SOCIAL MEDIA AND THE BEHAVIOR OF POLITICIANS:
EVIDENCE FROM FACEBOOK IN BRAZIL

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ABSTRACT

We study the relationship between the spread of social media platforms and the communication and responsiveness of politicians towards voters, in the context of the expansion of Facebook in Brazil. We use self-collected data on the universe of Facebook activities by federal legislators and the variation in access induced by the spread of the 3G mobile phone network to establish three sets of findings:(i) Politicians use social media extensively to communicate with constituents, finely targeting localities while addressing policy-relevant topics; (ii) They increase their online engagement, especially with places where they have a large pre-existing vote share; but (iii) They shift their offline engagement (measured by speeches and earmarked transfers) away from connected municipalities within their base of support. Our results suggest that, rather than increasing responsiveness, social media may enable politicians to solidify their position with core supporters using communication strategies, while shifting resources away towards localities that lag in social media presence.

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1 Introduction

The role of media in disclosing information, monitoring politicians, and making them accountable is widely seen as central to the proper functioning of democracies. The recent explosion of social media as another channel through which citizens can access news and information can thus be transformative for the responsiveness and accountability of politicians. At the same time, the political impact of social media has been the object of increased skepticism, as they offer opportunities to affect content and manipulate information in a way that can mislead voters and, some think, might threaten democracy.[1]

A distinctive feature of social media is the possibility of direct communication between voters and politicians at very low cost, which might affect politicians' behavior differently than traditional media. In spite of widespread evidence that traditional media can make politicians more accountable and responsive (Besley and Burgess, 2002; Strömberg, 2004b; Ferraz and Finan, 2008; Snyder and Strömberg, 2010; Strömberg, 2015; Varjão, 2019) and that social media can affect the political behavior of citizens (Falck et al., 2014; Campante et al., 2018; Enikolopov et al., 2020; Manacorda and Tesei, 2020; Guriev et al., 2021; Fujiwara et al., 2022), we still know relatively little about the impact of social media on the behavior of politicians.

We examine the interplay between social media and the responsiveness of politicians in the context of the rapid dissemination of Facebook in Brazil. Having started operations in the country in 2008, Facebook rapidly became the dominant social media platform, going from 4 million users in 2009 to 92 million by late 2014 (roughly 45% of the Brazilian total population). Over the same period, it acquired commensurate prominence in Brazilian politics. In a low-information setting regarding politicians and what they do, this new media environment greatly enhanced the possibilities for interacting with and acquiring information about elected representatives – in contrast with the media-saturated environments of developed countries, where social media might crowd out other channels of accountability.

We find that the spread of Facebook led to greater online activity by Brazilian legislators, which is in itself unsurprising, but also that this activity is strategically targeted at specific localities that are important to each legislator, in terms of their share of the votes obtained by the legislator. This targeted activity has policy-relevant content, and elicits online engagement from users. This increased online interaction, however, comes at the expense of *lower* engagement offline: those legislators become less likely to mention the

[1] This is most clearly exemplified by the phenomenon of so-called "fake news" (Allcott and Gentzkow, 2017; Allcott et al., 2019; Lazer et al., 2018). For broader skeptical accounts, see for instance Vaidhyanathan (2018) or, for a media account, Madrigal (2017).

municipality in floor speeches, and crucially, bring fewer resources from discretionary transfers. Our evidence thus indicates that the diffusion of social media gave rise to a *substitution* between online and offline behavior: politicians react to Facebook entry, within their base of support, by simultaneously increasing their online presence, and reducing their offline activity in the more connected localities.

Our empirical strategy leverages two features of the Brazilian setting. First, we take advantage of the expansion of 3G mobile internet in Brazil, over the same period that saw the dissemination of Facebook: between 2011 and 2014, the number of municipalities with 3G coverage more than doubled, going from 30% to about 67% – an expansion reaching about 30 million people. This staggered rollout of the 3G network in Brazilian municipalities introduces a source of variation in the ability to engage with social media, which in Brazil was and still is predominantly accessed via mobile phones. This allows us to adopt a reduced-form event study design, using within-municipality variation in 3G coverage in the absence of information on Facebook adoption at the local level.

Second, we exploit a characteristic of the Brazilian system to elect federal legislators, in order to go beyond the standard differences-in-differences strategy: federal legislators compete for votes in all municipalities of a given state, and multiple legislators are elected in each state. This allows us to control for a richer set of fixed effects, including at the legislator-municipality and municipality-year levels, thus alleviating concerns that unobserved factors could confound our results – say, if legislators were more likely to focus attention on strategically important locations, and also to facilitate access of those areas to the 3G network by lobbying mobile operators. It also allows us to consider how the response by politicians varies according to the importance of different localities for their electoral prospects, as measured the share of the politician's total pre-existing vote that comes from a given locality.

To study the online behavior of politicians, we scraped the universe of posts from all Facebook-active members of the Brazilian lower house (*Câmara dos Deputados*) over the 2011-2014 legislature from their public Facebook pages. We then developed and applied an algorithm that classified which municipalities were mentioned in each post, if any, and combined that with a topic modeling algorithm to classify the content of the posts. The 513 legislators in our sample posted over 460,000 times between 2011-2014, receiving millions of likes, shares, and comments on their posts. Of those, almost 170,000 mentioned at least one municipality and virtually all municipalities in the country were mentioned at least once. We also find that a significant number of those posts have policy-relevant content, discussing issues such as education, health, or public works.

We also look at how politicians behave offline, using two margins of legislative activity: congressional speeches and earmarked transfers. Speeches are a significant part of the politicians' daily routines, and in which they express their opinions and support for various types of bills and propositions (Moreira, 2019; Moreira, 2020). We analyze the contents of the universe of speeches and gather information on mentions to specific municipalities, and associated topics. To get at the actual allocation of resources across municipalities, we explore a feature of the Brazilian setting in which, on a yearly basis, legislators propose amendments to the federal budget, through which they can assign earmarked transfers. These amendments are strictly capped at the level of legislators, implying a strong opportunity cost of targeting the resources.[2] The associated pork-barrel spending is typically used by politicians to showcase improvements they bring to communities of their choice – roads, schools, and healthcare units are often funded in this way – such that proposed earmarked transfers tie the actions of a legislator to specific municipalities.

We first show that politicians change their online behavior swiftly and intensely on the Facebook platform when a municipality is covered by the 3G network. Legislators increase mentions to those municipalities by 15.7% compared to uncovered municipalities. We also find that voters interact more with those Facebook posts, as measured by likes, shares, and comments. This suggests that increased access to social media by constituents indeed raises the incentives of politicians to interact with them. Yet that online engagement does not translate offline: municipalities that get connected are mentioned less in speeches, and if anything, get fewer transfers.

The Brazilian context allows us to further unpack these results, by leveraging the municipality-politician variation. The results reveal a very clear pattern, whereby municipalities that get connected and are important to a politician get more interaction online: a one-standard-deviation increase in candidate vote share for municipalities with 3G access is associated with a given politician posting 69.2% more mentions. From a theoretical perspective, it is not obvious that this should be the case, as one might expect politicians to target municipalities with the largest number of swing voters, rather than those where they are ex-ante more popular. This underscores the peculiarity of social media, in which politicians mostly reach voters that chose to follow them in the first place, and could plausibly have consequences for polarization, as social media disproportionally increase the politicians' communication capacity with those core supporters.

Moreover, we show that the increase in online interaction with those municipalities is explained by their importance: important localities get more interaction, whether they are

[2] See Ames (1995a), Firpo et al. (2015) and Finan and Mazzocco (2021) on determinants and effects of earmarked resources in Brazil.

connected to the 3G network or not. This is consistent with the fact that communication via Facebook is very cheap, and does not face tight budget constraints; as the platform expands, it makes sense for the politicians to try and communicate with all municipalities that matter to them.

In contrast, the arrival of social media induces an important reallocation of offline resources within the group of important municipalities, in terms of speech mentions and targeted transfers. Strikingly, the politicians choose to shift resources away from the municipalities that get connected and towards those that remain off the 3G network. Consistent with the fact that the distribution of offline efforts faces real constraints in terms of available resources, we detect a real choice taking place across important municipalities: the pattern for speeches, and especially transfers, is driven by the variation in access to the 3G network within the group of municipalities at the top decile of importance. In other words, increased access to social media leads to a substitution of online interaction for offline responsiveness.

