Internet and Politics: Evidence from U.K. Local Elections and Local Government Policies*

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December 2015

Abstract

We empirically study the effects of broadband internet diffusion on local election outcomes and on local government policies using rich data from the U.K. Our analysis suggests that the internet has displaced other media with greater news content (i.e., radio and newspapers), thereby decreasing voter turnout, most notably among less-educated and younger individuals. In turn, local government expenditures (and taxes) are lower in areas with greater broadband diffusion, particularly expenditures targeted at less-educated voters. Our findings corroborate the idea that voters' information plays a key role in determining electoral participation, government policies and government size.

*We are grateful to Timothy Besley, Ruben Enikolopov, Leopoldo Fergusson, Matthew Gentzkow, Gilat Levy, Alessandro Lizzeri, Torsten Persson, Maria Petrova, Andrea Prat, Jesse Shapiro, Francesco Sobbrio, David Strömberg, Frank Verboven, and seminar participants at several universities and conferences for useful comments and suggestions; to Ofcom, to the Oxford Internet Institute, and to the Elections Centre at Plymouth University for providing data.

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1 Introduction

How does the internet affect the electoral process and governments' policies? In recent years, some observers have argued that the internet is responsible, in part, for decreasing political participation, heightening ideological polarization, and reduced checks on governments (Sunstein, 2007). The goal of this paper is to shed light on these issues using detailed data on internet penetration in the U.K. matched with outcomes of local elections and with local governments' policy choices (i.e., expenditures and taxation).

Voters' information plays a key role in the democratic process, helping to hold elected officials accountable to their electorate. Mass media are the primary source of information for voters, enabling them to monitor politicians and to use this information in their voting decisions. The internet has dramatically affected media markets, decreasing the costs of accessing information. At the same time, the internet has increased the availability of many forms of entertainment (such as movies, games and social media), potentially inducing individuals to substitute away from news and from traditional media, thus crowding out their political engagement (Prior, 2007).[1] For example, evidence from the introduction of then-new media in the U.S. shows remarkably different effects: Strömberg (2004b) documents that radio increased political participation, whereas Gentzkow (2006) shows that the introduction of television decreased it.

Moreover, the extent of political participation affects aggregate policy choices. Large increases in suffrage provide, perhaps, the most interesting historical episodes: Lott (1999) examines the growth of U.S. government spending as a result of women's voting rights; Lizzeri and Persico (2004) show that the extension of voting franchise in nineteenth century Britain was associated with an increase in expenditures on local public goods. Similarly, politicians' policy choices react to voters' information: Besley and Burgess (2002) show that the Indian government's responses to disasters is more rapid in areas with greater newspaper circulation; Strömberg (2004b) illustrates that the New Deal's federal spending in the U.S. was higher in areas with greater radio coverage; Snyder and Strömberg (2010) show that U.S. congressmen who receive greater press coverage channel more federal funds to their districts.

[1] Putnam (2000) also argues that television and the internet made leisure more private, thereby reducing social interactions, social capital and voter turnout.

The goal of this paper is to empirically study the effects of internet diffusion on election outcomes, as well as on politicians' policy choices. We exploit the dramatic growth of the internet in the U.K. through a rich dataset that reports the total number of local broadband subscribers in each node of British Telecom's local distribution network.

Our empirical analysis proceeds in three main steps. In the first one, we document broad trends in media markets in the U.K. in the decade 2001-2010. Specifically, since 2005, competition among broadband providers has led to a rapid diffusion of broadband internet among households. Aggregate trends suggest a broad substitution of the internet for traditional media, most notably those media with a greater amount of (local) news content, such as radio and newspapers. Moreover, different demographic groups display stark differences in their news consumption as the internet diffuses: less-educated and younger individuals are less likely than more-educated and older individuals to use the internet to consume news.

This broad evidence spurs our further investigations. Hence, in the second step of our analysis, we delve into the effect of internet penetration on electoral participation by merging our rich database on internet penetration to data on local election outcomes in each electoral ward in England.[2] Our empirical analysis faces one key empirical challenge: potential endogeneity concerns plague the identification of the effects of internet penetration on election outcomes. Internet penetration is correlated with several observable demographic characteristics (such as income and education) that are also correlated with political participation. Hence, it is also possible that some unobservable demographic characteristics could be correlated with both internet penetration and election outcomes.

We seek to resolve these demand-side endogeneity concerns by using two complementary identification strategies. The first one follows the insights of Altonji, Elder, and Taber (2005), as recently extended by Oster (2013), and constructs bounds on the effects of internet diffusion on voter turnout based on the correlation between observable controls and internet diffusion. The second one exploits instruments that affect the supply of broadband internet across different geographic areas and over time. Specifically, several regulatory reports document that the weather affects the costs of providing reliable broadband.[3] For

[2]While we have data on internet penetration for the entire U.K., we have electoral data only for England. Section 3.2 describes in detail our data.

[3]Andersen, Bentzen, Dalgaard, and Selaya (2012) provide evidence consistent with the idea that the

example, the industry regulator Ofcom (2014) describes how the weather contributes to fault levels: "The Environment Agency's Water Situation Reports provide further potential reasons for the rise in fault rates. These indicate ground water and soil saturation levels were much higher than normal in most places for much of the autumn of 2012 confirming the cumulative effect of the rain. [...] It seems likely that higher ground water levels and soil saturation levels may have contributed to the rise in the volume of underground network faults [...] It is likely that these conditions could have led to more underground structures flooding and more faults due to water ingress into failed joints and cables." Similarly, the regulated network operator Openreach (2014) argues: "Openreach access network [...] is vulnerable to a wide range of weather variables (e.g., rainfall, high winds, lightning, etc.). The direct effect of weather damage may be the need to replace or repair assets, and this can be extensive and costly, but highly significant in the context of this market review is the consequential generation of customer fault reports and failures of service to end-users that is perhaps the most relevant issue [...] Openreach's ability to service end-users and access its infrastructure is severely disrupted, and extensive damage is caused to infrastructure both over and underground, causing very high fault intake rates, [...] increased costs, longer travel times and significant health and safety concerns for engineering teams. All directly raising costs for the business. " Hence, we obtain monthly rainfall data from the U.K. Met Office, which we employ as the supply-side instrument that affects penetration across locations and over time through internet service providers' costs, and it is, arguably, uncorrelated with demand-side unobservables.

Both empirical methods imply that greater broadband penetration decreases aggregate turnout. The magnitude of this aggregate effect is non-trivial: the IV estimates indicate that a one-percentage-point increase in household internet penetration (which is broadly the order of magnitude that the local variation in rainfall implies) decreases voter turnout by approximately 0.29 percentage points. The bound based on the OLS estimates is not statistically different from the IV estimate, although slightly smaller in magnitude. Moreover, we find that the decline in electoral participation is concentrated in wards with a higher fraction of individuals who have less education and are younger. Finally, we validate our IV identification strategy through several falsification tests that use data from

weather affects IT diffusion in the U.S.

local elections held before the diffusion of broadband, finding that rainfall had no effect (precisely estimated) on voter turnout in these pre-internet elections.

In the third step of our empirical analysis, we investigate the effect of internet penetration on local governments' policies. To do so, we aggregate our broadband penetration measure at the level of each Local Authority, and then we merge it with data on Local Authorities' public finance choices. Our results indicate that local government aggregate expenditures and local property taxes are lower in areas with greater broadband penetration. The magnitudes of these effects are, again, quite large: the IV estimates indicate a one-percentage-point increase in internet penetration decreases local government expenditures and taxes by approximately 0.6 and 0.75 percent, respectively (again, the bound based on the OLS estimates agrees with the IV estimate). Moreover, we find some evidence that expenditures that target less-educated voters (whose participation declines the most), such as expenditures on social housing and social services, decrease the most, whereas expenditures that target more-educated individuals (whose participation declines the least), such as expenditures on education, decrease the least.

Overall, our empirical results suggest that broadband internet penetration decreases political participation, which, in turn, decreases the size of government, and point to the heterogeneity of these effects across different demographic groups. Thus, our results contribute to several strands of the political economy literature.

First, a growing body of papers study the role of media in politics: Strömberg (2004b), Gentzkow (2006), Larcinese (2007), DellaVigna and Kaplan (2007), Ferraz and Finan (2008), Prat and Strömberg (2005), Snyder and Strömberg (2010), Enikolopov, Petrova, and Zhuravskaya (2011), Gentzkow, Shapiro, and Sinkinson (2011), and Drago, Nannicini, and Sobbrio (2014) investigate how different media affect voters' behavior. In this strand of the literature, particularly related to our paper are the recent contributions of Falck, Gold, and Heblich (2014), who find that internet availability has had a negative effect on voter turnout in Germany; of Campante, Durante, and Sobbrio (2013), who find that broadband had an initial negative effect on turnout in Italian national elections, but, over time, has fostered other forms of online and offline participation; and of Miner (2013), who finds that areas with higher internet penetration in Malaysia experience higher turnout and higher turnover. However, none of these papers considers whether these changes in participation (due to the internet) had any effect on government policies—a key contribution of our paper. Moreover, we rely on novel identification strategies of the effects of internet diffusion, also performing falsification tests using data on elections before the internet developed. The magnitudes of our results are sizable and, thus, our paper complements other recent contributions that find large effects of the media on politics (Martin and Yurukoglu, 2014; Prat, 2014).

Second, our paper also contributes to a strand of literature that connects voters' information and voters' participation to policy outcomes. In addition to the aforementioned papers, Besley and Prat (2006) study the effect of governments' capture of the media on policy choices; Gavazza and Lizzeri (2009, 2011) analyze how voters' information affects taxation and expenditures, and show that greater voters' information could increase both.

Finally, our paper relates to recent work on the determinants of U.K. Local Authorities' policy choices. Most notably, Besley and Preston (2007) show how the electoral system allows parties to choose policies that favor their core supporters; and Lockwood and Porcelli (2013) show that English Local Authorities increased service quality and local taxation after the introduction of an incentive scheme for local governments.

The paper proceeds as follows. Section 2 describes the diffusion of broadband internet in the U.K., as well as broad trends in media and news markets as the internet diffuses. Section 3 describes the organization of U.K.'s local governments and introduces our data. Sections 4 and 5 present our empirical analysis of the effect of broadband internet on local elections and on local government policies, respectively. Section 6 summarizes our interpretation of our findings and concludes. Appendices A and B present a simple model of electoral participation and politicians' policy choices, and additional empirical results, respectively.

2 Internet, Media and News Markets in the UK

The introduction of a new technology, such as the internet, changes people's access to mass media. As in Strömberg (2004b) and Gentzkow (2006), access to new media is often heterogeneous across individuals, and this variation is well suited to studying the effects of the new medium on electoral politics and government policy. The goals of this section are to provide some background information on U.K. broadband markets, and to present some broad trends in media and news markets during the period of the diffusion of broadband internet in the U.K.

2.1 Broadband Market

As in most countries, several different technologies allow households to access the internet in the U.K. From 2000 to 2010, approximately 80 percent of the households with a broadband connection had it through the telephone network and approximately 20 percent through cable networks; fiber operators and mobile broadband operators were almost negligible, used by less than 0.1 percent of the total population.

The U.K.'s telephone network comprises 5,587 nodes, called Local Exchanges (LEs hereafter), that connect directly to houses, with every house connected exclusively to one LE. Each LE (sometimes called the "local loop") aggregates local traffic and then connects to the network's higher levels (e.g., the backbone) to ensure worldwide connectivity, typically through high-capacity fiber lines. British Telecom (BT hereafter) was the monopoly provider of telephone services until 1984 and still maintains a dominant role in U.K. communication markets. While the basic topology of BT's network was set up several decades ago, technology has proven extremely flexible. The old copper technology, until the end of the 1990s, provided low-speed connections via dial-up (i.e., a modem). Without having to change the cables in the local loop, the installation of special equipment in the LEs has allowed the provision of high-speed internet to households. A breakthrough occurred with a technology called ADSL, which uses a wider range of frequencies over the copper line, thus reaching higher speeds. The first major upgrade involved bringing the ADSL technology to each LE in early 2000 and took several years to complete.

In the early 2000s, deregulation also opened the market to entrants by allowing them to provide broadband internet services over BT's existing telephone network. This process involved several steps. First, Ofcom, the British telecom and media regulator, mandated in 2005 that BT split into two separate wholesale entities, Openreach and BT wholesale, along with a retail unit. Openreach maintains the network, while BT wholesale leases broadband lines to entrants. Second, Ofcom required BT to upgrade all LEs to allow entrants to invest in local-loop unbundling (LLU hereafter) technologies to supply internet services.

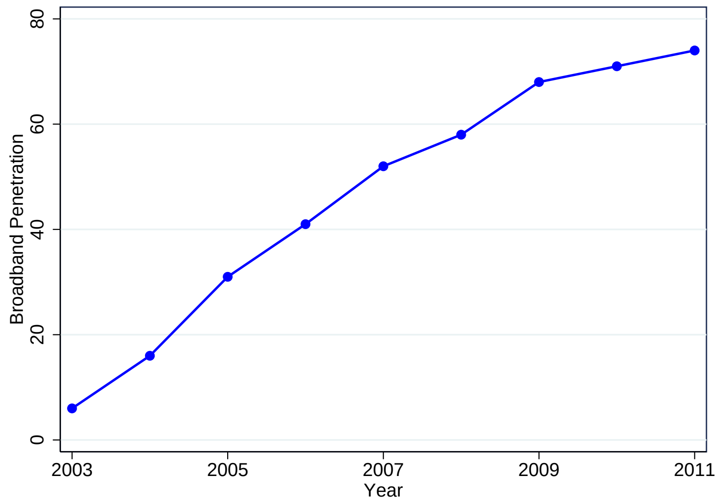

Figure 1: Internet diffusion 2003-2011.

