (2SLS) results

Table 4 presents the estimates for the second-stage equation of our two-stage least squares estimator (Eq. 2). Columns (1)–(3) show the results for our baseline rainfall measure. For the pooled sample of all referendums (column 1), a one-percentage-point increase in voter turnout causes a 1.6-percentage-point increase in referendum support.[28] When we examine the referendums separately by type, we see that this effect is driven by the social referendums. A one-percentage-point increase in voter turnout in social referendums causes a 1.6-percentage-point increase in support for the referendum. However, there is no statistically significant impact for regime-related issues.[29] The results are consistent when we use our alternative rainfall measure (deviations from average) in columns (4)–(6).

To check whether the coefficients for the social versus regime-related specifications in Table 4 are statistically significantly different, Table 7 of the Appendix shows the interaction terms from a pooled specification which interacts referendum type with all other covariates. For our main variable of interest, voter turnout, we see that the difference between the social and regime estimate, 1.168, is statistically significant.[30]

It is useful to comment on the magnitude of the voter turnout effect which, at 1.6, implies that a one-percentage-point increase in turnout leads to a 1.6-percentage-point increase in the percentage of yes votes. Therefore, the percentage point change in the referendum support is greater than the percentage point change in voter turnout. While this may appear somewhat counter-intuitive, it is plausible given the generally low levels of turnout (often below 50%). To illustrate this purely from an algebraic perspective, consider two identical constituencies with 100 eligible voters in each. In constituency 1, 40 individuals vote (turnout of 40%), and of these 40, 20 vote yes (50% yes vote). In constituency 2, due to better weather, 41 individuals turnout to vote (turnout of 41%), and the 41st individual votes yes, with all other votes the same as the first constituency (51.2% yes vote). Therefore, the percentage point change in the yes vote is greater than the percentage point change in turnout.

There is also another possibility for the magnitude of the turnout coefficient being above unity. In social referendums where people are heavily invested in the issue and are highly motivated to achieve the desired outcome, there may be spillover effects. For example, an exogenous increase in socially progressive voters attending the polling station may be enough to sway some other (somewhat undecided) voters to vote yes. While investigating such effects is beyond the scope of our current analysis, a related literature indicates intra-household spillover effects in terms of the voting decision (see, e.g., Bhatti et al., 2017).

For the other explanatory variables, the strongest evidence relates to the unemployment rate, the percentage of retired individuals and the percentage of farmers. The unemployment rate is positively associated with the percentage of yes votes, which may indicate that times of diminished employment opportunities provide a social environment conducive to the advancement of progressively liberal policies. A higher percentage of retired individuals, on the other hand, leads to lower referendum approval, plausibly indicating that this

[28] In Appendix Fig. 3, we verify the statistical significance of the estimate using bootstrapped standard errors, using Stata's *boottest* command.

[29] Our post-estimation test for endogeneity (estat endog) indicates that voter turnout is endogenous for the pooled sample and the social referendum sample, supporting the use of IV as our estimator. However, for the regime-related model, we cannot reject the null hypothesis that voter turnout is exogenous.

[30] Table S1 also indicates a statistically significant difference in the coefficients for farmers, socioeconomic homogeneity and the size of the electorate.

group is content with the status quo. The percentage of farmers is also associated with lower referendum support for social issue referendums but a higher level of support for regime-related referendums. Considering that one third of the 18 regime-related referendums involved ratifying treaties to expand the European Union, these results are consistent with economic self-interest, arguably arising from benefits attributable to the EU Common Agricultural Policy, on the one hand, and this group representing a socially conservative segment of the electorate on the other (Sinnott, 1995).

5.3 Robustness tests

The specification using deviations from average rainfall alleviates concerns relating to possible systematic differences between constituencies that experience higher rainfall amounts compared to those experiencing lower rainfall. As an additional check, we formally test for the presence of such differences by regressing rainfall (in deviations from the average) on observed constituency-level characteristics. The results are shown in column (1) of Appendix Table 8. While most characteristics show no strong significant relationship, the percentage of farmers shows a positive and statistically significant association. Further investigation reveals that this is driven by a small number of outliers consisting of high-farming-intensity constituencies that experienced inordinately high rainfall amounts on certain days. We re-run our analysis by dropping the highest-intensity farming constituencies (the top fifth percentile). When such constituencies are excluded, the relationship between the instrument (rainfall in deviations from the average) and the farming intensity variable does not persist (see column 2 of Appendix Table 8). As a robustness test, in columns (3)–(5) of Appendix Table 8, we show the 2SLS estimates are robust to the exclusion of these outliers. The results are consistent with our baseline estimates; voter turnout is associated with increased referendum support, driven by social referendums.

