



Could rainfall have swung the result of the Brexit referendum?

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ABSTRACT

Previous studies have shown that weather conditions may affect voter turnout, sometimes in ways that could plausibly swing the result of a close election. On the day of Britain's EU Referendum, the presence of torrential rain in the South-East of England and Northern Ireland raised concern in the media that voter turnout could be affected in a manner that favoured the Vote Leave campaign. To test this assertion, this paper takes data at the polling district level and overlays interpolated rainfall data using geographic information system (GIS) technology. Despite widespread expectations to the contrary, our analysis shows that the rain had the greatest effect on the leave vote, reducing the Brexiteer tally by as many as 4618 votes in one district. We find that if the referendum had taken place on a sunny day, there would have been a small increase in the margin of victory for Vote Leave.

Introduction

Torrential rainfall on the day of the Brexit referendum severely affected parts of the United Kingdom, particularly South East England, London and Northern Ireland. The Met Office issued an amber warning and the London Fire Brigade reported that it had responded to more than 400 incidents, including rescuing residents by boats (London Fire Brigade, 2016). The BBC published images of water “up to six inches deep” at polling stations (BBC News, 2016a) as reports emerged throughout the day that several referendum polling stations had closed because of flooding (Smith, 2016) and that rainfall had caused severe damage to property in the Kent districts of Canterbury, Swale and Thanet (ESWD, 2017). As a result of extensive rail disruption, thousands of commuters were stuck at central train stations across London before the polls were closed. Most notably, Waterloo train station in London, which serves up to 250,000 passengers per day, was closed after rainfall threw services into chaos (Tran, 2016). The severity of rain on polling day caused media reports to question whether the weather could affect the turnout of the referendum (Aron, 2016; Knapton, 2016). Following press speculation and several studies of the electoral effects of rainfall,¹ we address the question: could rainfall have changed the result of the UK's EU Referendum?

In this study we use fine-grained radar data on rainfall between 6 am and 10 pm on 23rd June 2016, a measurement window that allows

us to measure the effect of rainfall just before and during voting hours (7 am–10 pm). Rainfall was highly variable across the UK with much of the day's rain concentrated around London the South-East, Northern Ireland and parts of western Scotland, all areas that predominantly supported remain. The district of Hartsmere, some 15 miles north of London, experienced the heaviest downpour with 22 mm of rain over the 16 h period, nearly half the total expected rainfall in June of around 50 mm (Met Office, 2016).²

The distribution of rainfall on polling day warrants proper investigation of the intriguing question posed originally by media commentary, but also poses sizeable challenges to estimate the effect of rainfall at the district level and to assess its effect on the referendum result itself. We employ techniques developed to accurately model compositional electoral data (Tomz et al., 2002). We leverage recent innovations in statistical analysis (Fong, Hazlett, & Imai, 2017; Imai & Ratkovic, 2014) to improve balance on pretreatment covariates – a problem caused by the lopsided distribution of rainfall. We also use post-estimation techniques that allow us to determine the effect of rainfall on vote share through both differential turnout and by the recently defined ‘vote-shift’ channel (Horiuchi & Kang, 2017), by which rainfall causes undecided voters to change their mind through its effect on mood.

Our findings suggest that rainfall had a statistically significant but substantively inconsequential effect on the referendum. Our estimated

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¹ See Gomez et al. (2007), Persson et al. (2014), Eisinga et al. (2011), Knack (1994), Horiuchi and Kang (2017), Bassi and Williams (2017), Fraga and Hersh (2011), and Gatrell and Bierly (2002).

² Rainfall over the 24 h period showed even greater extremes, with 50 mm (roughly 2 inches) or more experienced by 8 London Boroughs.

rainfall effect is slightly in excess of existing estimations in the literature. More interestingly, we find that rainfall affected the leave vote more acutely than remain. This result refutes the conventional wisdom that leave supporters were more committed than remain supporters. Indeed, Nigel Farage – UK Independence Party (Ukip) leader and persistent campaigner to leave the EU – claimed that his voters would “crawl over broken glass” to vote for Brexit (BBC News, 2016b). Despite this, we find that a counterfactual election day in which no rain fell would have produced a slightly altered but much the same substantive result – a win for Vote Leave by a margin exceeding 1 million votes.

Rainfall, elections and the EU Referendum

Rainfall is among a set of variables commonly believed to affect the propensity to vote through its impact on the cost of voting as described in the rational voter model (Downs, 1957; Merrifield, 1993; Riker & Ordeshook, 1968). Accordingly, dedicated studies of rainfall and elections generally find a negative effect on turnout, but the extent to which rainfall substantively changes election results is far less certain. Eisinga, Te Grotenhuis, and Pelzer (2011) measure the effect of rainfall in the Dutch context between 1971 and 2010 and find that 25 mm of rainfall is indicative of a 1.02% percentage point decrease in the level of voter turnout. In the case of the United States, Gomez, Thomas, Hansford, and Krause (2007) find that an inch of rainfall decreases turnout by 0.98%, Horiuchi and Kang find a turnout decrease of 1.16% for every inch of rainfall and Gatrell and Bierly (2002) find that rainfall depressed turnout in Kentucky Primary elections. However, Persson, Sundell, and Öhrvall (2014) integrate the posited costs of high rainfall into the rational voter model and find that rainfall had no substantive negative effect on turnout in Swedish elections between 1976 and 2010.