This allowed entrants to install their equipment in the LEs, thereby improving the quality of their services. Third, Ofcom imposed a national wholesale access price for the lease of LLU lines and reduced it (by more than half) in 2004 and again in 2007.[4] Entrants undertook limited LLU investments until early 2005, mostly because the wholesale access price to BT's network was high. This determined a delay in LLU investments in the U.K. compared to other European countries, slowing down households' internet adoption. The entry process took off around 2005, following the separation of BT into Openreach and BT wholesale, and the lower access prices regulated in 2004.

Cable is the main technological alternative to the telephony network. The cable operator Virgin Media deployed its own cable network during the 1990s, primarily for the purpose of selling cable TV. Cable covers approximately 50 percent of U.K. households, mainly in urban areas. The cable network has not expanded since the 1990s, but it was quickly upgraded to support voice and broadband services. The broadband business of Virgin Media has never been subject to regulation. Virgin is not forced by the regulator to let entrants access its network (and Virgin has never done so).

Figure 1 plots Ofcom data on aggregate broadband penetration among U.K. households,

[4]This LLU investment allowed entrants to provide higher-quality services to costumers: Nardotto, Valletti, and Verboven (2015) show that the average download speed of bit-stream is 20.6-percent lower than BT's speed, while the average speed of LLU is 19.1-percent higher than BT's speed.

showing that it quickly expanded after the process of deregulation of the telephony network, increasing from six percent in 2003 to 74 percent in 2011.[5] Of course, the diffusion of broadband internet was not uniform across the U.K., and several demand and supply factors determined different penetration rates across markets and over time. First, local entry of new providers is the main reason for the expansion of broadband internet. In order to recover LLU's large investment, entrants first unbundled the larger and more profitable LE-markets and later expanded to cover a large share of the country.[6] Second, the shape and the extension of the area covered by each LE is an important determinant of entrants' costs, as the actual speed of a connection decays rapidly with the distance from the LE to a premise—i.e., it is very difficult to improve the speed of the internet connection of a home located more than two miles away from its own LE. Finally, rapid technological progress, along with entrants' learning curves, decreased costs over time. Our empirical analyses in Sections 4 and 5 will seek to identify the effects of internet penetration by exploiting weather-related factors that contribute to the costs of supplying reliable broadband across locations, such as heavy rainfall; Sections 3.2 and 4.1 provide more details on these supply-side instruments.

2.2 Internet, Other Media, and News Consumption

The diffusion of broadband internet has heavily affected traditional media (i.e., television, radio, and newspapers). Aggregate trends suggest a broad substitution from traditional media to the internet and, more generally, from text (and audio) to video content. Media with a greater amount of (local) news content seem to suffer the most from this substitution.

TV. The U.K. television market has traditionally been a single market dominated by five national public-service channels (BBC1, BBC2, ITV, Channel 4, and Channel 5) and

[5]At the end of 2009, BT had a retail market share of approximately 28 percent, Virgin Media (the cable operator) had a market share of approximately 22 percent, and the entrants (the main ones are Talk Talk, Sky, O2 and Orange), which supply their services via LLU (71 percent of entrants' subscriptions were provided via LLU in 2009), had the remaining 50 percent of the market.

[6]The catchment areas of LEs are heterogeneous. Unbundled LEs are typically in urban areas and can cover 12,135 households on average, with some LEs in bigger areas with over 50,000 households. LEs that have not been unbundled can reach only 1,243 households, on average. By the end of 2009, at least 86 percent of U.K. lines were in LEs that could be supplied by a new entrant.

several subscription-based channels (e.g., Sky). Local stations played almost no role; only after 2012 (thus after the period of our election data) did the government announce a plan to set up a network of local television stations, similar to the U.S. network-affiliate model.[7] Therefore, TV stations mainly provide national or regional news and play a minor role in most local elections, especially in those of small Local Authorities. Instead, the main sources for local news are radio stations and local newspapers. Generally, there has been a steady per capita consumption of TV of about four hours per day in the decade 2001-2010. Net advertising revenues have also been constant over the same period. However, the time devoted to news on the five public-service channels has decreased from a total of 3,299 hours in 2004 to 2,679 hours in 2011—a 20-percent decline. Meanwhile, subscription channels gained market share by greatly expanding the availability of sports programming, television series, and "reality shows."[8]

Radio. Radio traditionally enjoys a large number of listeners in the U.K. The most prominent national stations are the networks operated by the BBC. A few national commercial channels operate, but most commercial stations broadcast locally, within a radius of 20-50 miles. Some large radio groups own several local radio stations. Ofcom, using data collected by the Radio Joint Audience Research (the official body in charge of measuring radio audiences in the U.K.), reports that BBC radio national/local, which is the biggest supplier of news, experienced a 10.8-percent decline in listeners over the period 2007-2011, mainly due to the decline among young listeners. Commercial radio revenue per listener has been decreasing by almost 20 percent, from £16.59 per listener in 2006 to £13.55 per listener in 2011, implying that fewer resources have become available for news production (these figures exclude the license fee to the BBC). Finally, local radio news could also come from so-called community radio, which refers to a system of licensing small, local, non-profit radio stations. Community radio typically receives funding through grants, donor income, the National Lottery or charities, but these funds declined steadily, by over 25 percent, in

[7] Ofcom awarded licenses to operate local TV "multiplex" on digital terrestrial TV in 2013. The first station (London Live) was launched in April 2104, but it immediately applied to the media regulator to reduce the amount of local programming it had to produce according to its license condition, as it received zero audience ratings for some of its shows with local content. In general, there has been widespread skepticism within the media industry about the commercial viability of this new generation of local TV stations.

[8] All the data about TV, as well as those about radio that we discuss next, are available at http://stakeholders.ofcom.org.uk/binaries/research/cmr/cmr12/UK_3.pdf.

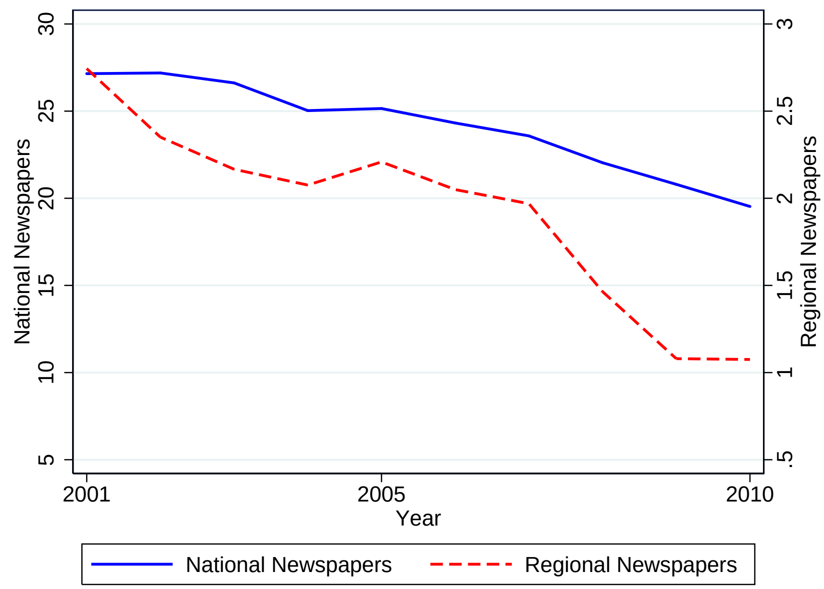

Figure 2: Circulation of National (left scale) and Regional (right scale) Newspapers 2001-2010.

the period 2008-2011.

Newspapers. Newspapers are the media with a richer content about politics, and regional newspapers are the main source of information about local politics. While newspaper circulations had been declining for several years, it seems that the internet has affected print media the most. Specifically, Figure 2 reports broad trends in national and regional newspaper circulations using data from the Audit Bureau of Circulations. From 2001 to 2010, the number of daily copies sold by national newspapers declined by approximately 25 percent. The decline in regional newspapers was even more dramatic: from 2001 to 2011, the number of regional weekly newspapers declined by 35 percent and the average number of weekly copies sold per (surviving) newspaper declined by 50 percent, leading to an overall decline of approximately 65 percent in total weekly copies.[9] Interestingly, Figure 2 suggests that the decline in regional newspapers' circulation was faster after 2005—exactly when internet broadband began to diffuse at a faster rate.

[9]The Audit Bureau of Circulations reports data for daily and weekly regional newspapers. Since most local newspapers are weekly, we report on them, although the trends of daily newspapers are very similar to those of weekly ones.

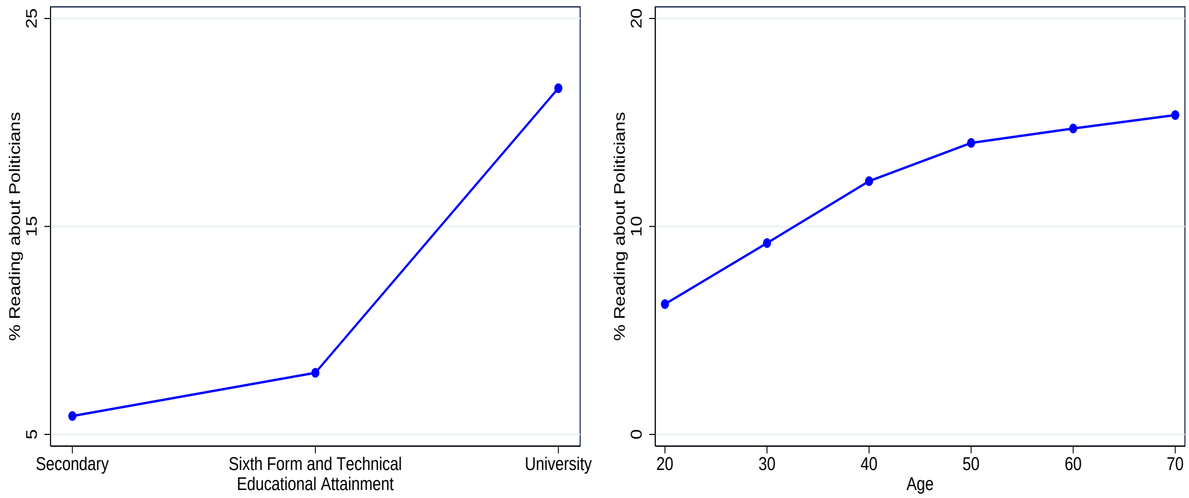

Figure 3: Fraction of internet users reading about politicians, by educational attainment (left panel) and age groups (right panel).

2.3 Internet Use and News Consumption

How do people use the internet? The Oxford Internet Surveys help us answer this question, as they provide useful information about internet use and attitudes in Britain.[10] The 2007 survey (Dutton and Helsper, 2007), at the mid-point of our data, reports that almost everyone uses the internet to communicate—93 percent of internet users reported using emails—and many use it for leisure and entertainment—54 percent reported downloading music, and 48 percent reported playing games. Interesting for our purposes, fewer individuals use it to access news—28 percent of internet users reported reading a newspaper online—and only 11 percent of users reported using the internet to look for information about an MP, local councillor, or politician.

The survey further collects individual demographic characteristics that are useful for understanding the heterogeneity of uses across different demographic groups, perhaps suggesting which demographic groups substituted away from news content the most. The left panel of Figure 3 plots the fraction of internet users who report using it to look for information about a member of parliament, local councillor, political party or candidate.

[10]The Opinions and Lifestyle Survey, administered by the Office of National Statistics, is another source that investigates internet access and use. It displays patterns about internet use across demographic groups very similar to those reported in the Oxford Internet Surveys.

Users are grouped according to their educational attainment, and the figure shows that individuals with a university degree are four times more likely than individuals with only secondary education to use the internet to access this information. Similarly, the right panel of Figure 3 plots the fraction of internet users, grouped by age, who report using it to look for information about a member of parliament, local councillor, political party or candidate, showing that younger individuals are less likely to access this information.[11]

2.4 Summary

Overall, the evidence reported in this section describes some stark changes in media and news markets in the U.K. Since 2005, competition among broadband providers has led to a fast diffusion of broadband internet connections, although with considerable cross-section variation because of the local nature of broadband access. People have taken to the internet, but with no immediate impact on TV consumption. TV is largely a national matter in the U.K., with almost no role for local stations. Yet news production over TV networks declined. Newspapers, the main sources of news, have suffered a more marked decline in sales, particularly among local newspapers. Local radio has also experienced a decline, especially among young people. Moreover, different demographic groups display stark differences in their news consumption as the internet diffuses. Specifically, less-educated and younger individuals do get access to the internet, but they use it much less to consume news, and their overall consumption of news declines.

(We should point out that these changes in media and news markets are not unique to the U.K., but the U.S. and several other countries display very similar patterns; see, among others, Anderson, Waldfogel, and Strömberg, 2015.)