Three of the social referendums occur on the same day (the 12th, 13th and 14th referendums). In our baseline specification, we treat each of these as separate referendums. As a robustness test, we re-estimate the model by consecutively dropping all but one of the three social referendums that occurred on the same day. That is, we begin by keeping just the 12th referendum, along with all other social referendums. We then proceed to specifications keeping just the 13th referendum, followed by the 14th referendum. The results are reported in Appendix Table 9. For all three specifications, the magnitude and statistical significance of the estimated effect of turnout on referendum support, while slightly higher, are similar to our baseline estimates.[31]

5.4 Counterfactual simulations

Having established that voter turnout affects the results of social referendums, we examine the extent to which different weather conditions on referendum day could have impacted the referendum result. Specifically, we examine the following four counterfactual scenarios: (1) all constituencies experience zero rainfall on referendum day, (2) all constituencies experience at least 10 mm of rainfall on referendum day, (3) all constituencies experience at least 20 mm of rainfall on referendum day, (4) all constituencies experience at least 30 mm of rainfall on referendum day. In scenarios 1–4, we refer to constituencies

[31] A one-percentage-point increase in turnout is estimated to lead to an approximately two-percentage-point increase in yes votes.

experiencing *at least* a given amount of rainfall. For example, in scenario 2, all constituencies with below 10 mm of rain are allocated counterfactual rainfall of 10 mm. However, constituencies that experienced greater than 10 mm remain unchanged. A similar approach, using 20 mm and 30 mm respectively, is applied for scenarios 3 and 4.

The maximum rainfall that we examine is 30 mm (in scenario 4). To put this into context, 30 mm of rainfall in 24 h triggers a yellow rainfall warning from Met Éireann. This is the least severe type of three warning types (the others being orange and red). It indicates no immediate threat to the general population, but some risk to individuals that are exposed "by nature of their location and/or activity". Therefore, 30 mm of rainfall in all constituencies, while not considered a dangerous amount of rainfall, would be considered a very wet day.

The actual results along with the counterfactual outcomes for each social referendum are shown in Table 5 below. For most of these referendums, the margin of victory is large enough so that simulated changes to election day weather cannot overturn the result. There are two exceptions—the 15th and 25th referendums. A "yes" vote in the 15th referendum was a vote to legalize divorce, which was previously prohibited in the Irish constitution. The result was close, with just 50.3% voting in favour of the proposal. Our simulations show that a modest increase in rainfall on referendum day could have overturned this result. Rainfall of at least 10 mm in each constituency would have been sufficient to overturn the result from 50.3% yes to 49.8% yes. The actual level of rainfall for the 15th referendum was quite high anyway, with an average of 13 mm per constituency. Imposing at least 10 mm in all constituencies, as per scenario 1, would have increased this average to just 15 mm. Nonetheless, this slight increase in rainfall could have been enough to change the result.

A "yes" vote in the 25th referendum was a vote to tighten the constitutional ban on abortion.[32] The actual result was close, with 49.6% voting yes. Our simulations show that an increase in rainfall to at least 10 mm per constituency could have been enough to overturn this result, changing the result from 49.6% yes to 51.8% yes (i.e., from the observed progressively liberal outcome to its politically conservative alternative).[33] Therefore, by impacting voter turnout, relatively modest changes to referendum-day rainfall could have led to a substantially different policy environment in Ireland in relation to divorce and abortion.

5.5 Voter turnout mechanism

Recall that our measure of support for social referendums can be viewed in terms of support for more liberal policies relating to issues such as same-sex marriage and abortion. Therefore, our results for social referendums suggest that individuals who are likely to vote less frequently are more likely to be ideologically predisposed to more liberal and progressive policies. This is consistent with previous work for general elections that has documented an increase in support for left-leaning parties as a result of higher voter turnout (see, e.g., Fowler, 2013; Gomez et al., 2007). In this regard, the fact that we do not detect significant impacts for regime-related referendums is not surprising as the regime-related issues are often not easily distinguishable on a left–right spectrum.