While this pattern could be partly due to technological substitution between online and offline engagement, it can emerge simply from the interplay of communication, transfers, and political competition. We show this in a simple model of "persuasion and pork-barrel," with two key assumptions. First, we assume that (online) communication is especially effective in reaching core supporters within those municipalities, in line with the social media feature that, to be reachable by the politician, one has to choose to follow them in the first place. In contrast, transfers benefit the municipality as whole, which makes them relatively more effective in attracting swing voters. Second, we assume that communication is relatively cheap, but transfers are limited by a budget constraint, as they are in practice. In this model, a shock that makes communication more effective, such as the arrival of Facebook, leads to increased communication efforts by politicians; this increases the attachment of core supporters, thereby reducing the number of swing voters and making transfers relatively less effective as a way of garnering additional votes. The politicians thus find it optimal to divert transfers to the municipalities that remain without 3G. Consistent with the model, we find electoral losses in the subsequent election, within the politicians' electoral base, in municipalities that receive 3G (relative to those that do not). Furthermore, the response in terms of reducing transfers comes entirely from legislators with relatively safe seats, for whom presumably the attachment of core supporters would be stronger.

In sum, we find evidence that access to social media increases the responsiveness of politicians, but only in the online realm. This comes at the expense of offline responsiveness, suggesting that there are real costs for voters. Intuitively, politicians can use social media to increase the attachment of core supporters, thereby increasing their political "market power" against voters. While what we capture here is a short-run response to the initial expansion of social media, that these changes might be persistent. First, even if access to 3G and social media eventually becomes universal, differences in exposure certainly remain, thereby leaving politicians with different incentives in different places. Besides that, even variation in initial exposure might persist – say, if the consolidation of core supporters persists over time, so that places that got earlier access to social media may end up with fewer swing voters even in the long run, and receive less offline attention as a result. More broadly, our findings stress the fact that social media is an inherently different arena, relative to other media environments, in that its low barriers to entry in the broadcasting of content entail that politicians can also use it as a tool to strengthen their position relative to voters.

Our paper relates to a number of different strands of literature. We add to the burgeoning empirical literature looking at the political impact of social media or mobile phones (Tufekci and Wilson, 2012; Bond, Fariss, Jones, Kramer, Marlow, Settle, and Fowler, Bond et al.; Pierskalla and Hollenbach, 2013; Halberstam and Montagnes, 2015; Flaxman et al., 2016; Acemoglu et al., 2018; Christensen and Garfias, 2018; Larson et al., 2019; Enikolopov et al., 2020; Manacorda and Tesei, 2020; Allcott et al., 2020; Levy, 2020; Guriev et al., 2021; Fergusson and Molina, 2021; Fujiwara et al., 2022). These contributions have focused mostly on the impact of social media on collective action and the flow of political information, while our focus is on the behavior of politicians.[3] Similarly, the literature on the political impact of the internet has mostly focused on voter turnout (e.g. Falck et al., 2014; Gavazza et al., 2019). Campante et al. (2018) also focus on the interplay between online and offline activities, but again on the side of citizens rather than politicians.[4]

More broadly, many have studied the political impact of the introduction of new media technologies (see for instance the survey by Prat and Strömberg, 2013). Most of the literature focuses on the behavior of voters – in terms of participation (Strömberg, 2004a,b; Gentzkow et al., 2011) or the ability to impose accountability by voting out incumbents (Ferraz and Finan, 2008). More closely related are papers that study impact of the media on the behavior of politicians, and the degree to which they respond to constituents (Snyder and Strömberg, 2010; Gavazza et al., 2019). We extend this literature to the context of social media, and of a relatively unsaturated media environment in terms of political coverage, and show that the impact of this particular new media technology

[3]On politicians, see Petrova et al. (2021) on the impact of politicians' entry into social media (Twitter) on the volume of contributions they obtain.

[4]For additional references, see Zhuravskaya et al. (2020) and references therein.

can actually go in the direction of reducing the (offline) responsiveness of politicians. In particular, we also show that the effect does not differ according to presence of pre-existing media outlets, suggesting that this reduction is not driven by the new technology crowding out previous sources of information.

The remainder of the paper is organized as follows: Section 2 provides relevant background on the Brazilian context, regarding the expansion of Facebook and mobile phones, the political environment, and describes our data sources and key variables. Section 3 describes our empirical strategy. Section 4 discusses the results. We rationalize the results with the model in Section 5, where we also discuss additional evidence. Section 6 concludes.

2 Background and Data

2.1 The entry of Facebook and the rise of social media in political communication

As the expansion of 3G internet took place, Facebook entered the Brazilian market. Facebook registered the domain `Facebook.com.br` in 2007, and the company effectively started operations in Brazil in 2008. It experienced a very rapid expansion from just over 4 million users as of mid-2009 to 92 million users in 2014 (about 45% of the total population of the country). The availability of 3G internet was crucial for this expansion as the access to social media in Brazil takes place largely via mobile phones. In fact, out of those aforementioned 92 million Facebook users, no less than 77 million accessed via mobile internet.[5]

Facebook became by and large the dominant social network platform in Brazil. In Table 1 Panel B we show data from Facebook use based on the Latinobarómetro survey. It shows an increase in the percentage of individuals that use Facebook from 13% in 2011 to 43% in 2013. Complementary data from Ibope Nielsen and Facebook show a similar trend. We can also use data from Google Trends to compare the interest in several social media platforms over time.[6] The number of Google searches for the terms “Facebook,” “Twitter,” and ”Orkut,” are displayed in Panel C, and reveal Facebook’s steep rise. While Orkut was the first social networking website with a significant presence, it was in clear

[5]Source: Facebook, available at `https://www.facebook.com/business/news/BR-45-da-populacao-brasileira-acessa-o- Facebook-pelo-menos-uma-vez-ao-mes`, accessed Jan 30th 2019.

[6]The index is based on the number of Google searches, normalized by the maximum number of search queries.

decline when Facebook started growing, and eventually shut down operations in 2014. Twitter, on the other hand, was not widely used in Brazil during our study period.

In the early 2010s, it was clear to many politicians that Facebook would become an important source of political information, and the adoption of Facebook as a communication tool spread quickly. Out of 513 Federal Deputies elected for the 2011-2014 legislature, 415 had created an active public official Facebook profile by the end of their term. In Table 2 we show that 17% of Federal Deputies had a Facebook account in the first year of their legislative term in 2011, while by the end of the term in 2014 80% had one.

To study the online communication of legislators, we scraped the universe of their Facebook profiles for their content, messages, and number of likes, shares, and comments. We obtained a database of 460,540 posts from the 415 active public official Facebook profiles. We show descriptive statistics of politician engagement on Facebook calculated over the distribution of yearly activity across users in Panel A of Table 2. In line with the idea that politicians increasingly used Facebook over this period, the average legislator posted 24.5 messages in 2011; it increased almost twenty-fold to 484.2 messages in 2014.

Our key outcome of interest that captures online activity is the number of times per year a politician mentions a municipality in their posts. This allows us to analyze the online engagement at the level of legislator-municipality pairs, and its evolution over time, which as we will see, is crucial for our empirical strategy. The main challenge for this task is that a considerable number of municipalities have names that also have other meanings in Portuguese. For example, whenever a politician said the word *Natal*, it could either mean the municipality with that name or a reference to Christmas (the word *Natal* means "Christmas" in Portuguese). To deal with that, we devised a text processing algorithm that matches each of the 460,540 posts in our sample to the 5,545 Brazilian municipalities.[7] We tested the performance of our approach in a sub-sample, with the algorithm providing a correct match for 89% of the true mentions, and a false match for only 2% of the posts.

We find that 36.7% of posts (just under 169,000) mention at least one municipality. These are the posts that constitute the core of our analysis, as they measure the engagement of the politician with the municipalities in their states of origin. Panel B of Figure 1 maps the incidence of the number of mentions to municipalities in 2011 and 2014, on

[7] We manually classified the municipality names into "dubious", ie names that could appear in contexts other than mentioning the municipality, and "non-dubious". We identified 898 municipalities with dubious names. For this subset, we required that the municipality name was preceded by an expression that commonly precedes a place in a sentence, such as "municipality of", "mayor of", or "airport of". The algorithm is presented in more detail in Appendix B.

a logarithmic scale. In 2011 Facebook is sparsely used and few municipalities are mentioned. In contrast, virtually all municipalities were mentioned at least once in 2014. We can also observe in the Figure the geographical concentration of Facebook posts in municipalities that had 3G access in 2011.