This broad evidence raises the questions of whether internet diffusion has had any effect on political participation and of whether participation has varied across different

[11] Of course, individuals use several media to access news. Ofcom's 2013 survey data report that 78 percent of adults use TV as a source of news; 40 percent use newspapers; 35 percent use radio; and 32 percent use the internet (these figures are available from `http://stakeholders.ofcom.org.uk/market-data-research/other/tv-research/news-2013/`). We should note that, although the Ofcom 2013 survey was administered six years after the aforementioned Oxford Internet Survey—that is, in a much more mature phase of internet diffusion—the percentage of people using the internet as a source of news has not changed dramatically. Different patterns of news consumption across socio-economic groups also stand out. Specifically, the survey reports that news consumption increases with social status (i.e., income and education) and age.

socio-economic groups, as their news consumption has. Furthermore, Appendix A presents a simple model that formally shows that politicians' incentives to choose expenditures targeted at specific demographic groups depend on those groups' electoral participation, thus suggesting that the internet may affect policy choices, as well (see, also, Strömberg, 2004b). The next sections empirically investigates these issues.

3 Empirical Context: U.K. Local Government

Local governments' elections and policies provide an ideal laboratory in which to analyze electoral participation and government responses. Specifically, local elections and policies usually exhibit greater variations than national ones; for example, national elections are often dominated by more-general issues (i.e., civil rights, security, foreign policy), as well as partisanship and ideology, which play a smaller role in local elections. Moreover, local elections are often viewed as the paragon of "bottom-up" democracy, selecting civic-oriented representatives with deep community ties (Oliver, Ha, and Callen, 2012).

In this section, we briefly describe the organization of local government and we introduce our datasets. Since the organizations and functions of local government vary between England, Scotland, Wales and Northern Ireland, and our electoral data cover only English wards, we focus on England.

3.1 Local Authorities in England

England is subdivided into nine regions. However, with the notable exception of London, which has an elected Assembly and Mayor, all other regions have limited administrative roles. Below the region level and excluding London, England has two different patterns of local government in use: single and two-tier authorities. London and other metropolitan areas have single-tier Local Authorities (LAs hereafter), and most rural areas have two-tier LAs. This distinction persists for historic reasons, and the most recent administrative reorganizations consolidated several two-tier LAs into single-tier ones. In two-tier LAs, district councils (lower tier) deal with public housing, local planning and development applications, leisure and recreation facilities, waste collection, environmental health, and revenue collection; county councils (upper tier) deal with education, strategic planning, transport, highways, fire services, social services, public libraries, and waste disposal. Single-tier LAs deal with all of these functions together. As of 2014, there were 152 single or upper-tier LAs in England—i.e., 55 unitary authority councils, 36 metropolitan borough councils, 32 London borough councils, 27 county councils, the City of London Corporation, and the Council of the Isles of Scilly—and 326 lower-tier LAs—i.e., 201 non-metropolitan district councils, 55 unitary authority councils, 36 metropolitan borough councils, 32 London borough councils, the City of London Corporation, and the Council of the Isles of Scilly.

The council is the governing body of each LA. The size of the council varies mainly according to population: it has an average of 49 seats and a standard deviation of 12 seats. Councils are divided into wards (on average, 23 wards per council), which are the primary unit of the electoral system; as of 2014, there were 7,707 wards in England. An independent commission determines wards' boundaries, adjusting them to account for changes in population, with the goal of keeping the number of eligible voters in each ward approximately constant. Each ward holds first-past-the-post elections, returning between one and three members to the local council. Finally, single and two-tier LAs differ in their electoral cycles. London boroughs and county councils elect all their members at a single election every four years, whereas metropolitan districts elect a third of their members on a rotating basis in each of three out of four years. Shire districts can choose either system.

The most important source of funding of LAs' expenditures are block grants from the central government. LAs also collect local taxation through the Council Tax, which is based on residential property and accounts for approximately 25 percent of LAs' revenues. This local taxation is of great importance for local politics, as it is highly visible to residents, and it constitutes the only source of funding to finance current spending. LAs cannot borrow to finance current spending, but they can do so to finance capital investments.

3.2 Data

Our empirical analysis focuses on the link between internet diffusion, voting behavior and administration of local governments in England for the years 2006-2010.[12] To this goal, we combine data on the outcome of local elections and on the budgetary decisions of LAs with

[12]It is important to note that an online voter registration system was introduced in the U.K. only in June 2014, so in our data the internet did not affect electoral registers.

data on the diffusion of broadband internet. We further complement these main datasets with additional data on the demographic composition and the geographic and weather characteristics of each area. These weather variables affect the costs of supplying reliable internet broadband and, thus, constitute the supply-side exogenous instruments that allow us to identify the effect of broadband internet. We now describe our data sources.

Data on LAs' Elections and Budgets. We collect data on the outcomes of all local-council elections that took place in England from 2006 to 2010 from the Elections Centre at Plymouth University. For each ward, the data report turnout, number of eligible voters, and each party's votes. The data report the party (if any) that holds more than half of all seats in the council, in which case we consider the party as in control. (We will also use data from all the local-elections held from 1996 to 2000—i.e., before the diffusion of broadband—to perform falsification tests that validate our identification strategy.)

We further gather yearly panel data on taxes and expenditures of 114 (out of the 152) single and upper-tier LAs, over the period 2006-2010: these are all the LAs for which we can track consistent public finances data throughout these years. Thus, we exclude two-tier LAs, as separate bodies make decisions over taxes and expenditures; 27 county councils, since they have different and fewer functions (as well as smaller budgets) than other single and upper-tier LAs; and single-tier LAs that were reorganized in 2008-2009.[13] The data report several broad categories of net current expenditures, including education, social services, housing services, transportation, and police. Since different LAs sometimes pool resources to jointly provide some services, such as transportation and police, we use the sum of current expenditures on education, on social services, and on housing services to define per capita aggregate expenditures.[14] These expenditures, together, account for approximately 75 percent of total net current expenditures. Moreover, we use the per capita

[13]New LAs have been created in Cornwall, Durham, Northumberland, Shropshire and Wiltshire. Cheshire split into two LAs: Cheshire East, and Cheshire West and Chester. Bedfordshire split into Bedford Borough and Central Bedfordshire.

[14]The Health and Community Care Act 1990 defines social services (or social care) as the provision of social work, personal care, protection or social support services to children or adults in need or at risk, or to adults with needs arising from illness, disability, old age or poverty. The Act establishes the following aims for social services: to protect people who use care services from abuse or neglect; to prevent deterioration of or promote physical or mental health; to promote independence and social inclusion; to improve opportunities and life chances; to strengthen families and to protect human rights in relation to people's social needs.

local Council Tax requirement, which is the per capita amount that a local authority collects through the Council Tax.[15] We deflate all values using the GDP Price Deflator, with 2005 as the base year.

Data on Internet Penetration. Ofcom, the U.K. communication regulator, collects quarterly information on several characteristics of the broadband market in fine geographic detail. Specifically, for each LE, which constitutes the smallest local market in the broadband industry, Ofcom collects the number of providers of broadband internet services, the number of subscribers for each of these providers, the availability of cable technology, and the number of cable subscribers. The Ofcom data also allow us to construct the exact local catchment area of each LE, as they include the complete list of full postcodes that each LE covers.[16] This is a rather unique characteristic of our dataset that, to the best of our knowledge, was not available in previous work on internet (and, perhaps more generally, new media) diffusion and political outcomes. These catchment areas depend on the topology of BT's network that was built around the 1930s for analog voice telephony. Local networks were constantly upgraded with technological advancements, but the catchment areas essentially have not changed for more than 80 years. We should point out that LEs' catchment areas determine competition and regulation in telecoms, but are not used for any other purpose (i.e., they are not used to define statistical units or school catchment areas). We further use some network characteristics, such as the average distance to the premises from the LE and the distance between the LE and the network backbone, as control variables in our regressions.

Data on Demographic, Geographic and Weather Characteristics. We obtain socio-demographic characteristics from the Census both for each ward and for each Local Authority: the age structure of the population, the ethnic composition, the fraction of individuals with high education (i.e., with a bachelor's degree or higher), and the fraction of individuals with high socio-economic status.[17] We also collect transaction prices of all

[15]The Council Tax is calculated as follows. Dwellings are allocated into one of eight bands (letters A to H) on the basis of their assumed capital value. Each LA sets the tax rate, expressed as the annual levy on a Band D property. This decision automatically sets the amounts levied on all types of households and dwellings.

[16]The U.K. is divided into 1.7 million postcodes, with an average radius of less than 100 meters.

[17]The ONS establishes individuals' socio-economic status based on their occupation and employment

residential property from the Land Registry, from which we construct the average prices of all properties transacted in ward i (or in LA I) and at year t.

We further gather geographic data from the Ordnance Survey. From these data, we calculate the $\textsc{Elevation}_i$ of ward i as the absolute elevation above the sea level, measured at the main LE within each ward; this controls for some geographic characteristics—for example, mountainous locations may be declining in population, which may affect political outcomes. We also construct wards' $\textsc{Relative Elevation}_i$ in the surrounding area within a 1.5-kilometer radius[18] as $\frac{\textsc{Elevation}_i - \textsc{Min Elevation}_i}{\textsc{Max Elevation}_i - \textsc{Min Elevation}_i}$, which is an index between zero and one that assays the ruggedness of the terrain in a ward, as this may affect productive activities and, thus, political outcomes (Nunn and Puga, 2012).

Finally, we obtain weather data that we use to construct our supply-side instruments that affect internet penetration across locations and over time. As we highlighted in the Introduction, several regulatory reports document that the weather affects the costs of providing high-quality, reliable broadband, and Section 4 will provide extensive evidence on these effects. Hence, we collect from the U.K. Met Office monthly rainfall data for each location, from which we construct the variable $\textsc{Rain}$, defined as the total rainfall in m/m^2 in the ward (or Local Authority) over the year.[19]

Data Matching. We match all our data by using the electoral boundaries of the wards or of the LAs as our reference geography. While this is straightforward for most variables of our datasets, the Ofcom data on internet diffusion require that we match the LEs and wards (and, then, LAs) whose areas are not exactly overlapping. We perform this match by exploiting the fact that Ofcom provides us with the exact seven-digit postcodes that each LE covers. Thus, we approximate each postcode's internet broadband subscriptions and number of households by assuming that they are equal across all postcodes within an LE's catchment area since postcodes have approximately equal populations. Furthermore, we sum broadband subscriptions and households across all postcodes within a ward. On average, one ward covers an area connected to 2.34 LEs (since the areas are not overlapping),

status, and then further dividing them according to the nature of their employment conditions. These conditions and relations range from higher managerial and professional occupations, through to routine occupations. The ONS classification is available at `http://tinyurl.com/plg3f98`.

[18] We also experimented with different radii, and the results do not change.

[19] The Met Office constructs weather data for each location by interpolating from approximately 4,000 open rain-gauge stations.

with a standard deviation of 1.56 LEs. Finally, we define our main variable of interest INTERNET_{it} as the ratio between the total number of broadband internet subscriptions in ward i in year t and the total number of households in ward i in year t. We further perform a similar aggregation from wards to LAs (on average, one LA has 21.11 wards, with a standard deviation of 5.34) to obtain INTERNET_{It} in LA I in year t.

A related issue is the timing of the variables. U.K. (local and national) elections usually take place in May, and this is always the case in our sample period. We match election outcomes of year t with internet diffusion recorded in December of year $t-1$, and we calculate our instrument RAIN as the cumulative rain between January and December of year $t-1$.

3.2.1 Summary Statistics

Table 1 reports summary statistics of our main variables.[20] Panel A refers to data at the ward level. The top three rows of Panel A report our main variables of interest. Average TURNOUT is quite low, at 43 percent, but the variation is quite large; some of this variation is due to the national elections of 2010, but a large cross-sectional variation persists within each year. The average value of INTERNET across ward-year pairs is 51 percent, with a standard deviation of 12 percent; some of this variation is due to the diffusion of the internet over time, but large cross-sectional variation persists within each year, even across wards within LAs. Similarly, RAIN displays substantial variation: the standard deviation is 0.2, and the range is approximately 12 times larger than the standard deviation; approximately 65 percent of the variance of RAIN is across LAs and 35 percent is across wards within LAs. The middle rows report socio-demographic characteristics of the wards; the bottom rows report election characteristics.

Panel B refers to data at the Local Authority level. The top rows report our main variables of interests. Per capita total expenditures equal approximately £1200, with expenditures on education and social services accounting for most of them (63 and 32 percent, respectively), whereas expenditures on housing services account for less than five percent. Per capita tax requirements equal approximately £350. These figures match those reported

[20]The variables that measure percentages within a ward or LA take on values between 0 and 100 and are denoted with the symbol (%) to distinguish them from indicator variables.