[32] Recall that for each referendum, apart from the 12th and 25th, a yes vote indicates support for a socially liberal policy. For the 12th and 25th, however, a yes vote indicates support for a socially conservative policy. Therefore, higher turnout increases the % Yes for all referendums except the 12th and 25th.

[33] The actual level of rainfall in the 25th referendum was very low, with a constituency average of just 1 mm.

Therefore, even if rainfall decreases voter turnout among left-leaning voters (the compliers), for regime-related issues, it is not clear that this should alter support for the regime-related issue as a "yes" vote is not necessarily a vote for a liberal policy.

To provide insights into the mechanism driving the results, we look to the Living in Ireland Survey for additional evidence. Specifically, we focus on the question that asks, "If there were a General Election tomorrow would you vote in it?", and compare the characteristics of those that respond "yes" to those that respond "no". One important characteristic that we examine relates to a potential voter's party preference. For individuals that indicate they would vote in a general election, they are asked, "Which political party would you vote for?" For those that indicate they would not vote, they are asked, "In general, which party do you feel closest to?" Muller and Regan (2021) show that individuals that support the Fine Gael and Fianna Fáil political parties are more right-leaning compared to supporters of other political parties. Therefore, by examining the party affiliations of individuals who indicate they would vote compared to those that indicate they would not, we can get an indication of the ideology of marginal voters compared to regular voters.

We also examine whether voters and non-voters differ by age, church attendance and wages, as existing research indicates that younger, non-religious, low-income individuals are more likely to be socially liberal voters (Elkink et al., 2020; Simon et al., 2018). We use a probit model to regress whether an individual will vote in the next election on party preference, age, church attendance and wages. The results are shown in Table 6 below. Firstly, we see that regular voters are 10 percentage points more likely to support the right-leaning political parties compared to people who say they will not vote. Regular voters are also older, have higher wages and are more likely to attend church. This evidence supports the suggested causal mechanism whereby those who vote infrequently are more likely to support liberal policies.

6 Conclusion

In this paper, we estimated the causal effect of voter turnout on the percentage of yes votes in support of referendums using an instrumental variables approach, in which rainfall is used as an instrument for voter turnout. By taking advantage of Ireland's extensive use of referendums, we are the first to examine whether the effects of turnout vary by referendum type (social versus regime-related referendums). We find that a one-percentage-point increase in voter turnout was associated with a 1.6-percentage-point increase in support for progressively liberal social policies relating to, for example, same-sex marriage and abortion. We find no effect for regime-related referendums.

Regarding the mechanism through which turnout impacts outcomes, we present descriptive evidence from survey data to show that individuals who vote frequently tend to be systematically different to those who vote infrequently. Specifically, those who vote frequently tend to be older, attend church regularly and are more likely to support right-leaning political parties. Such voters may have more conservative views. Therefore, rainfall on referendum day may depress turnout among the socially liberal, while resulting in disproportionately large numbers of conservative voters, whereas good weather on referendum day can boost turnout to the benefit of socially liberal policies.

By carrying out counterfactual simulations, we demonstrate the important implications of our findings. By impacting voter turnout, a slight increase in referendum-day rainfall

Table 5 Actual versus simulated outcomes (% Yes) for social referendums

Referendum	Actual result (%)	Scenario 1: Zero rain (%)	Scenario 2: 10 mm rain (%)	Scenario 3: 20 mm rain (%)	Scenario 4: 30 mm rain (%)
12	Yes: 34.6	Yes: 34.0	Yes: 36.4	Yes: 38.8	Yes: 41.2
13	Yes: 62.4	Yes: 63.0	Yes: 60.6	Yes: 58.2	Yes: 55.7
14	Yes: 59.9	Yes: 60.5	Yes: 58.1	Yes: 55.7	Yes: 53.2
15	Yes: 50.3	Yes: 53.2	Yes: 49.8	Yes: 48.2	Yes: 45.9
21	Yes: 62.1	Yes: 62.4	Yes: 60.0	Yes: 57.5	Yes: 55.1
25	Yes: 49.6	Yes: 49.4	Yes: 51.8	Yes: 54.2	Yes: 56.6
31	Yes: 58.0	Yes: 58.3	Yes: 55.9	Yes: 53.5	Yes: 51.1
34	Yes: 62.1	Yes: 62.1	Yes: 59.7	Yes: 57.3	Yes: 54.9
36	Yes: 66.4	Yes: 67.1	Yes: 64.7	Yes: 62.3	Yes: 59.9
37	Yes: 64.9	Yes: 65.3	Yes: 62.9	Yes: 60.5	Yes: 58.0
38	Yes: 82.1	Yes: 82.2	Yes: 79.8	Yes: 77.3	Yes: 74.9