Importantly, Facebook posts carry policy-relevant content. Among the posts that mention a municipality, keywords that are related to congressional activity were used in as many as 146,000. These keywords are, for the most part, the jargon used by the politicians and Congress associated with legislative activity or political support for various types of bills.[8] The contents of Facebook posts also contained information on other topics and public goods and services: keywords associated with education and healthcare were mentioned 27.3 and 23.2 thousand times, respectively.

Besides the number of posts by a politician mentioning a municipality, we also gather information on the sum of likes, shares, and comments on those posts. We use these measures of interactions with posts to study how access to the internet affected the communication between citizens and congress members. The limitation is that data from the individual citizens' Facebook profiles are typically private, unlike the politicians' public profiles. This means that we cannot know how many of those likes, shares, and comments are coming from citizens in a specific municipality. However, we use these measures as proxies for citizen engagement with a politician representing the municipality, assuming that locals will be a substantial part of the engagement obtained by posts mentioning a municipality. In Panel A of Table 2, we observe a remarkable increase in the interaction between Facebook users and legislators over time.

Between 2011 and 2014, Facebook use increased sharply, becoming adopted in Brazil by politicians and citizens alike. It became a mainstream channel for politicians to advertise themselves and their legislative activity and interact with the general public. The number of posts mentioning at least one municipality increased from an average of 4.44 per politician in 2010 to 177.56 in 2014. The behavior of the politicians was also met with citizens' engagement online. Messages posted by politicians that cited at least one municipality received 17.21 million likes, obtained 6.64 million shares, and 1.56 million comments over the years up to 2014.[9]

[8]More specifically, we looked for the following keywords "amendment", "audience", "committee", "commission", "congress", "deputy", "law", "party", "plenary", "project", "proposition", "agenda (or *pauta* in Portuguese) ", "voting".

[9]During our study period politicians could not buy Facebook ads for campaigns. They were only allowed in Brazil in the 2018 election.

2.2 The expansion of 3G internet in Brazil

Mobile internet was launched in Brazil in 2005, but until 2007 it had limited penetration with a small number of firms using their existing mobile phone concessions to implement the third generation of wireless mobile telecommunications (3G) transmission in 850 MHz frequencies.[10] Only 20 percent of households in Brazil had access to the internet from a home-based computer, and there was a large demand for the 3G internet expansion. At the end of 2007, Brazil's Telecom regulator (Anatel) designed a spectrum auction where 11 service areas were auctioned out. To promote regional competition, Anatel awarded four blocks of spectrum in each lot. Another auction took place in 2010 for Band H and the remaining personal mobile service radio frequencies for 3G use.[11]

Anatel introduced several contractual obligations for the winning firms. First, companies that obtained a block of spectrum to serve the richest parts of Brazil also had to serve a poor and unconnected region. For example, a company that won an auction to serve the metropolitan region of São Paulo (Brazil's richest region) also had to acquire and serve the Amazon region. Second, Brazil's telecom regulator introduced targets for the expansion of the 3G network to 2,740 municipalities that were out of the 3G internet network. First, all capitals and cities above 100,000 inhabitants needed to have full coverage of 3G internet (80% of urban area) by May 2013. Second, all municipalities with populations between 30,000 e 100,000 needed to be connected to 3G internet by June 2016, and 70% of those needed to be connected by May 2013. Finally, for smaller municipalities with a population of 30,000 people and below, companies were required to connect 20% of municipalities by May 2013, 75% by June 2016, and all needed to be connected by December 2019.[12]

Telecom companies got a concession for a given area, but they were given a choice over which municipalities to connect over time.[13] After the auctions and the identity of winners were disclosed, Anatel asked each Telecom company to select a list of municipalities they wanted to connect. As multiple companies were serving a given area, the choice was made in sequential order, with each firm taking turns choosing 5% of municipalities until no municipality in Anatel's pre-selected list was left.[14] After this procedure, Anatel signed a concession agreement with each Telecom company containing specific

[10] 3G refers to the third generation of wireless mobile telecommunications technology, which greatly increased the capabilities of mobile data transfer.

[11] See https://ihsmarkit.com/country-industry-forecasting.html?ID=106597317.

[12] A municipality being connected was defined as at least 80% of the urban area of the main district having a 3G signal.

[13] This original list was published in 2008 and appended with the last 3G spectrum auction in 2010.

[14] See Edital 002/2007.

municipalities and dates that 3G internet connections needed to be completed.[15] The expansion was dictated by the commercial interests of large companies, and strict rules based on population brackets set by the regulatory agency. As a result, politicians had a limited ability to influence the choices made by Telecom firms regarding the cities that received 3G. Thus in our empirical analysis, we use the staggered entry of 3G internet as the main source of variation.

We obtained data on whether a municipality was connected to 3G internet from Teleco, a telecommunications consultancy firm in Brazil.[16] They built the dataset from the information they collect directly from telecom companies. The dataset includes, for each municipality, the month and year of the first 3G internet connection and the month and year that other telecom companies entered the municipality. For our analysis, we create a variable measuring the fraction of year t for which the municipality had 3G internet.

Telecom companies complied with Anatel and starting in 2008 expanded the number of municipalities covered by mobile internet. The expansion was considerable over the period of our analysis. Between 2011 and 2014 the coverage more than doubled going from 30 to 67% of municipalities connected to 3G internet as shown in Panel A of Table 1. This corresponds to more than 2,000 municipalities connected to Mobile internet in this short spell. In terms of population, this expansion meant that, in four years, 30 million people gained access to broadband mobile internet coverage. While we do not have municipality-level data on 3G accesses, in Panel A of Figure 1 we show the trend in 3G access between 2008 and 2014. The figure shows a great expansion of access to 3G networks during our study period.

The rise in access to 3G technology was accompanied by an increase in the connectivity reported in the PNAD household survey. Table 1 shows that, at the start of our sample period in 2011, 36.6 percent of the households used the internet and in 2014 this share increased to 55 percent. The most common method of internet access was through mobile phones: 80.4 percent of the households reported in 2014 that at least one of its members used a mobile phone to connect to the internet.

2.3 The Brazilian Congress

Brazil has a bicameral federal legislature (National Congress), with a lower house (Chamber of Deputies) and an upper house (Federal Senate). The lower house has 513 federal

[15] Note that, although firms needed to connect a pre-specified list of municipalities, they could speed up the process and connect localities before the due date.

[16] See https://www.teleco.com.br

deputies (*deputados federais*) that represent each of the 26 states plus the Federal District. Federal Deputies, the focus of our analysis, are elected under an open-list proportional representation multimember district system. They have a four-year term and can run for reelection without any term limit.[17]

The electoral system worked as follows. Voters could choose to vote for one candidate or a party label. Political parties could form coalitions, and the allocation of seats in a given state was chosen proportionally to the share of votes obtained by a party or a coalition. The candidates who won those seats were the top individual vote-getters within the party (or coalition) ticket. At the time of our analysis, there was no minimum threshold for parties to enter parliament, and as a result, Brazil had a vast number of parties represented in the federal legislature.

Generally speaking, the combination of open-list proportional representation and large districts is seen as one of the main causes of poor accountability facing federal legislators in Brazil (Ames, 2002). The problem is compounded by a sparse media environment, with low newspaper penetration and an uneven presence of local radios and TV stations (Ferraz and Finan, 2008). As a result, most individual legislators receive very little media coverage and depend on local and visible achievements to make themselves known to the electorate. In this context, voters typically have deficient levels of knowledge regarding federal deputies.[18] The fact that each state is a single multimember district for the Chamber of Deputies implies that each candidate vying for congressional office can get votes from any municipality across the entire state. As we will show later, the distribution of votes for each candidate tends to be highly heterogeneous.

Once elected, the work of a legislator ranges from roll-call votes, public speeches, bill propositions, and participation in special committees. Prior to the advent of Facebook, politicians primarily used congressional speeches to communicate their legislative achievements to the voters. Most interestingly, for our purposes, legislators can also propose amendments (*emendas parlamentares*, EPs) to the federal budget, with which they earmark resources to specific projects in municipalities of their choice. These transfers aim to provide public goods and cannot exceed a ceiling.[19] This pork-barrel spending is a major part of the typical legislator's work: "Many if not most deputies spend the bulk of their time arranging jobs and pork-barrel projects for their benefactors and constituents." (Ames, 1995b, pp. 407)

[17] See Ames (2002) for a detailed analysis of Brazil's legislative electoral system.