Table 1: Descriptive Statistics

Panel A: Wards (N=14,141)	Mean	Std. Dev.	Min	Max
Turnout (%)	42.69	13.02	9.59	83.25
Internet (%)	50.73	12.09	14.78	100.00
Rain (m/m^2)	0.75	0.20	0.35	2.82
University Degree (%)	39.23	11.55	13.30	90.40
High Socio-Economic Status (%)	31.61	10.38	5.30	67.70
Average Age (Years)	39.86	4.20	22.80	57.00
White (%)	88.47	15.36	6.20	99.80
Employed (%)	62.63	7.33	6.60	83.20
Urban (%)	81.49	38.59	0.00	100.00
Labour Incumbent	0.28	0.45	0.00	1.00
Conservative Incumbent	0.40	0.49	0.00	1.00
Δ Share 1st-2nd Party	22.24	17.00	0.01	100.00
Multiple Vacancies	0.29	0.45	0.00	1.00
Panel B: Local Authorities (N=570)				
Per Capita Total Expenditures	1219.47	200.40	851.37	2213.32
Per Capita Expenditures on Education	773.86	128.53	416.57	1394.95
Per Capita Expenditures on Social Services	387.15	103.54	224.80	1115.77
Per Capita Expenditures on Housing Services	58.47	36.59	2.58	262.32
Per Capita Tax Requirements	349.05	58.27	147.07	568.59
Internet (%)	55.24	12.87	23.32	94.22
Rain (m/m^2)	0.74	0.19	0.40	1.49
University Degree (%)	40.11	9.73	25.80	75.60
High Socio-Economic Status (%)	30.72	8.43	19.00	66.80
Average Age (Years)	38.40	2.34	32.24	44.45
White (%)	79.96	17.08	29.00	98.60
Employed (%)	60.96	4.77	48.60	73.60
Urban (%)	94.58	10.80	45.82	100.00
Labour Majority	0.28	0.45	0.00	1.00
Conservative Majority	0.30	0.46	0.00	1.00

Notes: This table reports the summary statistics of the main variables used in our analysis. Panel A refers to data on wards, Panel B refers to data on Local Authorities.

in the Local Government Financial Statistics for England 2012-13, as well as those reported by Besley and Preston (2007). The average value of Internet across LA-year pairs is approximately 55 percent, with a standard deviation of 13 percent. The average value of Rain is similar to the one across ward-year pairs, but the standard deviation and, most notably, the range are smaller. The middle rows report socio-demographic characteristics of the LAs; the bottom rows report variables that capture the political composition of the council.

Overall, our data provide a rich description of broadband internet penetration in England in fine geographic detail, allowing us to precisely match them to other data. Thus, our data are ideally suited to investigating the effects of internet penetration on voter turnout and local councils' policy choices. We now turn to these analyses.

4 The Effect of the Internet on Local Elections

In this section, we investigate the effect of internet penetration on local-election outcomes. The basic framework for our analysis is the following equation:

$$Y_{it} = \beta \text{INTERNET}_{it} + \gamma X_{it} + \delta_I + \eta_t + \varepsilon_{it}, \tag{1}$$

where INTERNET_{it} measures household broadband penetration in ward i and year t; X_{it} is a vector of control variables that includes demographic characteristics, also interacted with polynomials in time, and election characteristics, such as the number of candidates, indicator variables for the party of the incumbent and a measure of "closeness" of the election (i.e., the difference in vote shares between the first and the second party); δ_I are fixed effects for the LA I to which ward i belongs;[21] and η_t are year fixed effects. Y_{it} is the outcome of interest: the (log of) voter turnout. We should point out that our outcome variable is measured at the individual level, whereas our main explanatory variable Internet is measured at the household level (on average, one household includes approximately two eligible voters).

The inclusion of LA (and year) fixed effects in equation (1) implies that we are iden-

[21] In the case of wards in two-tier LAs, we include fixed-effects for the upper authority.

tifying the effect of INTERNET on election outcomes exploiting exclusively local variation across different wards within the same LA (we cannot include ward fixed effects, as our data do not include multiple elections for more than 40 percent of the wards). Moreover, we include in X_{it} interactions between the main demographic characteristics of the ward obtained from the 2011 Census and a fourth-order polynomial in time. These interactions control flexibly for differences in the evolution of the determinants of electoral outcomes that may be correlated with internet diffusion. Specifically, we include interactions with: the share of population aged between 18 and 44; the share of whites; the share of population with higher education; the share of population employed; the share of population with a high socio-economic status; and the share of the ward that is classified as urban.

Nonetheless, a key challenge to estimating equation (1) remains: our main explanatory variable INTERNET_{it} may still be correlated with unobserved ward-level variables that could affect electoral outcomes. Specifically, internet adoption is positively correlated with observable demographic characteristics, such as income and education, that also affect political participation (Wolfinger and Rosenstone, 1980; Sondheimer and Green, 2010). Since our specification may not control for all the determinants of the demand for broadband internet, some unobservable demographic characteristics may confound the interpretation of OLS estimates of the coefficients of equation (1).

4.1 Identification

We address this key identification issues using several complementary strategies.

4.1.1 Bounds Based on OLS

While the OLS estimate of the coefficient INTERNET may suffer from omitted variable bias, we can construct informative bounds based on it.

Specifically, since unobserved demographic characteristics that increase turnout are positively correlated with internet penetration, the OLS estimate of the coefficient of INTERNET in equation (1) is likely to be biased upward. Hence, it should be an upper bound of the causal effect of the diffusion of the internet on voter turnout.

Moreover, Altonji, Elder, and Taber (2005) and Oster (2013) develop a more-formal bound for the omitted variable bias of the OLS estimate under the assumption that selection on unobservables is proportional to selection on observables. Oster (2013) shows that, if selection on unobservables is perfectly proportional to selection on observables, the bound equals

$$\beta^* = \tilde{\beta} - \left[\mathring{\beta} - \tilde{\beta}\right] \frac{R_{max} - \tilde{R}}{\tilde{R} - \mathring{R}}, \tag{2}$$

where $\tilde{\beta}$ is the OLS estimate of β in equation (1)—i.e., the regression with full controls—and $\tilde{R}$ is the corresponding R^2; $\mathring{\beta}$ and $\mathring{R}$ are the estimates of β and the R^2, respectively, of the OLS regression without controls; and R_{max} is generally set to 1.

4.1.2 Instrumental Variables

We further use instrumental variables that affect the supply of broadband internet across different geographic areas and over time. More specifically, our instruments exploit the fact that the weather affects the costs of providing reliable broadband.

Relevance. The Introduction quoted regulatory reports on the effects of rainfall on the reliability of broadband written by Ofcom, the regulator, and Openreach, the regulated network operator. Additional records of the effects of the weather abound, as further reported by internet service providers, as well as by consumers. For example, the provider TalkTalk writes on its website: "Adverse weather conditions like heavy rain and flooding, snow and frost can cause people in the affected area's connections to slow [...] Bad weather can cause cables to corrode or cause shorts, resulting in signals needing to be retransmitted and connections slowing down." Similarly, EE, another provider, writes on its website: "[B]ad weather and electrical interference can all affect the speed of your service." Moreover, *The Financial Times* reports[22] on consumer complaints: "BT will attempt to stem the tide of angry customer complaints about its broadband connections today with plans to employ a further 1,600 engineers to install and repair its copper and fibre network across Britain [...] During periods of heavy rain or snow, the incidence of faults on BT's network rises sharply." In summary, all market participants seem to note that bad weather compromises the quality of broadband service.

Moreover, the regulatory reports delve deeper into the more-specific effects of the weather and their magnitudes. Most notably, Openreach commissioned Deloitte to per-

[22] *Financial Times*, May 19, 2014.

form a systematic analysis of the determinants of fault levels and of fault repair times, and the report (Deloitte, 2013) states: "The results demonstrate a range of correlation coefficients between fault rates by type of fault and weather metrics. The correlation is mainly found in relation to precipitation and humidity [...]" Deloitte (2013) further shows how rain particularly affects the fault rates of broadband lines used for data rather than lines used only for voice. Ofcom (2014) performs a similar statistical analysis, finding that the relationship between rainfall and fault report volumes in the following month has a correlation coefficient of about 0.8. Ofcom (2014, p. 563) also suggests that the increase in the volume of faults reported to Openreach between a dry period (defined as a rainfall of around 50mm in a month) and a particularly wet period (defined as a rainfall of around 150mm in a month) is of the order of 50,000 faults, or 15 percent.[23]

While all these reports document that the weather and, most notably, rainfall affect the reliability of broadband services, the main focus of our analysis is on broadband diffusion. Service reliability affects household broadband uptake, as other vertical dimensions of quality, such as speed, do (Bouckaert, van Dijk, and Verboven, 2010; Nardotto, Valletti, and Verboven, 2015). Indeed, our rich datasets are ideally-suited to understand the direct relationship between rainfall and broadband penetration. Figure 4 displays two maps of England: the left one displays yearly rainfall levels, the right one displays broadband diffusion, both measured in 2006. In both maps, the black lines identify the boundaries of the electoral wards. Using wards as a unit of observation (thus, a population-weighted unit of observation), the correlation between rainfall and broadband penetration equals -0.22.

Since our regression equation (1) includes LA fixed effects, it is important to understand the variability of rain within LAs. We reported in Section 3.2.1 that approximately 65 percent of the variance of rainfall is across LAs and 35 percent is across wards within LAs. Since the overall variability of Rain is high—the standard deviation equals 0.02 m/m^2, approximately one third of the average in the full sample—as the left panel of Figure 4 displays, the residual variation of rainfall within LAs is non-trivial. To appreciate this variation, Figure 5 displays maps of two LAs, one urban, Birmingham (top panels), and one rural, Sefton (bottom panels). The left panels display rainfall levels and the left

[23]Openreach (2014) includes an extensive case study titled: "Recent U.K. Flooding and Implications for Openreach."

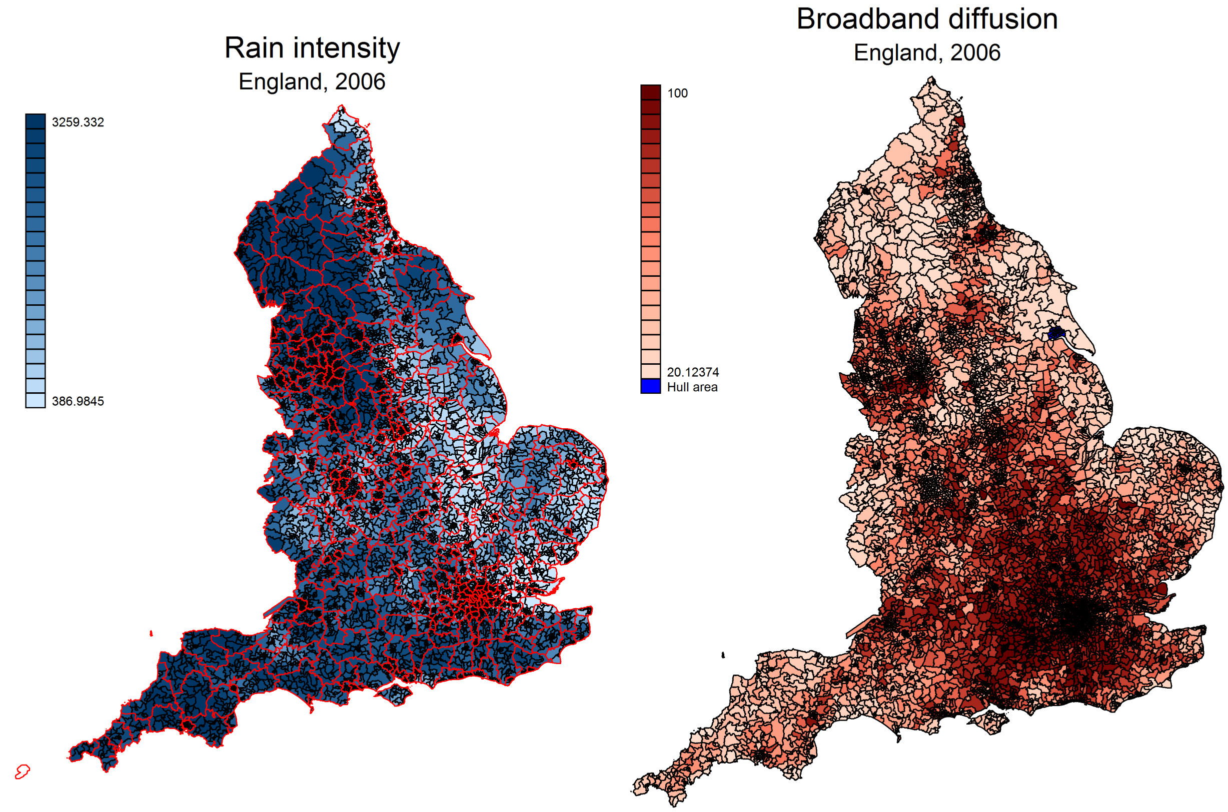

Figure 4: Rain intensity (left map) and broadband diffusion (right map) in England in 2006. The black lines identify the boundaries of electoral wards. The red lines on the left map identify the boundaries of Local Authorities.

panels display internet diffusion across wards within the LAs. These maps provide simple graphical evidence of the variation in rainfall that is typical of the full sample; they also seem suggest that a negative correlation between rainfall and internet diffusion persist across wards within these LAs.

Based on this body of the evidence, we employ instruments based on previous-year Rain as IVs for Internet in equation (1). More specifically, the first-stage regression includes a quadratic function of Rain to allow Rain to affect the costs of supplying broadband in a non-linear way and, thus, to capture the effect of severe weather events.