This table shows counterfactual simulations for referendum support associated with alternative referendum-day rainfall

Table 6 Characteristics of voters versus non-voters

Variables	Will vote in next election (yes = 1/ no = 0)
Supports right-leaning parties	0.10825***
	(0.00804)
Attends church	0.06870***
	(0.00878)
Weekly wage (in 000s euros)	0.00015***
	(0.00002)
Age (in years)	0.00245***
	(0.00022)
Observations	5332

The table shows the marginal effects from a probit model. The dependent variable equals 1 if respondents indicate they will vote in the next election, and zero if they indicate they will not vote. Standard errors in parentheses ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$

could have been enough to overturn high-profile referendum results relating to divorce and abortion liberalization.

Appendix

See Figs. 2, 3 and see Tables 7, 8, 9.

Acknowledgements We thank participants of the 2022 Public Choice Society Conference and the 2021 Political Studies Association of Ireland Conference, as well as seminar participants at Maynooth University and Dublin City University for their helpful comments and suggestions. We are grateful to the associate editor and three anonymous referees for their very helpful comments on previous versions of the paper.

Funding Open Access funding provided by the IReL Consortium.

Data availability The data used in this paper can be requested from the corresponding author.

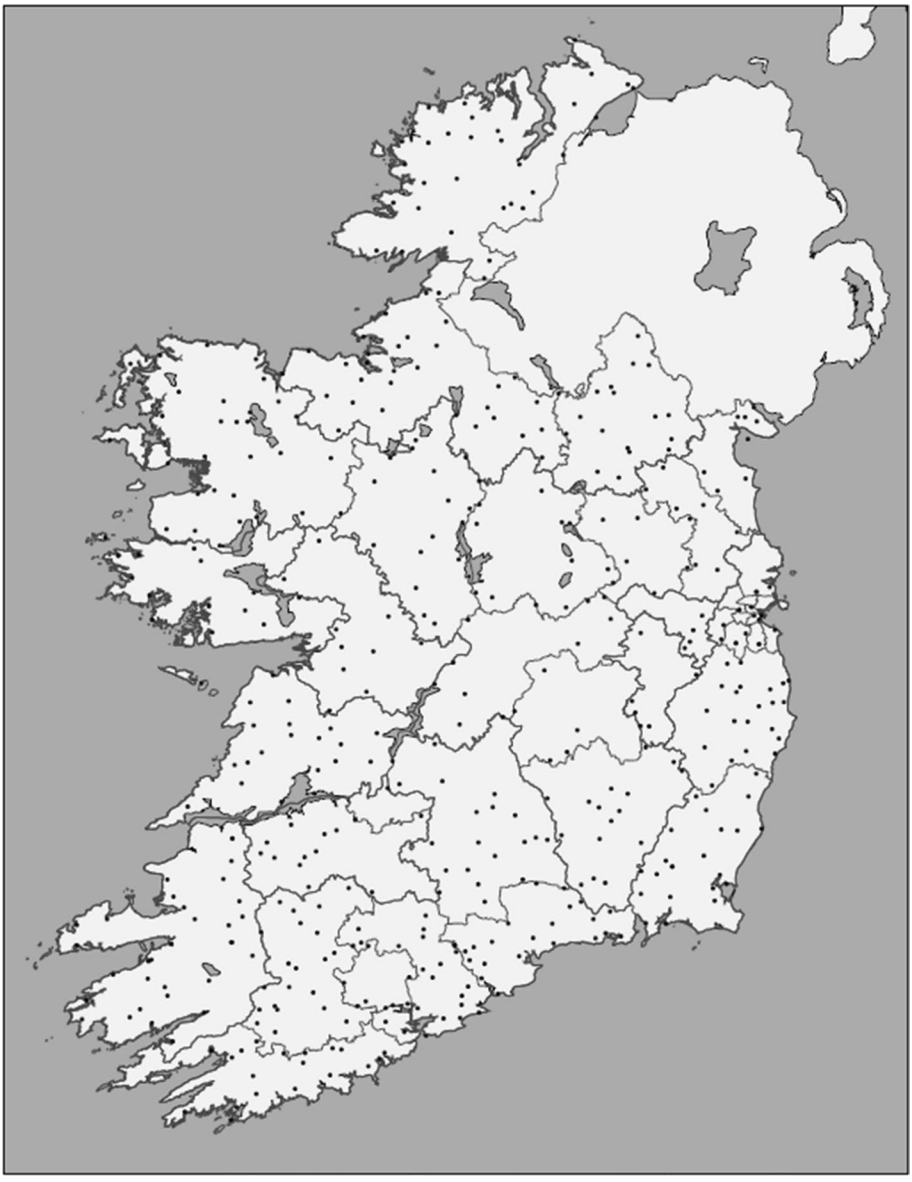

Fig. 2 Map of Met Éireann meteorological stations. (*Note*: lines denote the 2016 General Election constituencies' boundaries).

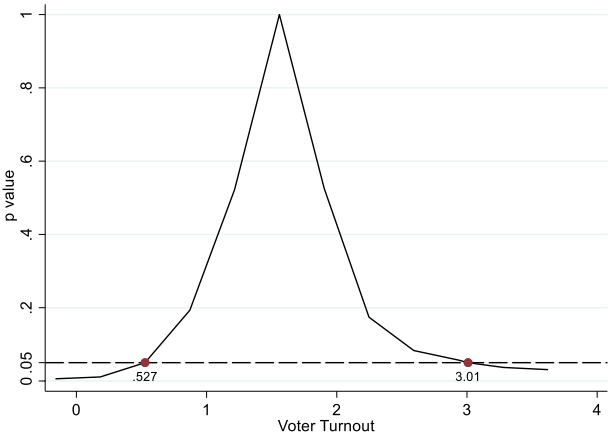