[18] There is evidence that many voters forget which candidate they voted for, as soon as one month after the elections. See http://media.folha.uol.com.br/datafolha/2013/05/02/intvoto_depfederal_20092010.pdf.

[19] The ceiling varied between 4.2 to 4.7 million US dollars for the 2011-14 period.

Legislative Activity We look at two dimensions of legislative activity, floor speeches and budget amendments (*emendas parlamentares*, EPs), which we can be tied to specific municipalities. For the former, we obtained the database of the universe of speeches made in Congress, which is available on the Chamber of Deputies website. We use the same algorithm from our Facebook analysis to detect if municipalities are mentioned during those speeches. In Panel B of Table 2 we see that politicians, on average, make two speeches per month. We also use the number of speeches as an outcome variable in our subsequent analysis.

As for the budget amendments, we obtain the original list of amendments from the government Open Data portal.[20] The dataset contains, for every amendment, the legislator responsible for it, the state and municipality targetted, the Ministry in charge, a text description of the project and the monetary value. From this information we use the amendments that are proposed by individual legislators and are targetted at municipalities (some amendments are proposed for whole states). We use the information of the municipality to match with the 3G internet dataset. In Panel B of Table 2 we show summary statistics of the amendments. The average legislator proposed 5.4 amendments per year to 5.5 municipalities. Given that the average congressman has 253 municipalities in his constituency (state), it is clear that politicians choose which localities will receive transfers very carefully.

Electoral Support In our empirical analysis we explore heterogeneity on politician's response to the entry of 3G internet based on the vote share obtained across municipalities in the previous election. To capture the geographical variation in electoral support for each legislator, we gather municipality-level election data made available by Brazil's Electoral Court (*Tribunal Superior Eleitoral*). We gathered data on the total valid votes obtained by each elected legislator in each municipality. We then compute the vote share:

$$\text{VoteShare}_{im} = \frac{\text{Votes of politician } i \text{ in municipality } m}{\text{Total votes of politician } i} \times 100,$$

which represents the importance of municipality m for legislator i. Some deputies get their votes from a few concentrated municipalities while others are elected from a much more disperse base of support. This is potentially reflective of different electoral strategies and the type of engagement between politicians and electorate. In fact, Ames (1995b) describe the former as the "concentrated" types, characterized either by being a dominant force in a municipality – their electoral bailiwicks, for instance – or by specializing

[20] Source: https://dados.gov.br/dataset/emendas-parlamentares

in specific segments of the population that happen to be geographically clustered. In contrast, the "scattered" types are often candidates that appeal to segments of the society with state-wide representation, such as business owners, or are well-known figures themselves (celebrities, ex-footballers). This is clearly exemplified in Figure 2, where we show the map of vote shares for the top two legislators elected in the state of São Paulo in 2010 (Tiririca, a famous TV professional clown, and Gabriel Chalita, the 2008 most-voted city council member in the city of São Paulo).

We will also explore non-linearities in the response of politicians, with respect to the importance of different municipalities for their electoral support. For that, we need to define thresholds along the distribution that differentiate between municipalities that are more or less important for a given politician. First, because there is a significant number of zero pairs, with legislators getting no votes from certain municipalities in their state, we define the set of such zero pairs as our reference group. We then define $VoteShareDecile^{\tau}_{im}$ dummies, equal to one if the vote share is in the τ-th decile of the overall distribution of positive vote shares across all politicians and municipalities, and zero otherwise. Appendix Table A1 shows the distribution of deciles, and it puts in evidence that there is a relatively small share of very important municipalities: more than 90% of the pairs are below 1%, and as a result the top decile contains by far the widest range of variation. The resulting pattern of behavior by politicians across the different deciles, shown in Appendix Figures A1-A3, underscores the possibility of non-linearities: legislators interact much more often, both online and offline, with the municipalities that are most important to them, and especially so when it comes to the very most important group of municipalities.[21]

3 Empirical Strategy

Our goal is to examine the response of Brazilian politicians to the arrival of Facebook in the country, in the 2011-14 period over which the platform was expanding rapidly. In the absence of data on the geographical variation in Facebook take-up, we make use of the variation in access introduced by the expansion of 3G internet: there was a staggered entry of 3G across municipalities over time, which allows us to compare the behavior of politicians before and after citizens get access to 3G. In addition to that, we exploit the fact that candidates compete for votes across their entire home state, which allows us to compare the change in the behavior of politicians across different municipalities as some of them get access to the 3G network.

[21] This pattern has been confirmed to us in conversation with legislative staff.

To fix ideas, let us start by considering a context where a single politician represents a congressional district (e.g. in Canada, U.K or the U.S.). In that case, we can use a two-way fixed-effect model and estimate the following regression:

$$y_{mst} \quad = \quad \beta \cdot 3G_{mt} + \lambda_m + \delta_{st} + \epsilon_{mst}, \tag{1}$$

where y_{mt} is the behavior of congressperson m in year t, $3G_{mt}$ is an indicator of whether there is 3G internet in constituency m in year t, λ_m is a politician and congressional district fixed-effect that controls for unobserved time-invariant politician and locality characteristics, δ_{st} is a state-by-year indicator that controls flexibly for unobserved state trends, and ϵ_{mst} is an error term. The coefficient of interest is β, which captures the differential response of politicians in municipalities that obtained 3G access over the period of analysis.

Our context allows us to go further and separately control for fixed effects at the level of legislator interacted with municipality. This is important, as these fixed effects account, for instance, for the possibility that legislators could lobby mobile operators to bring 3G to their electoral turf. We can add them because each state is a multi-member district in which multiple legislators compete for votes across all municipalities. Moreover, we observe 3G entry and political behavior at the municipality level, allowing us to observe the behavior of multiple legislators in municipalities with and without 3G internet access. Formally, we can estimate the following regression:

$$y_{imst} \quad = \quad \beta \cdot 3G_{mt} + \lambda_{im} + \delta_{st} + \epsilon_{imst}. \tag{2}$$

This equation has two differences in comparison to equation 1. First, the unit of observation is now the triple legislator i, municipality m, and year t. We observe all pairs of politicians and municipalities in their respective constituencies (i.e., state). Second, we add politician-municipality pair fixed-effect λ_{im}. Again, the coefficient of interest is β.

There are two potential issues with this specification. First, most politicians receive a meaningful number of votes from a handful of municipalities in their state. As such, the response in a municipality where a politician has little in the way of electoral incentives should be very close to zero. This is especially true for earmarked transfers, since the total number of transfers each politician typically makes is at least an order of magnitude smaller than the number of municipalities in their state. Second, as is the case for any application of difference-in-differences, our identification strategy will be invalid in the presence of a time-varying omitted variable correlated with 3G entry. This would be the case, for example, if mobile operators enter first in, and politicians give more attention to, municipalities with growing population or income. Although we show in Section 4 that trends are parallel between municipalities receiving 3G at different moments within our period of analysis, this could still be an issue.

We deal with both issues by leveraging the three-dimensional structure of our data. Specifically, we exploit the fact that there is substantial variation in the vote share of politicians across different municipalities. This allows us to compare the outcomes of legislator i before and after the entry of 3G internet, and across localities where they had different levels of electoral support in the previous election. Specifically, we estimate the following regression:

$$y_{imst} \quad = \quad \gamma \cdot 3G_{mt} \cdot \text{VoteShare}_{im} + \lambda_{im} + \delta_{mt} + \phi_{it} + \epsilon_{ismt} \tag{3}$$

where VoteShare_{im} is the vote share of legislator i in municipality m, defined in Equation (1). For ease of interpretation, we demean the variable *VoteShare*. Note that we include, besides the politician-municipality level (λ_{im}), fixed effects for politician-time (ϕ_{it}) and municipality-time (δ_{mt}). These account, respectively, for non-linear trends in the behavior of politicians (for instance, over the electoral cycle) and for the concern that 3G entry could correlate with time-varying unobservable factors at the municipality level. Note that, because we control for municipality-time fixed effects, the coefficient on 3G alone is not identified, and we thus focus our interest on the interaction between the availability of 3G internet and the vote share of politicians across municipalities, $3G_{mt} \cdot \text{VoteShare}_{im}$.