Exclusion Restriction and Exogeneity. We should point out that we control for the weather during the election period by including the rainfall during the month of the

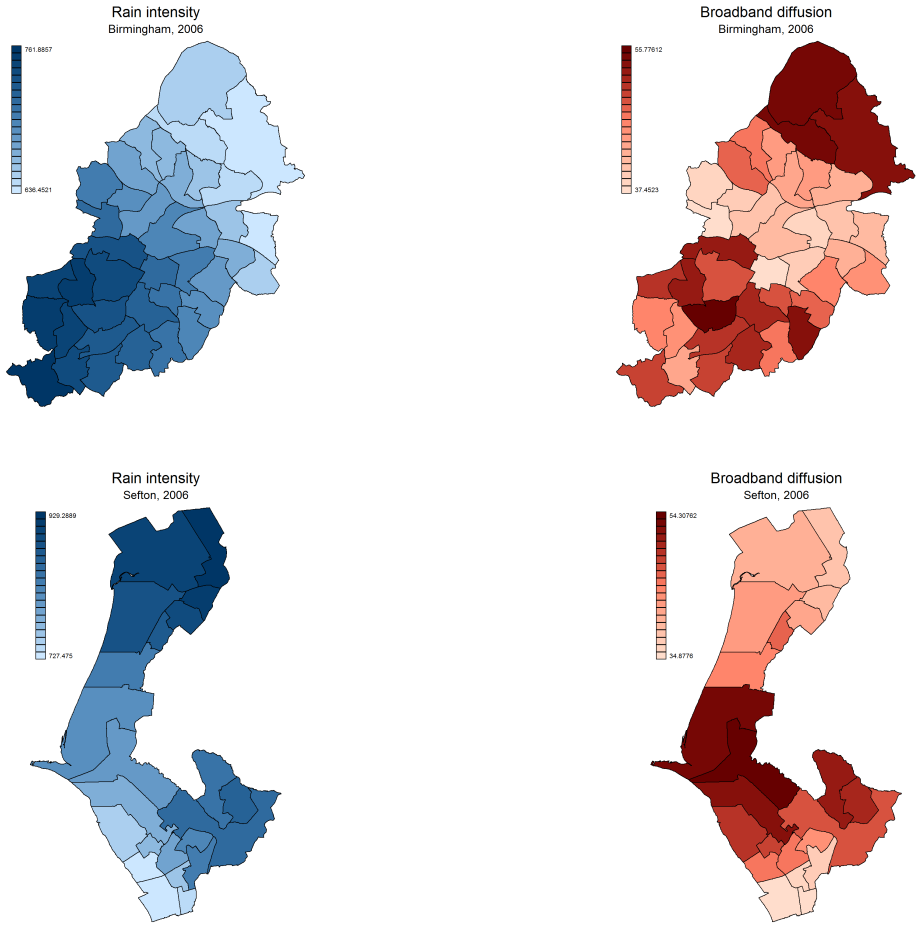

Figure 5: Rainfall (left panels) and broadband diffusion (right panels) across wards within the Local Authorities of Birmingham (top panels) and Sefton (bottom panels) in 2006. The black lines identify the boundaries of electoral wards.

election, thereby capturing any direct effect on the campaign period. Nonetheless, the main potential concerns with our instruments are that: 1) previous-year rainfall directly affects voting patterns—i.e., the exclusion restriction is violated; and 2) some unobservable is simultaneously affecting voter turnout and is correlated with rainfall—i.e., the instruments are not exogenous.

To address these main concerns, we use data on electoral turnout in local elections before the diffusion of broadband internet to investigate whether: 1) rainfall in previous years had any direct effect on electoral turnout in those years (this is equivalent to the "reduced form" of our IV regressions); and 2) electoral turnout before the diffusion of broadband internet anticipates its subsequent diffusion during our main sample period.

Since unobservables that are simultaneously affecting voter turnout and are correlated with broadband penetration (and rainfall, its supply-side shifter) are likely to change smoothly over a longer period of time rather than exclusively as broadband internet diffuses, these falsification tests effectively check for pre-existing trends in the data. In practice, we use data on local elections held in each year t between 1996 and 2000—ten years before our main sample period—matching them with the corresponding data on broadband penetration and rainfall in each year $t + 9$ between 2005 and 2009.

4.2 Main Results

OLS and IV Estimates. Columns (1) and (2) in Table 2 report the results of OLS and IV regressions, respectively, in which the dependent variable is the log of voter turnout in all local elections during the years 2006-2010.[24] The OLS estimates in column (1) indicate that household internet penetration and voter turnout are negatively correlated. As we argued that the OLS estimate of the coefficient of INTERNET should be an upper bound of the causal effect of the diffusion of the internet on voter turnout, this upper bound being negative suggests that broadband internet diffusion among households caused a significant decline in voter turnout.

Moreover, we use the OLS estimates as inputs to construct the bound in equation (2): it equals -0.434 (the values of the components are: $\tilde{\beta} = -.06$, $\tilde{R} = 0.826$, $\mathring{\beta} = 1.19$ and $\mathring{R} = 0.24$). The comparison between the OLS estimates in column (1) and this bound stresses that selection on observables is quite high in our data, perhaps suggesting that selection on unobservables could be high, as well.

Column (2) reports IV estimates. The first-stage regression shows that our instruments are quite powerful: the F-test on the excluded instruments is above 45. The effect of the excluded instruments on broadband diffusion are as expected: a higher amount of RAIN decreases broadband penetration. The magnitude is also of interest: one m/m^2 of rainfall decreases broadband penetration by seven percentage points, on average. Since the within-

[24] We calculate the standard errors by clustering them at the ward level. We also calculated standard errors that take into account the spatial correlation of the residuals following Conley (1999), as rainfall is spatially correlated. Using weights across distances consistent with the findings of Fukuchi (1988) and Burton, Glenis, Jones, and Kilsby (2013), we obtained standard errors adjusted for spatial correlation that are very similar in magnitudes to those reported in Table 2.

Table 2: Internet Diffusion and Electoral Turnout

Dependent Variable: Log(Electoral Turnout)	2006–2010			1996–2000				
	(1)	(2)		(3)	(4)	(5)	(6)	
	OLS	IV 1st	IV 2nd	OLS	OLS	OLS	IV 1st	IV 2nd
Internet	-0.06**		-0.68**			-0.05		-0.03
	(0.03)		(0.29)			(0.05)		(0.40)
Rain		-0.08***		0.00	0.02		-0.07***	
		(0.02)		(0.00)	(0.07)		(0.02)	
Rain^2		0.01		-0.00	-0.01		0.00	
		(0.01)		(0.00)	(0.03)		(0.01)	
University Degree	-0.73*	-0.36***	-0.91**	1.08***	1.08***	1.09***	0.12	1.08***
	(0.41)	(0.10)	(0.41)	(0.37)	(0.37)	(0.37)	(0.10)	(0.37)
High Socio-Economic Status	1.44***	0.67***	1.80***	0.09	0.10	0.11	0.09	0.11
	(0.51)	(0.14)	(0.53)	(0.59)	(0.59)	(0.59)	(0.15)	(0.58)
White	0.44***	-0.06**	0.39***	-0.66***	-0.64***	-0.64***	0.13***	-0.64***
	(0.12)	(0.03)	(0.12)	(0.18)	(0.18)	(0.18)	(0.03)	(0.19)
Labour Incumbent	-0.03***	-0.01***	-0.03***	-0.09***	-0.09***	-0.09***	-0.00	-0.09***
	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)	(0.01)	(0.00)	(0.01)
Conservative Incumbent	-0.02***	-0.00	-0.03***	0.02***	0.02***	0.02***	-0.00	0.02***
	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)	(0.01)	(0.00)	(0.01)
Δ Share 1st-2nd Party	-0.27***	0.01	-0.26***	-0.46***	-0.46***	-0.46***	0.02***	-0.46***
	(0.02)	(0.01)	(0.02)	(0.03)	(0.03)	(0.03)	(0.01)	(0.03)
(Δ Share 1st-2nd Party)^2	0.21***	0.00	0.21***	0.28***	0.28***	0.28***	-0.02	0.28***
	(0.03)	(0.01)	(0.03)	(0.04)	(0.04)	(0.04)	(0.01)	(0.04)
Multiple Vacancies	-0.04***	-0.00	-0.04***	-0.01	-0.01	-0.01	-0.00*	-0.01
	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)	(0.01)	(0.00)	(0.01)
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Demographics $\times$ Time	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
LA Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
F-test			45.322					42.098
R^2	0.826		0.797	0.725	0.724	0.724		0.617
Observations	14141	14141	14141	12570	12582	12582	12582	12582

Notes: The dependent variable is the log of electoral turnout in ward i in year t. Specifications (1) and (2) use data on all local elections during the years 2006-2010. Specifications (3)-(6) use data on all local elections during the years 1996-2000. In specifications (1)-(3), Rain refers to rainfall in year $t-1$; in specifications (4)-(6), it refers to year $t+9$. All regressions further include the fraction of individuals between 18 and 44 years old; the fraction of individuals employed; the fraction of individuals living in urban areas; the average housing price; the Elevation of the ward; the Relative Elevation of the ward with respect to their surrounding areas; the interaction between Relative Elevation and Rain; the average distance between the LEs covering the ward and the backbone, and its square; the average distance between the LEs and the houses, and its square; the number of political parties with at least one candidate; and an indicator variable for the incumbent belonging to a party other than Conservative, Labour or Liberal Democrats (the excluded category). University Degree, High Socio-Economic Status, and White are rescaled to vary between 0 and 1. The standard errors in parentheses are clustered at the ward level. *, ** and *** denote significance at the 10, 5 and 1 percent level, respectively.

LA standard variation of Rain equals .121, the first-stage regression implies that we are identifying the effect of broadband penetration on voter turnout exploiting local variation in Internet that is smaller than its overall variation in the sample: two standard deviations of Rain within-LAs imply approximately a 1.75-percentage-point variation in Internet.

The comparison between the OLS and the second-stage IV estimates reported in columns (1) and (2), respectively, show that the magnitude of the coefficient of Internet is greater in the IV estimates that exploit the variation in internet penetration across wards within an LA due to supply-side factors exclusively, thereby confirming that unobserved demographic characteristics that increase turnout are positively correlated with internet penetration. The IV estimates are also not statistically different from the bound of equation (2), although slightly larger in magnitude, suggesting that selection on unobservables may be more-than-proportional to selection on observables.

Overall, the IV estimates indicate that broadband internet caused a large, significant decline in turnout: column (2) reports that a one-percentage-point increase in household internet penetration (which is broadly the order of magnitude that the within-LA variation in Rain implies) decreases voter turnout by 0.68 percent. Since average turnout equals 43 percent in our sample, this implies an approximately 0.29-percentage-point decline in turnout—a sizable effect.[25]

The coefficients of the demographic variables are mostly consistent with those reported in the literature. More specifically, turnout is higher in wards with a greater fraction of white population, in areas with more people with high-socio economic status (a combination of wealth and education), and in non-urban wards. Similarly, the added controls for election characteristics indicate that turnout is higher in closer elections, although the estimated effect is small: moving from a relatively sure election with a gap of 20 percent between the parties to a more competitive one with a gap of five percent is associated with a 1.1-percent

[25]Since Internet is a household rate and turnout is an individual rate, the coefficient implies that the diffusion of broadband affects the electoral participation of approximately 1.45 out of 10 individuals connected to the internet.

increase in turnout.[26]

Falsification Tests. Columns (3)-(6) in Table 2 report the results of OLS and IV regressions, respectively, of the falsification tests that seek to determine the validity of the exclusion restriction. The dependent variable is the (log of) voter turnout of all local elections during the years 1996-2000. The specification in column (3) shows that the OLS estimate of the effect of previous-year rainfall on turnout is zero, and the standard error indicates that this estimate of zero is very precise. This regression suggests that the exclusion restriction of our main IV results is valid. The regressions reported in columns (4)-(6) indicate that voter turnout does not seem to anticipate future broadband diffusion. Specifically, regression (4) shows that the OLS estimate of the effect of future rainfall on turnout is not statistically different from zero. Similarly, regression (5) shows that the OLS estimate of the effect of future broadband penetration is substantially smaller than the one reported in column (1) and is not statistically different from zero. Finally, regression (6) confirms that the IV estimate of the effect of future broadband penetration is also not statistically different from zero. Hence, we conclude that any changes in voter turnout observed as broadband internet diffuses are not the continuation of pre-existing trends.

Overall, we believe that regressions (3)-(6) provide a powerful validation of our instruments and our identification strategy.

4.3 Results on Subsamples

We further investigate the heterogeneity of the effect of internet penetration on voter turnout in three ways. The first two focus on understanding the effects of internet penetration on voter turnout across different demographic groups that have been differentially affected by the diffusion of the internet. The third one compares the effect of internet penetration on voter participation in local elections in years with and without a national election, respectively.

[26]Our data do not allow us to assess the relative importance of the two main mechanisms through which voter turnout declines as the internet diffuses: a decline in voters' information and, as Putnam (2000) argues, a decline in social capital and civic engagement. However, the descriptive evidence reported in Section 2 is suggestive of an overall decline in voters' information on local politics, and Bauernschuster, Falck, and Woessmann (2014) find no evidence that the internet reduces social capital in Germany. We leave further analysis on U.K. data to future research.