Fig. 3 Testing statistical significance with bootstrapped standard errors. [*Notes*: We test the statistical significance of the estimate of voter turnout on referendum support (Table 4, column (1): estimated impact of 1.56). We implement the bootstrapping technique using Stata's *boottest* command, using 999 replications (the default number of replications). The graph above shows the confidence set for the null hypothesis for each corresponding *p* value. For example, the 95% confidence set for the null hypothesis is [.527, 3.01]. The estimated impact is statistically significant at 99% confidence (*p* value of 0.007)]

Table 7 Pooled specification with interactions: differences in second-stage coefficients (social vs regime)

Variables	(1) pct_yes
Social # turnout	1.168**
	(0.525)
Social # real income	0.394
	(0.255)
Social # unemployment rate	0.567**
	(0.254)
Social # % retired	−0.249
	(0.204)
Social # % farmers	−0.539***
	(0.0706)
Social # socioeconomic homogeneity	0.538**
	(0.236)
Social # % post-2nd-level	0.0381
	(0.0544)
Social # electorate (in 000s)	0.030*
	(0.016)
Observations	1145
R-squared	0.918

This table shows the interaction coefficients from a pooled specification that includes all observations and a full set of interactions between referendum type (i.e., a social referendum dummy variable) and all other explanatory variables. The coefficients indicate the difference in the estimated effects between social and regime-related referendums shown in columns (1) to (3) of Table 4. Robust standard errors in parentheses, clustered using 26 constituency-based clusters. ***$p<0.01$, **$p<0.05$, *$p<0.1$