As we have seen in Section 2, politicians seem to pay special attention to their electoral strongholds, and thus might be expected to respond differently in those places. To capture this possibility, we estimate a more flexible model where we allow for the effects to be non-linear with the vote share. we estimate:

$$y_{imst} \quad = \quad \sum_{\tau=2}^{10} \gamma_\tau \cdot 3G_{mt} \cdot \text{VoteShareDecile}^{\tau}_{im} + \lambda_{im} + \delta_{mt} + \phi_{it} + \epsilon_{imst} \tag{4}$$

with the $\text{VoteShareDecile}^{\tau}_{im}$ dummies we defined in Section 2.

The coefficients of interest in equations (3) and (4)) are γ and γ_τ. The former captures the differential impact in the response to 3G entry in municipalities where the politicians had more votes, in linear fashion,while the latter does so for different groups of municipalities, according to their degree of importance to the politician. Intuitively, the "treated" municipalities are those that receive 3G access and are relatively important to the politician, and the coefficients of interest estimate the response in those municipalities, relative to the "control" group including municipalities that did not receive 3G (regardless of importance), as well as municipalities that are unimportant.

Our setting allows us to further unpack the response of legislators, by distinguishing the role of 3G access from that of the municipalities' importance to the politician. Specifically, we control for other potential time-varying factors affecting the effort of politicians directed to all municipalities that are of similar importance to them, by adding year fixed effects interacted with the $\text{VoteShareDecile}_{im}^{\tau}$ dummies:

$$\begin{aligned} y_{imst} \; = \; & \sum_{\tau=2}^{10} \gamma_\tau \cdot 3G_{mt} \cdot \text{VoteShareDecile}_{im}^{\tau} + \sum_{\tau=2}^{10} \kappa_t^{\tau} \cdot \text{VoteShareDecile}_{im}^{\tau} \\ & + \lambda_{im} + \delta_{mt} + \phi_{it} + \epsilon_{imst}. \end{aligned} \tag{5}$$

In words, these interactions allow us to control for trends over time that affect municipalities of similar importance in a similar way, irrespective of their 3G access. In a scenario of rapidly decreasing costs of communication due to the arrival of Facebook, these terms capture the incentive of politicians to respond by communicating with all municipalities in their base of support. The coefficients γ_τ then capture the differential response to 3G access.

All our dependent variables include a large number of zeroes. To deal with that, unless otherwise stated, we apply the inverse hyperbolic sine transformation (IHS) to the dependent variable.[22] Finally, the standard errors in specification 1 are clustered at the municipality level, while specifications 2-4 are two-way clustered at the municipality and politician levels (Cameron et al., 2011).

4 Results

4.1 How Do Politicians Respond When Facebook Comes to Town?

Municipality-Level Evidence. We begin by estimating regressions at the municipality level to examine the response of politicians in terms of social media activity, speeches, and earmarked transfers, leveraging the variation introduced by the expansion of the 3G network. These initial regressions help us establish broad patterns in the data, as well as assess the validity of our difference-in-differences research design.

Our first step is to define the proper comparison group in our analysis. In our setting, we have three groups of municipalities: those that gained access to 3G internet before

[22]The IHS transformation is very similar to log away from zero, but has the advantage of being defined when the dependent variable has value zero. All our results are robust to using $log(1+x)$ transformation instead.

2011 (the *always-treated* in our period of analysis), those that obtained 3G access between 2011 and 2014 (the *switchers*), and those that remained unconnected as of 2014 (the *never-treated*). The always- and never-treated represent very different comparison groups regarding the potential response of politicians following access to the 3G network. What is more, in Table 3, which presents characteristics of municipalities in these distinct groups, we see that municipalities that get early access to 3G are different in many observable characteristics compared to those that get connected during our study period (2011-2014) and afterward. They are, on average, wealthier, larger, and more urban, consistent with telecom companies expanding 3G internet according to a profit-maximizing objective and targeting first large and more affluent localities.

These differences come to the fore as we estimate a specification checking for the presence of parallel trends across the different groups:

$$y_{mst} \quad = \quad \sum_{j=-3}^{3} \beta_j \cdot 3G_{m,t+j} + \lambda_m + \delta_{st} + \epsilon_{mt}, \tag{6}$$

where $3G_{m,t+j}$ is a variable that takes the value of 1 if municipality m gained 3G access at time $t+j$, and zero otherwise. We estimate it twice, on different samples: one excluding municipalities that had 3G prior to 2011 (always-treated), and one excluding those that did not have 3G access in 2014 (never-treated). In Figure 3, we plot the coefficients from estimating Equation (6) for six dependent variables, keeping the two comparison groups (always-treated and never-treated) separate. The first four use the measures of Facebook engagement by politicians and the response from their followers. The last two plots use speeches and targeted transfers to measure politicians' offline behavior. As is clear from the figure, jurisdictions connected to 3G internet prior to 2011 followed a very different trend in Facebook posts and targeted transfers.

Based on the differences in characteristics and pre-trends, we proceed to use as the comparison group the localities that remained without access to 3G internet until after the 2011-2014 legislature. The focus on this group also underscores that the more natural comparison is not with the municipalities that did not gain 3G access over the period of analysis because they already had it, but rather with those that remained without access: not having access at all is rather different from having it throughout.

Upon treatment, Figure 3 shows that there is a quick and substantial increase in Facebook activities by politicians and users after a municipality receives 3G internet. One year after municipalities got 3G internet, politicians' Facebook posts mentioning those municipalities increased by approximately 10 percent, reaching a 30 percent increase in two years. This pattern is similar when we measure the number of likes, comments, and shares on these posts. When it comes to offline behavior, however, the pattern is strikingly different: when municipalities get 3G internet access, they receive fewer mentions in speeches made in Congress by the legislators (4% fewer mentions in the year of adoption, and 9% fewer two years later). Moreover, although noisy, we find no evidence that municipalities getting access to 3G internet receive more transfers from politicians.

We summarize these patterns in the differences-in-differences estimates in Table 4, again using the never-treated as the comparison group. Columns *(i)*-*(iv)* show that municipalities that get connected to 3G internet experience a 15.7% relative increase in the number of Facebook mentions by legislators, accompanied by an increase of 26.3%, 25.5% and 21.0% in likes, shares and comments obtained by those posts. In contrast, politicians mention municipalities that got 3G access 4% less often in speeches in Congress (column *(v)*). Column *(vi)* shows a negative estimate of 15% for targeted transfers, though rather imprecisely estimated.[23]

Note that our setting displays the "staggered adoption" pattern that has been recently shown to raise pitfalls for two-way fixed effects research designs. To address such concerns, we implement the procedure suggested by Callaway and Sant'Anna (2021). We show the results in Appendix Table A4, where Panel A reproduces the baseline estimates for convenience. We first adapt our specification to closely match the setting in Callaway and Sant'Anna (2021) (Panel B), and then implement their estimation for the average treatment effect for the treated subpopulation (ATT, in Panel C).[24] We find that all ATT point estimates are statistically significant, and in fact slightly larger in magnitude than in previous specifications – with the exception of the effect on transfers, which remains insignificant and small throughout. This dispels the possibility that the effects we detect are spuriously driven by the well-known biases in estimating two-way-fixed-effects regressions.

[23]In Appendix Table A2, we show that the results cannot be attributed to broader trends in Facebook activity that correlate with the 3G rollout – for instance, if Facebook activity was trending upwards more strongly for larger or urban municipalities, which just happened to have a faster 3G rollout as well. To tackle this concern, we include into the specification population and urbanization controls (a dummy for above-median population and urban share) interacted with the state-year fixed effects, thereby allowing for differential trends. Coefficients are smaller in magnitude but significant with the population control, and essentially unchanged with urbanization control.

[24]The changes with respect to the baseline model are: 1) replace the state-year fixed effects with less flexible year fixed effects (all specifications have municipality fixed effects); 2) code the treatment variable as a dummy equal to one if the municipality had 3G signal for more than six months in year t, as opposed to the share of months with 3G signal we use in the baseline specification. Overall, as shown in Panel B, we find that the coefficients are similar in magnitude (for the number of posts and speeches) or larger (likes, shares and comments), or remain insignificant (transfers).