Table 3: Internet Diffusion and Electoral Turnout: Heterogeneous Effects

Dependent Variable: Log(Electoral Turnout)	Low Educated (1)		High Educated (2)		Low median age (3)		High median age (4)		No National elec. (5)	
	IV 1st	IV 2nd	IV 1st	IV 2nd	IV 1st	IV 2nd	IV 1st	IV 2nd	IV 1st	IV 2nd
Internet		-1.33*		-0.15		-1.09*		-0.31		-0.90***
		(0.68)		(0.35)		(0.66)		(0.31)		(0.32)
Rain	-0.06***		-0.11***		-0.06**		-0.11***		-0.08***	
	(0.02)		(0.03)		(0.03)		(0.02)		(0.02)	
Rain^2	0.01		0.01		0.01		0.02***		0.01	
	(0.01)		(0.01)		(0.01)		(0.01)		(0.01)	
University Degree	0.02	0.23	-0.47**	-0.50	-0.19	-0.74	-0.56**	-3.48***	-0.36	-1.30
	(0.17)	(0.72)	(0.18)	(0.75)	(0.12)	(0.50)	(0.25)	(0.82)	(1.53)	(3.26)
High Socio-Economic Status	0.35*	0.76	0.81***	2.17**	0.33**	1.75***	1.17***	4.27***	0.42	4.29
	(0.20)	(0.86)	(0.22)	(0.87)	(0.16)	(0.68)	(0.29)	(0.93)	(1.93)	(4.29)
White	-0.02	0.31**	-0.28***	0.30	-0.11***	0.33**	0.04	0.39	1.04**	1.69
	(0.03)	(0.15)	(0.08)	(0.28)	(0.03)	(0.15)	(0.17)	(0.58)	(0.41)	(2.12)
Labour Incumbent	-0.00**	-0.03***	-0.01**	-0.00	-0.00***	-0.03***	-0.00	-0.04***	-0.00***	-0.04***
	(0.00)	(0.01)	(0.00)	(0.01)	(0.00)	(0.01)	(0.00)	(0.01)	(0.00)	(0.01)
Conservative Incumbent	-0.00**	-0.03***	-0.00	-0.02***	-0.00	-0.01***	-0.00	-0.05***	-0.00	-0.03***
	(0.00)	(0.01)	(0.00)	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Δ Share 1st-2nd Party	-0.00	-0.27***	0.03**	-0.26***	-0.01	-0.31***	0.02*	-0.19***	0.00	-0.31***
	(0.01)	(0.03)	(0.01)	(0.04)	(0.01)	(0.03)	(0.01)	(0.03)	(0.01)	(0.02)
$(\Delta \text{ Share 1st-2nd Party})^2$	0.02	0.29***	-0.03	0.12**	0.04*	0.30***	-0.03	0.12***	0.01	0.27***
	(0.02)	(0.05)	(0.02)	(0.05)	(0.02)	(0.07)	(0.02)	(0.04)	(0.01)	(0.04)
Multiple Vacancies	-0.00	-0.04***	0.00*	-0.04***	0.00	-0.03***	-0.00*	-0.03***	-0.00	-0.03***
	(0.00)	(0.01)	(0.00)	(0.01)	(0.00)	(0.01)	(0.00)	(0.01)	(0.00)	(0.00)
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Demographics × Time	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
LA Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
F-test		11.718		23.543		13.610		25.066		43.852
R^2		0.771		0.814		0.776		0.786		0.506
Observations	9470	9470	4671	4671	9470	9470	4671	4671	11221	11221

Notes: The dependent variable is the log of electoral turnout in ward i in year t. Specifications (1)-(4) and (6) use data on all local elections during the years 2006-2010; specifications (5) uses data on all local elections during the years 2006-2009. Specification (1) uses data from the subsample of wards in which the fraction of individuals with at least a bachelor degree is below the 66th percentile of the distribution across wards; specification (2) above the 66th percentile. Specification (3) uses data from the subsample of all wards in which the median age is below the 66th percentile of the distribution across wards; specification (4) above the 66th percentile. All regressions further include the fraction of individuals between 18 and 44 years old; the fraction of individuals employed; the fraction of individuals living in urban areas; the average housing price; the Elevation of the ward; the Relative Elevation of the ward with respect to their surrounding areas; the interaction between Relative Elevation and Rain; the average distance between the LEs covering the ward and the backbone, and its square; the average distance between the LEs and the houses, and its square; the number of political parties with at least one candidate; and an indicator variable for the incumbent belonging to a party other than Conservative, Labour or Liberal Democrats (the excluded category). University Degree, High Socio-Economic Status, and White are rescaled to vary between 0 and 1. The standard errors in parentheses are clustered at the ward level. *, ** and *** denote significance at the 10, 5 and 1 percent level, respectively.

More specifically, the evidence that we reported in Section 2 indicates that the usage of the internet differs remarkably across individuals, depending on their age and socio-economic status. Therefore, we expect the negative effect of broadband internet penetration on voter turnout to be larger in wards with a higher fraction of individuals with low educational attainment and in wards with a higher fraction of younger individuals. Columns (1) and (2) in Table 3 present the results of IV regressions performed on the subsamples of wards split according to the fraction of residents with at least a bachelor's degree; the subsample used in column (1) includes all wards in which this fraction is below the 66th percentile of the distribution across wards, and that used in column (2) includes all wards in which it is above the 66th percentile.[27] The results reported in column (1) show that internet penetration has a large negative effect on voter turnout in the subsample of wards with a higher fraction of less-educated individuals: a one-percentage-point increase in internet penetration (which is broadly the order of magnitude that the within-LA variation in Rain implies) decreases turnout by 1.33 percent, which represents approximately a 0.57-percentage-point decline in turnout—a large effect. The results reported in column (2) show, instead, that there is no significant effect of internet penetration on voter turnout in the subsample of wards with a higher fraction of highly-educated individuals, and the point estimate is small.

Columns (3) and (4) in Table 3 present the results of IV regressions performed on the subsamples of wards split according to the median age of residents; the subsample used in column (3) includes all wards in which the median age is below the 66th percentile of the distribution across wards, while that used in column (4) includes all wards in which it is above the 66th percentile.[28] The results reported in column (3) show that internet penetration has a large negative effect on voter turnout in the subsample of wards with relatively younger voters: a one-percentage-point increase in internet penetration decreases turnout by 1.10 percent, which represents a 0.47-percentage-point decline in turnout—again, a large effect. The results reported in column (4), instead, show that there is no significant effect of internet penetration on voter turnout in the subsample of wards with

[27] This split guarantees reasonable values of the F-tests on the excluded instruments in both subsamples (although the one in column (1) is marginally low). Other splits deliver similar second-stage results, but have lower first-stage F-statistics.

[28] We choose this threshold again because the resulting subsamples guarantee reasonable values of the F-tests on the excluded instruments, but we obtained similar second-stage results in other subsamples.

a higher fraction of older voters.

We further investigate the heterogeneity of the effect of internet penetration on voter turnout by excluding from our sample all local elections held in 2010 since the U.K. held a national general election on the same day as the local elections. We expect the effect of internet penetration on voter turnout to be larger in the subsample of local elections held from 2006 to 2009 since the general election receives much wider media coverage than local elections. Column (5) of Table 3 reports the IV estimates on this subsample. The absolute value of the point-estimate of the coefficient of INTERNET suggests that the effect of broadband diffusion on voter turnout is indeed larger in years without general election: a one-percentage-point increase in internet penetration decreases turnout by 0.90 percent (versus 0.68 percent in the full sample), which represents approximately a 0.38-percentage-point decline in turnout.[29]

4.4 Additional Results

Appendix B reports on two additional results. First, our identification relies on local variation in rainfall, which determines variation in internet penetration that is of the order of five/six percentage points—a non-negligible magnitude, but smaller than the overall variation in the sample. To compare the magnitudes of our main IV estimates, we use two alternative identification strategies that borrow ideas from other papers in the literature and exploit slightly larger within-LA variation in internet penetration: A) Falck, Gold, and Heblich (2014) exploit the idea that the capacity of ADSL technology depends on the length of the copper wire between the LE and the house. Similarly, Campante, Durante, and Sobbrio (2013) argue that it is more expensive to deploy an optical fiber connection between LEs that are farther away from the network backbone, thereby affecting the pattern of ADSL rollout across different areas. Hence, we present results that use the average distance between the LE and houses in a ward and the distance between the LE and the network backbone as a supply-side instruments. B) Gentzkow (2006) studies the effect of TV introduction on voter turnout, exploiting the fact that individual television stations broadcast over a large area and, thus, reach several small counties when entering into a

[29]We also investigated the robustness of our results excluding all local elections held in wards within the administrative area of Greater London, finding results very similar to those reported in Table 2.

larger city. Hence, sharing the idea that proximity to a large market is uncorrelated with unobserved shocks that affect turnout, demand characteristics of nearby markets are valid instruments for internet penetration, once we control for the same characteristics in a given market (see, also, Fan, 2013). Both alternative identification strategies have strong first-stage results, and the second-stage estimates of the effects of internet diffusion on electoral participation are not statistically different from the estimate reported in column (2) of Table 2. We should point out that the important advantage of our instruments relative to these alternatives is that they display variation over time, which will be key in the analysis of LAs' policy choices of Section 5.

Second, an important question is whether changes in media markets favor incumbents, thereby accounting for their rising advantage; for different media, see, among others, the contributions of Falck, Gold, and Heblich (2014), Gentzkow, Shapiro, and Sinkinson (2011), and Prior (2007). While this is not the main focus of our analysis, our data are, nonetheless, well suited for investigating this issue. The point-estimates suggest a positive effect of internet diffusion on the performance of incumbent parties.

5 The Effect of the Internet on Local-Government Policies

Several influential papers document that the extent of voters' information and of political participation affects aggregate policy choices. For example, government expenditures are higher in U.S. districts in which congressmen receive greater press coverage (Snyder and Strömberg, 2010), and they increased dramatically after large increases in suffrage in the U.S. and in the U.K. (Lott, 1999; Lizzeri and Persico, 2004). Moreover, our simple model presented in Appendix A formalizes the idea that politicians with electoral concerns direct greater public expenditures towards groups of swing voters whose participation more likely changes the election outcome (for related models, see also Lindbeck and Weibull, 1987; Strömberg, 2004a,b).

The evidence reported in previous sections shows that broadband internet diffusion had negative effects on voters' information (Section 2) and on political participation (Section 4). Hence, our evidence from the U.K., along with that of the prior literature documenting that voters' information and participation affect public expenditures, raises this natural followup question: Does broadband internet diffusion affect local-government policies? The above arguments suggest that, as internet broadband diffuses, local councils may set a lower level of expenditures because average voters' information and electoral participation are declining; in turn, taxation may decline, as well.[30] Moreover, Figure 3 and Table 3 show that the diffusion of the internet has differentially affected different socio-demographic groups. Thus, an additional interesting question is whether LAs' expenditures display heterogeneous patterns across different categories, related to how these categories of expenditures target different socio-demographic groups whose news consumption and electoral participation changed as the internet diffused.

The goal of this section is to investigate these issues. To do so, we use an empirical framework similar to that of equation (1). More specifically, our outcome variables are the key fiscal variables that local councils determine in their annual budgets: the (log of) per capita aggregate expenditures in each LA, calculated as the sum of the per capita expenditures on housing services, social services, and education; and the (log of) per capita tax requirements, i.e., the per capita amount that LAs collect through the council tax. We further calculate internet diffusion—along with our instrument Rain and socio-demographic and political control variables—for each LA by aggregating the corresponding variables that we used in the ward-level analysis of electoral turnout.

We further include in our specifications year fixed effects to capture aggregate effects that vary across years; fixed effects for each LA to capture any time-invariant unobserved factor specific to each LA; and indicator variables for the party in control of each LA. This rich set of fixed effects implies that we identify the effect of internet penetration on LAs' expenditures by exploiting only within-LA variation in internet diffusion over time. In practice, since our demographic variables exhibit negligible changes within LAs in the short time period of our sample, LAs' fixed effects absorb the impact of demographic characteristics on LAs' choices of expenditures and taxes.

[30] An alternative hypothesis is that politicians are budget-maximizers, and, thus, LAs' aggregate budget choices may not depend on electoral participation (Niskanen, 1974).

5.1 Identification

Our identification strategies follow closely those that we employed in Section 4, adapted to differences in the data. Specifically, one important difference is that we have panel data for Local Authorities. Therefore, since we include fixed effects in our regressions, the identification of the effect of internet diffusion on LAs' policy choices relies on variation over time within LAs, whereas it relied (mainly) on cross-sectional variation within LAs in our analysis of voter turnout.

Moreover, the aggregation of the data from wards to LAs implies that our empirical analysis of local governments' policy choices faces two challenges, in addition to those we already faced in the analysis of voter turnout. First, it drastically reduces the number of observations—from $14,141$ ward-year observations to 570 LA-year observations—thereby reducing the statistical power of our analysis. Second, it smoothes out some of the cross-sectional variations in our explanatory variables and, most notably, in our instrument RAIN: Panel B of Table 1 reports that its range and its standard deviation are lower across LA-year pairs than across ward-year pairs. Overall, these challenges prevent us from performing a rich analysis on subsamples based on demographic splits (similar to the one that we performed in Section 4). Rather, they prompt us to disaggregate total expenditures into their components that plausibly target different demographic groups.

Overall, since this section will uncover findings that are consistent and complementary to our previous findings of Section 4, we believe that the different variation and the different ways of slicing the data in the analysis of LAs' policy choices, relative to that of voter turnout, buttress the robustness of our findings.

OLS Estimates. The OLS estimate of the coefficient of internet penetration is likely to be biased, since unobserved demographic characteristics that affect expenditures are likely to be correlated with internet penetration. Nonetheless, the OLS estimates may be still be useful to construct bounds.