Table 8 Robustness of results to excluding high farming intensity constituencies

Variables	(1) Rainfall (full sample)	(2) Rainfall (exclude farmer > 25%)	(3) Referendum support (full sample)	(4) Referendum support (social)	(5) Referendum support (regime)
Voter turnout (%)			1.838**	2.445**	0.281
			(0.782)	(1.185)	(0.450)
Real income (in 000s euros)	0.081	0.104	0.038	0.764*	0.135
	(0.070)	(0.080)	(0.411)	(0.414)	(0.266)
Unemployment rate	−0.173*	−0.121	0.664***	1.293**	0.241*
	(0.094)	(0.089)	(0.224)	(0.611)	(0.128)
% Retired	0.009	0.003	−0.735**	−0.714*	−0.206
	(0.027)	(0.025)	(0.360)	(0.366)	(0.208)
% Farmers	0.079***	0.045	−0.119	−0.142	0.213**
	(0.021)	(0.037)	(0.188)	(0.170)	(0.096)
Electorate (in 000s)	−0.002	−0.000	0.074*	0.087*	0.017
	(0.005)	(0.005)	(0.043)	(0.048)	(0.018)
Socioeconomic homogeneity	−0.042	−0.128	0.433	1.036	−0.056
	(0.109)	(0.153)	(0.545)	(0.882)	(0.243)
% Post-2nd-level education	0.001	−0.003	0.045	0.176	0.173***
	(0.008)	(0.007)	(0.088)	(0.136)	(0.061)
Constant	−3.286*	−2.480	−23.310	−87.596	−1.044
	(1.678)	(2.247)	(32.711)	(69.494)	(18.080)
Referendum fixed effects	yes	Yes	Yes	Yes	Yes
Province fixed effects	yes	Yes	Yes	Yes	Yes
Observations	1145	1054	1054	393	661
R-squared	0.667	0.611	0.700	0.172	0.948

Column (1) regresses rainfall (in deviations from average) on constituency-level covariates using the full sample. In column (2), the sample is restricted by excluding constituencies where the percentage of farmers exceeds 25%. Columns (3)–(5) show the IV results for the impact of turnout on referendum support for the restricted sample (excluding farmers > 25%)

Table 9 2SLS Second-stage results: social referendums

Variables	(1) 13th & 14th referendums dropped	(2) 12th & 14th referendums dropped	(3) 12th & 13th referendums dropped
Voter turnout (%)	1.980**	2.273***	2.192***
	(0.858)	(0.880)	(0.852)
Observations	361	361	361
R-squared	0.532	0.400	0.438

This table shows the estimated (second-stage) coefficients of the effect of voter turnout on referendum support (% Yes). Column (1) shows results from a specification including all social referendums except the 13th and 14th. In column (2), the 12th and 14th referendums are excluded, and in column (3) the 12th and 13th are excluded. Robust standard errors in parentheses, clustered using 26 constituency-based clusters. ***$p<0.01$, **$p<0.05$, *$p<0.1$

Code availability The code used in this paper can be requested from the corresponding author.

Declarations

Conflict of interest No potential conflicts of interest.

References

Andrews, I., Stock, J. H., & Sun, L. (2019). Weak instruments in instrumental variables regression: Theory and practice. *Annual Review of Economics, 11*(1), 727–753.

Arnold, F., & Freier, R. (2016). Only conservatives are voting in the rain: Evidence from German local and state elections. *Electoral Studies, 41*, 216–221.

Artés, J. (2014). The rain in Spain: Turnout and partisan voting in Spanish elections. *European Journal of Political Economy, 34*, 126–141.

Barrett, G. (2017). The use of referendums in Ireland: An analysis. *The Journal of Legislative Studies, 23*(1), 71–92.

Bhatti, Y., Dahlgaard, J. O., Hansen, J. H., & Hansen, K. M. (2017). How voter mobilization from short text messages travels within households and families: Evidence from two nationwide field experiments. *Electoral Studies, 50*, 39–49.

Bloom, N., Bunn, P., Chen, S., Mizen, P., Smietanka, P., & Thwaites, G. (2019). The impact of Brexit on UK firms. *National Bureau of Economic Research*. Working Paper No. w26218. https://www.nber.org/papers/w26218

Bound, J., Jaeger, D. A., & Baker, R. M. (1995). Problems with instrumental variables estimation when the correlation between the instruments and the endogenous explanatory variable is weak. *Journal of the American Statistical Association, 90*(430), 443–450.

Cebula, R. J. (2008). Influence of the number of statewide referendums involving emotionally-charged issues on voter turnout, 2006. *Atlantic Economic Journal, 36*(4), 383–393.

Cox, G. W. (1988). Closeness and turnout: A methodological note. *Journal of Politics, 50*(3), 768–775.