Exploiting the Variation across Politicians and Municipalities. The evidence above is consistent with a substitution pattern between politicians' online and offline activities. However, this municipality-level evidence does not capture the heterogeneity in the behavior of politicians across different municipalities. This may be especially problematic in the case of earmarked transfers, since politicians only send transfers to a fraction of all municipalities: seven, on average, towards the end of the sample period, out of hundreds of municipalities in the typical state (see Table 2). To deal with this issue, we move to the model described by Equation (3), in which we introduce politician-municipality and municipality-time fixed effects, and interact the 3G entry dummy with the municipality's share in the legislator's vote.

We show results from this specification in Table 5. Column (1) shows that the entry of 3G internet was associated with a relative increase in the number of posts made by politicians citing the newly connected municipality, in places that represented a larger share of the politician's vote. For a sense of magnitudes, the standard-deviation of the vote share (which ranges between 0 and 100), is 2.33 units in our sample. Our estimates imply that a one-standard-deviation increase in candidate vote share for the municipalities that had 3G access is associated with a given politician posting $2.33 \times 29.7 = 69.2\%$ more. Columns (2)-(4) in turn show that followers also increased the relative number of likes, shares and comments to politicians' posts mentioning those important connected municipalities. Together, these results imply that politicians indeed communicated more through social media with voters in more important localities, as their access improves.

We examine in columns (5) and (6) of Table 5 how the entry of 3G internet affects the number of congressional speeches mentioning and of transfers targeted to a given municipality, depending on its importance to the politician. Connected municipalities that are one standard deviation above the average politician's vote share have a 30% lower probability of ever being mentioned in a speech in any given year. Similarly, these localities are also 69.9% less likely to receive at least one transfer, and receive on average 5.6% less resources, although the latter estimate is not significant at conventional levels. Together with the results at the municipality-level, we conclude that these municipalities seem to have received less political attention using traditional political tools such as Congressional speeches and directed transfers.

The specification above already captures heterogeneity in politicians' behavior across municipalities. However, as we have previously noted, there may well be non-linearities in how politicians respond to municipalities according to their importance as captured by the vote share. To allow for these non-linear effects, we estimate the semi-parametric specification from Equation (4), which interacts the 3G indicator with the vote share decile. We show the results for all six dependent variables in Figure 4 where each dot represents the γ coefficient for a given decile with the respective 95% confidence interval in bars.[25] The first four panels show that, consistent with our previous results, access to 3G internet is associated with more posts made by politicians, as well as likes, comments and shares of those posts by Facebook users. These effects are especially pronounced for the top two deciles of vote share, confirming the non-linear treatment effects based on the electoral importance of a municipality. The bottom two figures show the effects for offline behavior as measured by speeches and transfers to municipalities. We find that in the top decile – that is, the localities that account for a large share of the votes obtained by the politician in question – they reduce both the mentions of a municipality in speeches, as well as the transfers directed to these municipalities.

This underscores the pattern of substitution between online and offline interactions, for the municipalities that are most important to a politician: they witness greater online engagement, at the expense of fewer offline resources. To further unpack these patterns, we turn to the specification in equation (5), including the interactions of all $\text{VoteShareDecile}^{\tau}_{im}$ with year fixed effects. This allows us to decompose the response of politicians in a given municipality into two parts: the role of the municipality's importance to the politician, and the role of its entry into the 3G network. Specifically, the year interactions capture the role of importance in a given year: a common component moving the response for all municipalities within a given decile, irrespective of 3G access. Conversely, the 3G interaction captures the role of 3G access: a differential response affecting connected municipalities in a given decile, relative to the municipalities of similar importance that remain unconnected.

The results are in Figures 5 and 6, where the estimates for the interactions of each vote share decile with the 3G dummy, and with the indicators for years 2012 to 2014, are respectively shown.The pattern is strikingly different for the online and offline types of engagement. When it comes to online activities, the role of importance clearly dominates. In other words, as Facebook expands, politicians mention important municipalities more often on Facebook (and these posts get stronger user engagement), and that effect (in Figure 6) swamps the variation coming from 3G access.

The pattern for earmarked transfers, in particular, is the reverse, with the role of 3G access being the much more prominent one, as is clear from Figure 5. In other words, municipalities in the top decile that obtain 3G access lose resources, in relative terms.

[25]The wider confidence intervals for the top decile are the natural implication of the wider range of variation in vote shares within that decile, as discussed in Section 2. In other words, the top decile contains substantially more heterogeneity in terms of the relative importance of municipality-legislator pairs within it.

Where do the resources go? Figure A3 already showed that the distribution of transfers is heavily concentrated in the top decile, indicating that, on the margin, legislators switch transfers within that group, from municipalities with 3G to others without 3G.[26] The pattern for speeches sits somewhere in between, with a role for both components, though less precisely estimated.

These contrasting patterns are consistent with the relative cost and scarcity of online versus offline activities. In the online realm, communication via Facebook is very cheap, and does not face tight budget constraints. As the platform expands, it makes sense to try and communicate with all municipalities that matter to the politician's prospects. In contrast, the constraints on the allocation of offline activity are much tighter: there is a strictly limited amount of resources available for earmarked transfers, and a real limit on the amount of time available for floor speeches. This forces choices on politicians, and the striking result is that they choose to move resources away from the localities with better social media access, via the 3G network.

In sum, upon the entry of 3G into a municipality, politicians for whom that municipality is important interact more with it online, by dint of their importance. Yet the presence of 3G induces them to redirect their offline efforts away from those municipalities, and towards the municipalities of comparable importance that remain outside of the 3G network. In other words, we confirm the pattern of substitution in which 3G access induces a decrease in offline responsiveness towards important municipalities, in spite of the increased interaction in the online realm.

Robustness and Heterogeneity We also conduct exercises to confirm the robustness of our baseline findings, as well as explore possible dimensions of heterogeneity. We start by looking at the possibility that there would be anticipation effects, where leads of 3G entry would predict behavior, which could lead to concerns about some form of endogeneity of entry that would not be picked up by the municipality-time fixed effects. Figure A4 shows that leads are not significant predictors of politician behavior. We also account for the fact that 3G internet coverage does not stop at the administrative border between municipalities, by excluding from the sample municipalities in years when they had not obtained 3G, but neighboring municipalities already had access to the technology.[27] Despite a smaller number of observations, results are qualitatively

[26] In fact, the increase in transfers between 2011 and 2014 (an election year) is on average 126% for the municipalities who did not have 3G as of 2014, compared to 107% for those who had acquired access by then.

[27] We defined as neighboring municipality the ones for which the closest distance at any two points in their polygons is smaller than 50km, which is the maximum coverage of 3G antennas. We also exclude

similar from our baseline specification, as can be seen in Figures A5 and A6.

We also consider other dimensions that could affect our baseline results. We input a missing value for the variables that describe Facebook activity if a politician did not have an open Facebook account in that period, which makes the panel unbalanced. In addition, it could be the case that part of the response is being driven by the politicians opening Facebook accounts. Figure A7 balances the panel by restraining the analysis to politicians who already had a public Facebook profile by 2011, and Figure A8 does so by setting values for politicians without an account to zero instead of a missing value. The results are very similar.

Up to now we have considered that all municipalities are homogeneous, but some localities are much larger than the others. Because legislators get elected based on total votes, not vote shares, they might respond differentially to more populous jurisdictions. We account for this by estimating the baseline specification weighing each observation by the population of the municipality. The results shown in Figure A9 are qualitatively similar to our main specification. Similarly, Appendix Figure A10 shows that the effects are similar for relatively large and small municipalities, as defined by having a population above or below the median.

Finally, we also check for heterogeneity along the characteristics of politicians. Appendix Figure A11 shows results for age, with below- and above-median politicians. While we cannot statistically tell them apart, it seems that, if anything, older politicians respond more strongly. This suggests that the familiarity of individual politicians with the new technology – which one may assume would be stronger for younger legislators – is not relevant for the online response. This is consistent with the fact that most politicians outsource their social media presence to staff.[28] By the same token, it does not seem like more educated legislators (namely, those with college degrees) are more likely to respond online (Appendix Figure A12).

4.2 Looking at the Issues

What do politicians talk about when they talk about municipalities on Facebook?

We have shown that politicians are more likely to mention municipalities on their Facebook feeds when these municipalities get connected to 3G internet, especially those that are politically important to them. As we mentioned in Section 2, politicians post mes-

municipalities that are within the same "population arrangement", as defined by the Brazilian Statistical Bureau (IBGE).

[28]This has been confirmed to us in conversation with legislative staff.

sages with policy content, as captured by keywords associated with legislative activity, and with education and healthcare. It seems reasonable to expect that their additional messages mentioning municipalities may include policy-relevant content as well.