The direction of this bias is, perhaps, more difficult to determine a priori than in the voter turnout analysis of Section 4. However, internet adoption is positively correlated with observable demographic characteristics of more-informed voters, such as income and education, and several papers document that more-informed voters receive more-favorable policies, often through higher expenditures. Therefore, it seems plausible that unobserved demographic characteristics that increase expenditures may be positively correlated with internet penetration. In this case, the OLS estimate of the coefficient of internet penetration should be biased upward and, thus, should be an upper bound of the causal effect of the internet diffusion on per capita expenditures. Furthermore, we employ these OLS estimates to construct the bound in equation (2).

IV Estimates. We use the instrument RAIN now aggregated at the LA level and, for consistency with our previous ward-level regressions, the same quadratic function that we employed in the first stage reported in Table 2.

5.2 Results

Expenditures. Columns (1) and (2) in Table 4 report the results of OLS and IV regressions, respectively, in which the dependent variable is the log of the per capita aggregate expenditures in LA I in year t.

The OLS estimates in column (1) indicate that internet diffusion and per capita expenditures are negatively correlated. As we argued that unobserved demographic characteristics that affect expenditures are likely to be correlated with internet penetration, the OLS estimate of the coefficient of INTERNET should be an upper bound of the causal effect of the diffusion of the internet on per capita expenditures. This upper bound being negative suggests that broadband internet diffusion caused a significant decline in LAs' per capita expenditures.

We further employ the OLS estimates as inputs to construct the bound in equation (2): it equals -3.386 if we consider the OLS regressions on LA-demeaned data (the values of the components are: $\tilde{\beta} = -.30$, $\tilde{R} = 0.363$, $\mathring{\beta} = .188$ and $\mathring{R} = 0.263$), and -0.314 if we consider the OLS regressions without de-meaning the data from their LA-averages (the values of the components are: $\tilde{\beta} = -.30$, $\tilde{R} = 0.964$, $\mathring{\beta} = 0.147$ and $\mathring{R} = 0.015$). The values of the coefficient $\mathring{\beta}$ that enter into the calculation of the bound are very similar whether we de-mean the variables or not—i.e., they equal .188 or .147, respectively—but per capita expenditures display a large variation across LAs; the LA fixed effects absorb this variation, thereby affecting the calculation of the R^2 of the regressions and accounting for the

Table 4: The Effect of Internet on Local Authorities' Expenditures and Taxes

Dependent Variables:	Log(Expenditures)						Log(Taxes)	
	(1)	(2)		(3)	(4)	(5)	(6)	(7)
	OLS	IV 1st	IV 2nd	IV 2nd Hous. Serv.	IV 2nd Soc. Serv.	IV 2nd Educ.	OLS	IV 2nd
Internet	-0.30***		-0.59**	-2.22	-0.84*	-0.27	-0.27**	-0.76***
	(0.11)		(0.28)	(2.24)	(0.46)	(0.36)	(0.12)	(0.23)
Rain		0.34***						
		(0.07)						
Rain^2		-0.14***						
		(0.03)						
Rel. pos. × Yearly rain		-0.23**	0.04	-0.27	0.00	0.05		0.05
		(0.11)	(0.05)	(0.51)	(0.07)	(0.05)		(0.05)
Conservative Majority	0.01	0.01	0.01	0.06	0.00	0.01	0.01	0.01
	(0.01)	(0.00)	(0.01)	(0.12)	(0.02)	(0.01)	(0.01)	(0.01)
Labour Majority	0.00	-0.00	0.00	0.05	-0.00	0.00	0.01	0.01
	(0.01)	(0.01)	(0.01)	(0.11)	(0.02)	(0.01)	(0.01)	(0.01)
Election Year	-0.00	-0.01***	-0.01	0.01	-0.01*	-0.00	-0.00	-0.01**
	(0.00)	(0.00)	(0.01)	(0.04)	(0.01)	(0.01)	(0.00)	(0.00)
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
LA Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
F-test			15.808	15.808	15.808	15.808		15.808
R^2	0.363	0.968	0.341	0.009	0.080	0.376	0.245	0.141
Observations	570	570	570	570	570	570	570	570

Notes: The dependent variable is the log of LA's per capita: total expenditures in specifications (1) and (2); expenditures on housing services in specification (3); expenditures on social services in specification (4); expenditures on education in specification (5); and tax requirements in specifications (6) and (7). All regressions further include the number of telephone lines in the LA; the number of telephone lines that are also covered by the cable operator; the interaction of relative position with the amount of rainfall; an indicator variable for the party in control other than Conservative, Labour or Liberal Democrats (the excluded category); and an indicator variable if elections were held in LA I in the same year. The standard errors in parentheses are clustered at the local-authority level. *, ** and *** denote significance at the 10, 5 and 1 percent level, respectively.

difference between the magnitudes of these bounds. Overall, the difference in the coefficient of INTERNET between the OLS regressions without any control (which equals either .188 or .147, depending on whether we de-mean the variables or not) and the regressions with controls seems to corroborate that selection on observables is quite high in our data.

Specification (2) reports IV estimates of the regression that treats internet penetration as endogenous. The first-stage regression shows that the instruments are jointly significant and are not weak, although their estimated effect on LAs' internet penetration differs slightly from that on wards'—indeed, the variation exploited is different—but confirm the role of severe weather events, as we reported in Section 1 and 4.1.[31] The absolute value of the (second-stage) IV estimate of the coefficient of internet penetration is larger than that of the OLS estimate in specification (1), indicating that the unobserved demographic characteristics that increase LAs' expenditures are positively correlated with internet penetration. According to the IV estimates in column (2), a one-percentage-point increase in internet penetration (which, we reiterate, is broadly the order of magnitude that the within-LA variation in RAIN implies) decreases local-government expenditures by 0.59 percent. Since per capita total expenditures amount to approximately £1,200, on average, the percent decrease corresponds to a decrease of £7, which is more than 3 percent of one standard deviation of per capita expenditures in our sample—a non-negligible effect.

Columns (3)-(5) in Table 4 further report IV estimates of regressions that focus on the three specific categories of expenditures: the dependent variables are the (log of) the per capita aggregate expenditures in Local Authority i in year t on housing services, social services, and education, respectively. These categories plausibly benefit different socio-demographic groups of the electorate, and our previous analyses showed stark differences in the news consumption and electoral participation of these groups as the internet diffuses. Specifically, expenditures on housing services target individuals with lower incomes (and, thus, less education); expenditures on personal social services also target mainly individuals with lower incomes and, to a smaller extent, provide assistance to elderly with special needs; and expenditures on education, however, appear to target quite different demographic groups than expenditures on housing services and social services, as more-educated and

[31] Specifically, since the second-stage regression controls directly for the interaction of relative position with the amount of rainfall, the coefficients imply that the effect of RAIN on INTERNET is essentially flat up to a level of 0.8 m/m^2; it is then negative when RAIN is above 0.8 m/m^2.

higher-income individuals seem to invest proportionally more in the human capital of their children than less-educated and lower-income individuals (Guryan, Hurst, and Kearney, 2008; Ramey and Ramey, 2010).

The IV point-estimates of the coefficients of internet penetration in these regressions show that all expenditures are lower in LAs with greater broadband diffusion. Moreover, the point-estimates suggest that internet penetration has the largest effect on housing services and social services, which target low-income voters—i.e., exactly the demographic group that the diffusion of the internet affected the most with regard to news consumption and electoral participation. At the same time, internet penetration had the smallest effect (almost zero) on expenditures on education, which are the expenditures that higher-income individuals arguably pay close attention to—i.e., exactly the demographic group that the diffusion of the internet affected the least with regard to news consumption and electoral participation. We should point out that the estimate of the effect of internet penetration on expenditures on housing services is quite imprecise, perhaps because of their overall small amounts.

Taxes. Columns (6) and (7) in Table 4 report the results of OLS and IV regressions, respectively, in which the dependent variable is the log of the per capita tax requirements in Local Authority I in year t. Both specifications include several demographic controls, as well as fixed effects for each LA to capture any unobserved factor specific to each LA. These regressions provide a natural robustness check of the results on expenditures since, through LAs' budget constraints, local taxation should move in the same direction as local expenditures. In addition, since the Council Tax establishes higher tax rates on more valuable properties, by construction, a reduction in tax requirements implies that households that occupy these more valuable properties, such as higher-income and older individuals (Banks, Oldfield, and Wakefield, 2002), pay less taxes.

The results show that taxes are lower in LAs with greater broadband internet penetration, consistent with the results on expenditures. Specifically, we argued that the OLS estimate of the coefficient of Internet in column (6) should be an upper bound of the causal effect of the diffusion of the internet on taxes; the estimate being $-.027$ suggests that broadband internet diffusion caused a significant decline in LAs' per capita taxes. Moreover, the bound of equation (2) based on these OLS estimates equals -3.1637 if we consider the OLS regressions on LA-demeaned data (the values of the components are: $\tilde{\beta} = -.267$, $\tilde{R} = 0.245$, $\mathring{\beta} = .109$ and $\mathring{R} = 0.263$), and -0.278 if we consider the OLS regressions without de-meaning the data from their LA-averages (the values of the components are: $\tilde{\beta} = -.267$, $\tilde{R} = 0.980$, $\mathring{\beta} = 0.274$ and $\mathring{R} = 0.041$). Again, the LA fixed effects account for the large differences between these two calculations of the bounds.

The IV estimates confirm the qualitative effect of internet diffusion based on the OLS estimates, and the magnitudes are slightly larger: according to the IV estimates in column (7), a one-percentage-point increase in internet penetration decreases per capita tax requirements by 0.76 percent, which corresponds to approximately £3, or approximately five percent of one standard deviation of the tax requirements in our sample.

Overall, these results on taxes further corroborate our previous findings that LAs' policy choices seem to favor the demographic groups—i.e., higher-income and older voters—whose electoral participation changes the least as the internet diffuses.

6 Conclusions

Understanding political participation and election outcomes is a major research question within the social sciences. For example, voter turnout is considered fundamental to sustaining the legitimacy of the democratic process (Lijphart, 1997). In turn, election outcomes form the basis for the design of public policy.

In this paper, we investigate how the diffusion of the internet affects voters' information, thereby shaping both election outcomes and public policies. We exploit the dramatic growth of the internet in the U.K. through a uniquely rich dataset that reports the total number of local broadband subscribers in each node of British Telecom's local distribution network. Using complementary identification strategies, our data paint a consistent picture: internet penetration decreases voter turnout, most notably among less-educated and younger individuals; in turn, local-government expenditures (and taxes) are lower in areas with greater broadband penetration, more so those targeted at less-educated voters and less so those targeted at more-educated individuals.

Overall, our findings highlight the effects of the media on electoral politics. They suggest that internet penetration has displaced media with a richer political content (i.e., radio and newspapers). Our findings also buttress the idea that voters' information plays a key role in determining electoral participation, government policies and government size.

In our view, these results lead to at least two observations. The first one is that several countries have enacted policies to decrease the "digital divide" by subsidizing the supply and/or the demand of internet broadband, with the goal of decreasing economic and social inequality between different demographic groups. However, our results suggest that the use of these technologies varies dramatically across demographic groups, and they point to some potentially unintended consequences of such policies, such as increasing the "political divide" between groups. The second observation is that many countries have recently increased the devolution of powers towards local governments. Our results show that participation in local elections has dramatically declined in recent years, in part as the internet has displaced other media with greater local news content, thereby raising the question of the accountability of these decentralized governments.

Finally, we are hoping that future research could address some limitations of this paper. First, our analysis is deliberately descriptive, and we are unable to make statements about the overall welfare effects of our results. Second, while we believe that the main mechanisms underlying our findings—i.e., the substitution from traditional media to the internet—is quite general, we focus on local elections in one country only and during a relatively short period of time, potentially calling into question the external and long-run validity of our results and of their magnitudes.

APPENDIXES

A A Simple Model

The purpose of this appendix is to introduce a simple model that shows formally how the internet can affect the propensity to vote of different groups and, as a result, the policy response of competing parties.

Assume that there are two groups of voters, denoted by L, R (one could think of poor/rich, or young/old), and two competing parties A and B. Parties can implement policies that favor one particular group only. Specifically, party i can offer policies along the real line $D_i \in (-\infty, \infty)$. Group R likes policies to the right of zero, while group L likes those to the left of zero. We assume that policy $D_i > 0$ is liked one-for-one by group R and is equally disliked by group L, and vice versa when $D_i < 0$. Policies are costly, and increasingly so if a party caters to a specific group. We use a cost function $|D_i|^2/2$, identical for each party.

In addition to policies, each group has preferences for parties along a standard unit Hotelling line, where party A is located at 0, and party B is located at 1. Group L (resp., R) also has an ideological bias towards party A (resp., B). This means that, if both parties implement the same policy, they still get more than 50 percent of the votes of their "core" group. We denote by B_j the bias of each group j.

The utility of each member of a group is, thus, determined by the policy, the bias, and the distance from the preferred policy. Specifically, for a member of group R located at x, utility is $D_A - tx$ if voting for party L, and $D_B - t(1-x) + B_R$ if voting for party R.

The timing of the game is as follows:

1. Each party announces its policy D_i and commits to it.

2. Each group decides on the group's turnout (more on this below).

3. Individuals of each group that turn out cast their vote.

4. The party that gets the most votes is elected.

We look for the symmetric subgame Nash equilibrium of this game.