Cox, G. W., & Munger, M. C. (1989). Closeness, expenditures, and turnout in the 1982 US House elections. *American Political Science Review, 83*(1), 217–231.
Elkink, J.A., Farrell, D.M., Marien, S., Reidy, T., & Suiter, J. (2020). The death of conservative Ireland? The 2018 abortion referendum. *Electoral Studies, 65*.
Fowler, A. (2013). Electoral and policy consequences of voter turnout: Evidence from compulsory voting in Australia. *Quarterly Journal of Political Science, 8*(2), 159–182.
Fujiwara, T., Meng, K., & Vogl, T. (2016). Habit formation in voting: Evidence from rainy elections. *American Economic Journal: Applied Economics, 8*(4), 160–188.
Garcia-Rodriguez, A., & Redmond, P. (2020). Rainfall, population density and voter turnout. *Electoral Studies, 64*, 102128.
Gomez, B. T., Hansford, T. G., & Krause, G. A. (2007). The republicans should pray for rain: Weather, turnout, and voting in US presidential elections. *The Journal of Politics, 69*(3), 649–663.
Gong, H., & Rogers, C. (2014). Does voter turnout influence school bond elections? *Southern Economic Journal, 81*(1), 247–262.
Hansford, T. G., & Gomez, B. T. (2010). Estimating the electoral effects of voter turnout. *American Political Science Review, 104*(2), 268–288.
Imbens, G. W., & Angrist, J. D. (1994). Identification and estimation of local average treatment effects. *Econometrica, 62*(2), 467–475.
Kaniovski, S., & Mueller, D. C. (2006). Community size, heterogeneity and voter turnouts. *Public Choice, 129*(3–4), 399–415.
Kavanagh, A., Mills, G., & Sinnott, R. (2004). The geography of Irish voter turnout: A case study of the 2002 general election. *Irish Geography, 37*(2), 177–186.
Knack, S. (1994). Does rain help the republicans? Theory and evidence on turnout and the vote. *Public Choice, 79*(1), 187–209.
Kurrild-Klitgaard, P. (2013). It's the weather, stupid! Individual participation in collective May Day demonstrations. *Public Choice, 155*(3), 251–271.
Leslie, P. A., & Barış, A. (2018). Could rainfall have swung the result of the Brexit referendum? *Political Geography, 65*, 134–142.
Lind, J. T. (2020). Rainy day politics. An instrumental variables approach to the effect of parties on political outcomes. *European Journal of Political Economy, 61*, 101821.
Matsusaka, J. G. (1993). Election closeness and voter turnout: Evidence from California ballot propositions. *Public Choice, 76*(4), 313–334.
Matsusaka, J. G. (2005). Direct democracy works. *Journal of Economic Perspectives, 19*(2), 185–206.
Matsusaka, J. G. (2018). Public policy and the initiative and referendum: A survey with some new evidence. *Public Choice, 174*(1), 107–143.
Matsusaka, J. G., & Palda, F. (1999). Voter turnout: How much can we explain? *Public Choice, 98*(3), 431–446.
Mellon, J. (2021). Rain, rain, go away: 176 potential exclusion-restriction violations for studies using weather as an instrumental variable. *Available at SSRN 3715610*.
Mueller, D. C., & Stratmann, T. (2003). The economic effects of democratic participation. *Journal of Public Economics, 87*(9–10), 2129–2155.
Muller, S., & Regan, A. (2021). Are Irish voters moving to the left? *Irish Political Studies, 36*(4), 535–555.
Riker, W. H., & Ordeshook, P. C. (1968). A theory of the calculus of voting. *American Political Science Review, 62*(1), 25–42.
Rudolph, L. (2020). Turning out to turn down the EU: The mobilisation of occasional voters and Brexit. *Journal of European Public Policy, 27*(12), 1858–1878.
Simon, C. A., Matland, R. E., Wendell, D. G., & Tatalovich, R. (2018). Voting turnout and referendum outcomes on same-sex marriage, 1998–2015. *Social Science Quarterly, 99*(4), 1522–1534.
Sinnott, R. (1995). *Irish voters decide: Voting behaviour in elections and referendums since 1918*. Manchester University Press.
Søberg, M., & Tangerås, T. P. (2007). Voter turnout in small referendums. *Electoral Studies, 26*(2), 445–459.
Staiger, D., & Stock, J. H. (1997). Instrumental variables regression with weak instruments. *Econometrica, 65*(3), 557–586.
Wang, W. (2021). *Wild bootstrap for instrumental variables regression with weak instruments and few clusters, MPRA Working Paper 106227.*