To study this in greater depth, we trained a topic-modeling algorithm to detect policy-relevant content in the Facebook posts. We manually classified 2,000 posts into four topics: two related to the provision of public goods – health and education – and two that measure direct parliamentary activity in the Congress – projects and amendments. The latter category is particularly important because, as we have mentioned, transfers to municipalities are typically implemented through amendments to the annual budget law. We then ran a penalized logistic regression to predict our manual classification, using the count of words mentioned in those posts as explanatory variables. We use the trained algorithm to automatically detect the topics in the remaining 169,000 posts.[29]

We use the posts classified by topic to estimate a series of semi-parametric regressions as the ones specified by Equation (4), but replacing the dependent variable with the number of posts where politician i cites municipality m while also talking about a given topic (e.g. education), as detected by our algorithm. We show the results in Figure 7, panel A, where each color represents a different topic. The results suggest that politicians indeed used their Facebook pages to convey messages related to policy and legislative policy-making to specific municipalities, especially those that are most important to them.

What kinds of transfers do politicians shift around in response to 3G entry?

Along similar lines, we can also ask what kinds of tranfers are driving by the patterns we have detected. In Figure 7, Panel B, we present results from the same specification, but using as dependent variables the earmarked transfers classified by topic. To do so, we use information on the ministry or government agency that implemented the earmarked transfer (e.g. Ministry of Education). We focus on spending pertaining to the five biggest spending categories: 1) health, 2) education, 3) agriculture, development, and environment, 4) industrial and urban development, and 5) integration and defense.

The results show that, unlike what was the case for online activities, the response in transfers is more concentrated in some topics. Specifically, it is education- and agriculture-related projects that are most responsible for the shift from connected to unconnected municipalities that occurs at the top decile of support. Health and urbanization, in con-

[29]We also used combinations of two and three words. Prior to this step, we used the Portuguese dictionary to stem the words, and eliminated the ones which are unlikely to carry predictive power such as articles. We then evaluated the out-of-the-sample performance of the algorithm, and found that 96% of the posts that mentioned amendments were correctly classified as such.

trast, are largely unaffected. That said, we don't have enough precision to establish that the response is statistically different across different topics, so a word of caution is warranted in interpreting these results. Still, the broad pattern is in line with the tighter constraints to which offline activity is subjected.

The role of traditional media

The finding that Brazilian legislators shift resources away from from municipalities in their base of support that get connected to the 3G network, even as they engage online with them more, is in contrast with the body of literature that points to an increase in responsiveness of politicians in the presence of traditional media, due to better-informed voters receiving more favorable policies (Strömberg, 2001, 2004a,b; Besley and Burgess, 2002; Eisensee and Stromberg, 2007; Snyder and Strömberg, 2010). This suggests that the effectiveness that traditional media often has in increasing politicians' accountability does not necessarily translate to online social media. It also points to a margin of substitution between online and offline parliamentary activity: because politicians get much more exposure on Facebook, they can attempt to get away by doing less for municipalities that can see their posts, shifting resources instead to municipalities that do not have 3G internet.

Given this contrast with the impact of more traditional media, it is worth considering how these pre-existing media sources may interact with the arrival of 3G internet in affecting the response of politicians. For that we exploit the fact that there is wide variation in the availability of traditional media at the local level, across Brazilian municipalities, In Figure 8, we estimate the effects of 3G internet by deciles of vote, as before, but splitting the sample between municipalities with and without the presence of local mass media (radio and TV). For ease of comparison we plot the coefficients from both samples in the same graph. While the point estimates of 3G internet are slightly larger in localities without local media, we cannot reject that the effects are the same between the two types of municipalities. Thus it seems that the change in the behavior of politicians driven by the arrival of 3G internet does not hinge on the presence of pre-existing media outlets.

The patterns in the data indicate that the mechanism behind the online-offline substitution is not related to the new media technology crowding out information that would have been provided by pre-existing media that are being displaced (e.g. Gentzkow, Gentzkow; Falck et al., 2014). If that were the case, one would have expected the effect to be driven by localities with stronger presence of pre-existing outlets. This is consistent with the fact that coverage of federal legislators in traditional media is very low to begin with, which makes them a less meaningful source of accountability for these politicians.

5 Interpretation

Our key results establish that the expansion of internet access in a municipality, via its entry into the 3G network, led to an increase in the online engagement of politicians for whom that municipality is an important part of their electoral base. This was matched, however, by a decrease in the politicians' offline engagement, and particularly in their inclination to transfer earmarked resources to the municipality. What might explain this pattern?

One straightforward explanation is that online and offline engagement are substitutes in a technological sense. For instance, it could be that, by amplifying the extent to which people learned about the politician's offline efforts, online engagement would render the latter less necessary. While this is certainly possible, it turns out that the substitutability pattern can emerge simply from how political competition plays out when politicians can strategically use both communication and transfers as means to secure votes. This establishes the possibility that improvements in communications can more generally lead to reduced effort directed by politicians to voters, along other dimensions, even in the absence of technological substitution between communications and effort. Instead, the pattern can arise as long as politicians are able to strategically use the communications technology to increase the attachment of their core supporters.

To see this more clearly, it is useful to sketch a conceptual framework distilling some of the forces at play. We propose a model of communication and electoral competition embedding two key assumptions that match the context of the expansion of social media: communication is more targeted to strong supporters than transfers (e.g. voters choose whom to follow on Facebook while loca public goods benefit all citizens in a locality), and communication doesn't face a budget constraint in the same way as transfers do. This being an illustrative framework, we will focus here on the intuition, while leaving the details of the model itself to Appendix C.

5.1 Facebook and Pork: A Conceptual Framework

Key Elements

The idea is to capture the key forces at play in the simplest possible way: consider two politicians (incumbent and challenger) competing for votes across all municipalities in a state. There are two instruments with which they can try to increase their votes in any given municipality: communication, available to both politicians, and earmarked transfers, available only to the incumbent.

Specifically, a voter will choose a given candidate if she derives greater utility from voting for them than for the other candidate; that utility is increased by transfers (in the case of the incumbent), communication effort, and general popularity in the municipality, and reduced by ideological distance. Politicians choose the optimal policies to maximize their vote share across all municipalities combined, minus the total cost of communications, which involves the amount of communication that is chosen for each municipality, and municipality-specific cost parameters. We will model the arrival of Facebook as a reduction in this cost parameter.

The first key assumption is that communication can only reach voters who start with a relatively high level of idiosyncratic preference for the politician. This is meant to capture the idea that it is only voters who are more aligned with a politician who will choose to follow them on Facebook, or, more generally, choose to pay attention to what the politician says. This defines a group of "core" supporters of each politician in any municipality (a group that will be larger in localities where the politician is more popular): communication can only increase the utility a candidate provides to a voter if that voter belongs to that core group of supporters.[30] The second key assumption is that the transfer budget is restricted, so that at most one municipality can be contemplated.

Main Results

The first key set of results characterizes the optimal communications strategy for a given transfers strategy. First, politicians will focus their communication efforts on municipalities where they are more popular. This is because their popularity translates into a larger set of core voters, who are reachable by those efforts. Second, a reduction in the cost of communication implies increased communication efforts, meaning that the arrival of Facebook will increase those efforts towards that municipality.[31] In fact, this impact will itself be stronger in places where the politician is more popular.

From this we can characterize the optimal transfer strategy, and the comparative statics in response to the arrival of social media. First, as long as the costs of communication are the same across municipalities, the (incumbent) politician will choose to direct trans-

[30]We assume that the core groups are non-overlapping, which removes the added complexity of strategic interactions between communication decisions, allowing us to focus on the interplay between transfers and communication.

[31]This seems obvious, but strictly speaking it requires the assumption of non-overlapping core sets. If the core sets of the two politicians overlap, then communication becomes a strategic substitute across politicians, which makes the comparative statics ambiguous. Intuitively, while a reduction in the cost of communication has the direct impact of increasing a politician's efforts, that increase triggers an incentive for other politicians to reduce their effort, which pushes the equilibrium comparative statics in the opposite direction.

fers to the municipality that is most important to them. Things change, however, if communication targeted at that municipality becomes relatively more effective, because of the expansion of the 3G network. In that case, they may choose to direct resources *away* from it, to the benefit of other municipalities where they are still popular (even if less so). In fact, they are willing to do that even at the cost of losing votes in the former, in exchange for obtaining additional votes in the latter.