Conditional on turning out, these are the votes for party A from each group (party B gets the complement to 1):

$$\begin{aligned} x_R &= \frac{1}{2} + \frac{D_A - D_B - B_R}{2t}, \\ x_L &= \frac{1}{2} + \frac{-D_A + D_B + B_L}{2t}. \end{aligned}$$

Let us denote by S_j turnout of group j—i.e., the percentage of voters of group j who cast their vote. Party A wins if

$$S_R(2x_R - 1) + S_L(2x_L - 1) \geq \epsilon,$$

where ϵ is an i.i.d. error with zero mean, distributed uniformly on a large enough support $[\frac{-1}{2q}, \frac{1}{2q}]$. Thus, the probability of A winning is

$$\Pr A = 1/2 + q[S_R(2x_R - 1) + S_L(2x_L - 1)],$$

and party B wins with probability $\Pr B = 1 - \Pr A$.

We assume that the each group has mass one. Hence, aggregate turnout equals $(S_L + S_R)/2$.

To close the model, we need to determine who goes to vote at stage 2. We use a rule of ethical voting within each group (see Coate and Conlin, 2004; Feddersen and Sandroni, 2006). Each citizen belonging to group j has a cost of voting that is uniformly distributed, $c_j \in [0, C_j]$. The rule of ethical behavior consists of a threshold c_j^* such that all citizens with $c_j \leq c_j^*$ vote. The group chooses this threshold to maximize the group's expected utility. Since $S_j = \frac{c_j^*}{C_j}$, group R chooses the threshold c_R^* to maximize the following group utility (the expression for group L is similar):

$$\Pr A \cdot D_A + \Pr B \cdot (D_B + B_R) - \frac{{c_R^*}^2}{2C_R}.$$

Note that the policy of the winning party applies to every member in a group (even if they do not vote), while the costs are paid exclusively by those who vote, $\int_0^{c_R^*} \frac{c_j}{C_R} dc_j = \frac{{c_R^*}^2}{2C_R}$. The maximization results in thresholds that determine the turnout of the groups:

$$\begin{aligned} S_R &= \frac{(D_B - D_A + B_R)^2 q}{tC_R}, \\ S_L &= \frac{(D_B - D_A + B_L)^2 q}{tC_L}. \end{aligned}$$

The share of those who turn out to vote depends on announced policies and on the strength of the ideological bias.[32] The share also increases if the support of c_j decreases: this could be the role of the internet. The internet can affect C_j directly, but it can additionally influence policies indirectly at stage 1.[33]

At stage 1, party A chooses policy D_A to maximize its payoff (similarly for party B):

$$\frac{1}{2} + \frac{(D_B - D_A - B_L)^3/C_L - (D_B - D_A + B_R)^3/C_R}{t^2} q^2 - \frac{|D_A|^2}{2}.$$

In a symmetric equilibrium, the first-order condition imply that the equilibrium policies are:[34]

$$|D_A| = |D_B| = \frac{3q^2}{t^2}\left(\frac{B_R^2}{C_R} - \frac{B_L^2}{C_L}\right). \tag{3}$$

Hence, in a symmetric equilibrium, aggregate turnout equals:

$$Turnout = \frac{q}{2t}\left(\frac{B_R^2}{C_R} + \frac{B_L^2}{C_L}\right). \tag{4}$$

Equations (4) and (3) summarize the main results on turnout and on the policy chosen by the parties, respectively. Policies are directed towards the group that it is easier to attract; that is, it has a lower support of the cost of voting relative to the bias. If $\frac{C_R}{C_L} < \frac{B_R^2}{B_L^2}$, then policies in favor of group R are implemented, and vice versa.

Suppose, now, that the internet increases the upper bound C_j of the support of the distribution of the cost of group j, perhaps because it increases the opportunity cost of

[32]The expressions also illustrate why we introduced a term capturing ideological bias to avoid the otherwise obvious point of no turnout if policies are identical in a symmetric equilibrium, independent from their magnitude.

[33]See Godefroy and Henry (2015) for a model in which shocks in voting costs affect turnout and the quality of elected politicians.

[34]The second-order condition is $-1 - \frac{6q^2}{t^2}\left(\frac{B_R}{C_R} - \frac{B_L}{C_L}\right)$, which we assume to be satisfied at equilibrium (we need to put simple parametric restrictions to ensure this, as well as to obtain plausible voting shares that do not exceed the support).

becoming informed through the availability of richer entertaining content. Thus, following Proposition obtains.

Proposition 1 *a) Suppose that C_j increases. Then, the turnout S_j of group j declines.*

b) Suppose that C_L increases relatively more than C_R. Then both parties choose policies that favor group R more than group L.

Proof. Part a) follows from the fact that, in a symmetric equilibrium, $S_j = \frac{{B_j}^2 q}{tC_j}$, which is decreasing in C_j. Part b) follows from equations (4) and (3), since $\frac{\partial Turnout}{\partial C_L} < 0$ and $\frac{\partial D_k}{\partial C_L} > 0$, that is, each party adopts a policy that shifts to the right. ■

B Additional Results

In this section, we report on two additional results. First, we use two alternative identification strategies to that employed in Section 4, exploiting alternative instruments that borrow ideas from other papers in the literature:

A) Falck, Gold, and Heblich (2014) exploit the fact that the capacity of the ADSL technology depends on the length of the copper wire between the LE and the house. Similarly, Campante, Durante, and Sobbrio (2013) argue that it is more expensive to deploy optical fiber connections between LEs that are farther away from the network backbone, thereby affecting the pattern of ADSL rollout across different areas. Hence, we use our data to calculate two distances as supply-side instruments: 1) the average distance between houses in a ward and their respective LE; and 2) the distance between the LE and the network backbone. In our main specification, we use these variables as controls, whereas we now employ them as excluded instruments.

   Column (1) in Table 5 reports IV estimates based on this identification strategy. The first-stage regression shows that instruments are relevant—most notably, the distance between the LE and the network backbone—and strong (i.e., the F-test is above 40). The second-stage estimate of the coefficient of Internet implies that a ten-percentage-point increase in internet penetration decreases turnout by 4.3 percent, which corresponds to a 1.8-percentage-point decline in turnout. Hence, the point-estimate using these alternative instruments is lower in absolute value than that of column (2) of Table 2, but the standard errors mean that they are not statistically different.

B) Gentzkow (2006) studies the effect of TV introduction on voter turnout, exploiting the fact that individual television stations broadcast over a large area and, thus, reach several small counties when entering a larger city. Thus, sharing the idea that proximity to a large market is uncorrelated with unobserved shocks that affect turnout, demand characteristics of nearby markets are valid instruments for internet penetration, once we control for the same characteristics in a given market (see, also, Fan, 2013). More specifically, we calculate the number of telephone lines and of cable lines between ten and 15 miles from the LEs serving each electoral ward, and we use them as instruments, while controlling for the number of telephone and cable lines between zero and ten miles from the LEs.

Column (2) in Table 5 reports IV estimates based on this identification strategy. The first-stage regression shows that instruments are relevant and not weak (the F-test is greater then 30). The second-stage estimate of the coefficient of INTERNET is also greater in absolute value and less precise than those obtained using other instruments. However, it is not statistically different from that of column (2) of Table 2.

Second, we perform additional regressions that investigate whether internet diffusion affects the vote share of the incumbent party. Specifically, we use ward-level data and estimate equation (1) with two related outcome variables: the first is the difference in vote share of the incumbent party in subsequent elections; the second is an indicator variable that equals one if the incumbent party wins the election, and zero otherwise. Columns (1) and (3) of Table 6 report OLS estimates of the coefficients, whereas columns (2) and (4) report the IV estimates, using the same instruments based on RAIN that we employed in Table 2 (thus, the first-stage is the same as that reported in Table 2). For both outcome variables, both the OLS and the IV estimates suggest a positive effect of internet diffusion on the performance of incumbent parties.

Table 5: Internet Diffusion and Elections, Alternative Instruments

Dependent variable: Log(Electoral Turnout)	(1)		(2)	
	IV 1st	IV 2nd	IV 1st	IV 2nd
Internet		-0.38**		-1.01***
		(0.18)		(0.33)
Distance LE-Backbone	-0.12***		-0.11***	-0.04
	(0.01)		(0.01)	(0.05)
Distance LE–Homes	0.46		1.16**	5.70***
	(0.49)		(0.52)	(1.51)
$(\text{Distance LE–Homes})^2$	-0.00		-0.00**	-0.00***
	(0.00)		(0.00)	(0.00)
$(\text{Distance LE–Backbone})^2$	0.00***		0.00***	-0.00
	(0.00)		(0.00)	(0.00)
Lines 10-15 Miles			0.04***	
			(0.01)	
Cable Lines 10-15 Miles			-0.04***	
			(0.01)	
University Degree	-0.31***	-0.80*	-0.27***	-0.99**
	(0.11)	(0.41)	(0.10)	(0.43)
High Socio-Economic Status	0.62***	1.59***	0.57***	1.97***
	(0.14)	(0.53)	(0.14)	(0.56)
White	-0.06*	0.42***	-0.06**	0.39***
	(0.03)	(0.12)	(0.03)	(0.12)
Labour Incumbent	-0.01***	-0.03***	-0.01***	-0.04***
	(0.00)	(0.00)	(0.00)	(0.00)
Conservative Incumbent	-0.00	-0.02***	-0.00	-0.03***
	(0.00)	(0.00)	(0.00)	(0.00)
Δ Share 1st-2nd Party	0.01	-0.26***	0.00	-0.26***
	(0.01)	(0.02)	(0.01)	(0.02)
$(\Delta \text{ Share 1st-2nd Party})^2$	0.00	0.21***	0.00	0.21***
	(0.01)	(0.03)	(0.01)	(0.04)
Multiple Vacancies	0.00	-0.04***	0.00	-0.04***
	(0.00)	(0.00)	(0.00)	(0.00)
Year Fixed Effects	Yes	Yes	Yes	Yes
Demographics $\times$ Time	Yes	Yes	Yes	Yes
LA Fixed Effects	Yes	Yes	Yes	Yes
F-test		43.460		26.779
R^2		0.802		0.784
Observations	14141	14141	14141	14141

Notes: The dependent variable is the log of electoral turnout in ward i in year t. All regressions further include the fraction of individuals between 18 and 44 years old; the fraction of individuals employed; the fraction of individuals living in urban areas; the average housing price; the Elevation of the ward; the Relative Elevation of the ward with respect to their surrounding areas; the interaction between Relative Elevation and Rain; the number of political parties with at least one candidate; and an indicator variable for the incumbent belonging to a party other than Conservative, Labour or Liberal Democrats (the excluded category). University Degree, High Socio-Economic Status, and White are rescaled to vary between 0 and 1. The standard errors in parentheses are clustered at the ward level. *, ** and *** denote significance at the 10, 5 and 1 percent level, respectively.

Table 6: Internet Diffusion and Elections, Effect on Incumbent Parties

Dependent variables:	Δ Sh. Incumbent		Re-election	
	(1)	(2)	(3)	(4)
	OLS	IV 2nd	OLS	IV 2nd
Internet	0.08***	0.49*	0.28***	1.59**
	(0.03)	(0.29)	(0.08)	(0.80)
University Degree	-0.44	-0.31	-2.32**	-1.93*
	(0.36)	(0.37)	(1.09)	(1.12)
High Socio-Economic Status	0.72	0.47	2.92**	2.13
	(0.47)	(0.51)	(1.43)	(1.52)
White	0.21*	0.23**	-0.04	0.05
	(0.12)	(0.12)	(0.39)	(0.39)
Labour Incumbent	0.01	0.01*	0.02	0.03*
	(0.00)	(0.00)	(0.01)	(0.02)
Conservative Incumbent	0.02***	0.02***	0.07***	0.07***
	(0.00)	(0.00)	(0.01)	(0.01)
Δ Share 1st-2nd Party	0.16***	0.16***	1.51***	1.50***
	(0.02)	(0.02)	(0.06)	(0.07)
(Δ Share 1st-2nd Party)^2	0.14***	0.14***	-1.28***	-1.28***
	(0.04)	(0.04)	(0.10)	(0.10)
Multiple Vacancies	-0.02***	-0.02***	-0.02**	-0.03**
	(0.00)	(0.00)	(0.01)	(0.01)
Year Fixed Effects	Yes	Yes	Yes	Yes
Demographics × Time	Yes	Yes	Yes	Yes
LA Fixed Effects	Yes	Yes	Yes	Yes
F-test		45.322		45.322
R^2	0.229	0.163	0.170	0.101
Observations	14141	14141	14141	14141

Notes: The dependent variable in specifications (1) and (2) is the difference between the vote share of the incumbent in ward i in year t and in the previous election; in specifications (3) and (4) is an indicator variable equal to one if the incumbent is elected in ward i in year t, and zero otherwise. All regressions further include the fraction of individuals between 18 and 44 years old; the fraction of individuals employed; the fraction of individuals living in urban areas; the average housing price; the Elevation of the ward; the Relative Elevation of the ward with respect to their surrounding areas; the interaction between Relative Elevation and Rain; the average distance between the LEs covering the ward and the backbone, and its square; the average distance between the LEs and the houses, and its square; the number of political parties with at least one candidate; and an indicator variable for the incumbent belonging to a party other than Conservative, Labour or Liberal Democrats (the excluded category). University Degree, High Socio-Economic Status, and White are rescaled to vary between 0 and 1. The standard errors in parentheses are clustered at the ward level. *, ** and *** denote significance at the 10, 5 and 1 percent level, respectively.

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