The discrepancy in findings is likely due to a number of factors, notwithstanding considerable variation in data collection and measurement. Firstly, voter characteristics may contribute to heterogeneous treatment effects. Studies of differential turnout argue that differences in voter commitment between US political parties condition how damaging rainfall is to voter turnout in each political group (Gomez et al., 2007; Horiuchi & Kang, 2017). According to Gomez et al., “bad weather may be the last straw for peripheral voters, and according to the conventional wisdom, these voters may be disproportionately inclined to support the Democratic presidential candidate” (Gomez et al., 2007, p. 658). Similarly, Knack (1994) finds that the negative effect of rainfall on turnout is limited to voters with low levels of civic duty, contributing to the expectation that parties relying on such voters in greater numbers will be more susceptible to the effect of inclement weather.

Secondly, electoral systems and circumstances appear to matter. Where systems are proportional and political participation is high (Persson et al., 2014), the cost of voting is lower than in other systems, since votes are less likely to be redundant than in single member districts. In such cases, voters are less likely to conclude that the discomfort caused by a walk in the rain is futile. In single member district systems, voters may only feel the same level of motivation in districts where the election race is considered close (Fraga & Hersh, 2011; Shachar & Nalebuff, 1999), diminishing the effect of rainfall in marginal districts. Thus, in typical single member district elections, rainfall may have a significant effect on vote share in safe districts without affecting the results for tightly contested seats.

Recently, researchers have extended the analysis of weather events beyond the differential turnout hypothesis to suggest that rainfall may also systematically affect the vote choice of undecided and moderate voters (Bassi & Williams, 2017; Horiuchi & Kang, 2017). The conjecture is that inclement weather affects mood, which according to the predictions of prospect theory (Kahneman & Tversky, 2013) affects risk aversion, resulting in a vote-shift towards candidates seen as the least risky option. Where political options are considered distinct in terms of risk – as is the case in the USA where Democrat candidates are considered the riskier option (Kam & Simas, 2010) – estimates of a vote-

shift channel of the rainfall effect are estimated to account for at least two thirds of the Republican rainfall advantage (Kam & Simas, 2010).

The literature on euroscepticism in Britain provides important information on the demographic structure and political motivation on the Vote Leave campaign, and so sheds light on expectations for differential turnout. On the one hand, the EU Referendum provided the British electorate a vote on an issue substantially different from general elections. Some reports suggested that Vote Leave may have stood to profit from decreased turnout, since it was claimed that Brexiteers had arguably more strongly held beliefs vis-a-vis the European Union and would therefore be more enthused about the prospect of voting (Dunford & Kirk, 2016; Twyman, 2016). Some of this dedication was reflected in the reportage of the referendum itself, with pro-leave voters urging each other to mark ballots with pen instead of the pencils provided in the belief that corrupt election officials would attempt to re-assign pencil marked ballots (Griffin, 2016). If, as discourse suggests, pro-leave voters were more dedicated to their cause, then adverse weather conditions may have given an advantage to the Vote Leave campaign.

However, Ford and Goodwin (2014, p. 152) note that the demographic support for Ukip (the pro-Brexit party) is “anchored in a clear social base: older blue-collar voters, citizens with few qualifications, whites and men”. Low education and social class are typically associated with reduced political engagement in Britain (Hansard Society, 2017) and in other advanced industrial economies (Gallego, 2010; Kasara & Suryanarayan, 2015; Lijphart, 1997), but were strong predictors of Brexit support in the lead-in to the referendum (Twyman, 2016). Studies have shown that once people have become accustomed to voting regularly, they are less likely to be deterred by factors such as rainfall impacting upon their decision to vote (Aldrich, Jacob, Montgomery, & Wood, 2011; Gerber, Donald, Green, & Shachar, 2003). The relative lack of voting habit among important demographics of the pro-Brexit support shows a greater susceptibility of the leave vote to differential turnout in rainy conditions.

Another factor that may indicate a negative effect of rainfall on differential turnout is that older and poorer voters are potentially more likely to be physically deterred by poor weather for reasons of safety or reliance on public transport or walking (Eisinga et al., 2011; Gomez et al., 2007; Knack, 1994, p. 191), though there is little conclusive evidence for this in statistical analysis. Nevertheless, the theoretical expectation remains that the preponderance of older voters in the pro-Brexit camp could have led to a differential turnout caused by a deterrent effect of rainfall on the elderly.

With regard to vote-shift (where marginal voters change their vote choice due to rainfall), the expected direction of effect is clear. Remain, as the least risky *status quo* option (Clarke, Goodwin, & Whiteley, 2017; Harries, 2016, p. 4), should have a significant advantage over undecided voters in rainy conditions (Bassi & Williams, 2017; Horiuchi & Kang, 2017). This expectation is magnified by the parallel expectation that the high issue salience of the referendum should have reduced the effect of rainfall on turnout (Persson et al., 2014). The combination of these expectations is that rainfall may affect the vote share of leave and remain more than it affects turnout. In such a situation, differential turnout cannot account for the entire effect of rainfall on vote share and therefore vote-shift must logically account for some of the difference. In this case we expect vote-shift to benefit the remain vote share – i.e. we expect marginal voters to switch their vote choice from leave to remain because of the poor weather.

We form three hypotheses linking rainfall to the UK's EU referendum result. Our first hypothesis follows the literature on rainfall and elections (H1: rainfall reduces referendum turnout).

Our theoretical expectations for vote share are split into two sub-categories: differential turnout and vote-shift. Theoretical expectations of the effect of rainfall on differential turnout are in conflict – on the one hand, media commentary on the referendum indicated that issue salience and voter commitment was stronger among leave supporters

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