Intuition

The intuition behind the results, in terms of our empirical context, is as follows. The arrival of Facebook, increasing the effectiveness of communication, leads politicians respond by increasing their communication efforts towards the more important municipalities. In our context, this means more Facebook posts targeted at those municipalities, as we find in the data. It follows that the core supporters of each politician will become more attached to them.

This in turn means that the incumbent politician will have a weakened ability to steal their competitor's core voters away by using transfers. As a result, they have an increased incentive to shift transfers towards another municipality that is important to them, but where communication remains less effective – namely, those that remain without 3G internet, again consistent with our findings. That is because this is where more voters are up for grabs, and transfers are the instrument that has a comparative advantage in reaching those "swing" voters. The result of the shift in transfers is an increase in the incumbent's votes in the latter municipality, while they may even lose votes in the municipality that joined the 3G network.

Our model thus showcases a mechanism through which online and offline engagement are substitutes, even in the absence of any technological feature inducing that substitutability. Instead, what leads to that pattern is that transfers are less targeted to core supporters than communication efforts: online engagement increases the attachment of core supporters, thus making transfers relatively less effective as a way of garnering additional votes.

More broadly, our model underscores the more general point that the expansion of social media need not increase the (offline) responsiveness of politicians. This is because politicians – unlike with previous media technologies – are also directly engaged in the provision of content, which means that they can avail themselves of the new technology to increase the attachment of their core supporters. In doing so, they increase their "market power" with respect to competitors and voters, which in turn induces them to switch their offline efforts to places where the ability to reach swing voters with transfers remains relatively high.

A final note on interpretation, beyond the specific scope of the model, has to do with the patterns we would expect to develop over time. It could be the case that places that gained increased access to social media first would lose transfers initially, only to eventually regain them as communication becomes more effective in the other municipalities. While this is possible, any feature leading to the persistence of the effects of transfers – for instance, if transfers can increase the politician's general popularity in the target municipality over time – would push in the opposite direction. More broadly, access to 3G internet is but one source of variation in social media presence. As long as variation in that presence remains, the logic of our model suggests that politicians would still be tempted to allocate their scarce offline efforts, on the margin, towards the less engaged places.

5.2 Additional Evidence

Our model highlights a possible channel whereby the reduction in transfers in response to the arrival of Facebook via 3G internet is due to the politicians' enhanced ability to increase the attachment of their core supporters. In that spirit, we can explore some tentative evidence as to whether the response we find in the data is indeed driven by politicians who are more likely to rely on core supporters.

To get at that, we construct a measure of seat safety by recomputing the rank of candidates in their states of origin. We consider that legislators who were in the lowest quartile of the vote-ranked list of elected candidates have relatively unsafe seats, and were therefore less able to rely on a core set of supporters. In Figure A13, we show evidence that those vulnerable legislators respond to 3G entry just as much as their higher-ranked counterparts, when it comes to making greater use of Facebook. Yet they do not reduce mentions in congressional speeches, or, more importantly, transfers to the municipalities in their electoral base of support: the effects on those variables are largely driven by the legislators we would expect to be better able to rely on an attached set of voters. This does not seem like what one would expect coming from pure technological substitutability.

This is further corroborated, at least in part, with an additional indirect measure of political competition: politicians who are not the only members of their party elected in their home states are more likely to face competition – in this case, given the Brazilian open-list system, from within their own party. Again, we find that these more vulnerable politicians respond just as strongly as the less vulnerable, when it comes to online behavior, but they do not reduce congressional speeches or transfers (Figure A14). Those effects are, as with the previous measure, driven by the arguably more core-reliant politicians.

It is also informative to look at the patterns of voting in the subsequent election, in 2014. For that, we estimate our baseline equation (4), with the the outcome variable being the votes obtained in 2014 by legislator i in municipality m. The results are shown in Panel A of Appendix Figure A15. We find that politicians lost votes in their electoral strongholds that got 3G, relatively to those that did not, between the 2010 and 2014 electoral cycles.

In fact, if we replace the municipality-year fixed effects with municipality fixed effects, we can recover estimates for the overall effect of 3G access across deciles, which we could not do in our baseline specification because 3G access varies at the level of municipality-year. Panel B of Appendix Figure A15 depicts those results. The straight line shows the level 3G effect (with the 95% confidence band in dashed lines): the presence of 3G is associated with increased vote shares on average, consistent with the presence of a better technology for communications. The estimates on the political base of support deciles, however, indicate negative and strongly heterogenous effects along the initial importance of the municipality. More specifically, the overall effect is strong and negative for the top deciles: in their strongholds, politicians lost votes in municipalities that obtained 3G access, relative to those that did not. This is in line with the pattern followed by transfers, and is consistent with the optimization suggested by our framework.

On a separate note, we can also consider heterogeneity in the degree to which the arrival of social media represents a reduction in communication costs. Specifically, we take into account the fact that, before the advent of online communication, mayors supplied a local platform through which candidates vying for a seat at the national Congress could disseminate their political positions and achievements. As such, we posit that this created significant disadvantages in communicating with local voters for politicians who were not in the party coalition of the local mayor, as the latter would be less willing to advance the interests of someone from a competing political party.[32] This would imply that the reduction in communication costs entailed by the new technology would be more significant in that case. Consistent with that, we find tentative evidence that politicians used Facebook more often to target municipalities in which the mayor was in a *different* coalition of parties, as shown in Figure A16, though without enough precision to make more definitive statements.

In sum, broadly speaking, this additional evidence underscores that the impact of

[32]Mayoral elections do not coincide with elections for the Congress. They are held every four years, in between national mandates. Thus, mayors elected in 2008 were in power during the 2010 national elections, with few exceptions.

social media on the behavior of politicians can be at least in part understood through the political competition channel spelled out in our conceptual framework. The reduction is offline effort seems to be observed mostly for the legislators who would be more reliant on a core set of supporters, the subsequent electoral outcomes match the patterns predicted by the model and the response in online effort seems to be stronger for politicians for whom new technology would have represented a larger reduction in communication costs.

6 Conclusion

We have examined the response of Brazilian legislators to the spread of Facebook in the country. We find that politicians respond by increasing their social media interactions with municipalities that are important for their electoral prospects. The ability to communicate very cheaply leads them to write more Facebook posts mentioning those municipalities, and these posts get more comments, shares, and likes from their followers.

Their behavior offline follows a very different pattern. The real and very tight constraints on how many localities they can target with their offline efforts forces politicians to make choices of where to allocate resources among their base of support. Far from indicating greater overall responsiveness to the voters reached by the new technology, the data instead show that the increased online interaction is countered by decreased effort, in terms of offline behavior, directed at important municipalities with better social media access, as induced by the presence of 3G internet. Politicians bring fewer resources to the municipalities that received 3G access, and mention them less often in congressional floor speeches. We show that this reduced offline effort is rationalized by a model in which the more effective communication technology brought by social media allows politicians to increase the attachment of their core supporters, allowing them to switch transfers to other municipalities, which end up with a relatively larger presence of swing voters. In short, social media does not seem to increase the responsiveness of politicians, because they allow them to increase their "market power" relative to voters as a group.

These results underscore the fact that social media are a fundamentally different kind of media technology, because they are not simply tools for the spread of news and information. Instead, their low barriers to entry allow politicians to become content providers, and that in turn changes the optimal mix of forms of engagement between politicians and voters. To the extent that actual resources are valuable, and more so than online engagement per se, this can actually be costly from the standpoint of voters.

Of course, our setting does not allow us to consider many important factors. For instance, it is not possible to make a clear welfare assessment, especially since we do not have a good way of measuring the social welfare impact of the local public goods financed via transfers. By the same token, what we observe is a relatively short-run response, as social media access spread rapidly across the country, although we have argued that it is not hard to imagine circumstances under which the short-run variation ends up persisting over time. Last but not least, it is evidently possible that what we have found in the Brazilian context may be different elsewhere, even though we have argued that there would be reason to believe, *prima facie*, that the positive impact of social media on accountability and responsiveness would have been particularly likely in that context, with its relative paucity of pre-existing sources of information.

With those caveats in mind, our evidence provides additional reasons to be skeptical of positive effects of social media on political accountability, even leaving aside concerns with "fake news" or misinformation that have become widespread in recent years. Social media can empower politicians relative to voters, and make them overall less responsive as a result.

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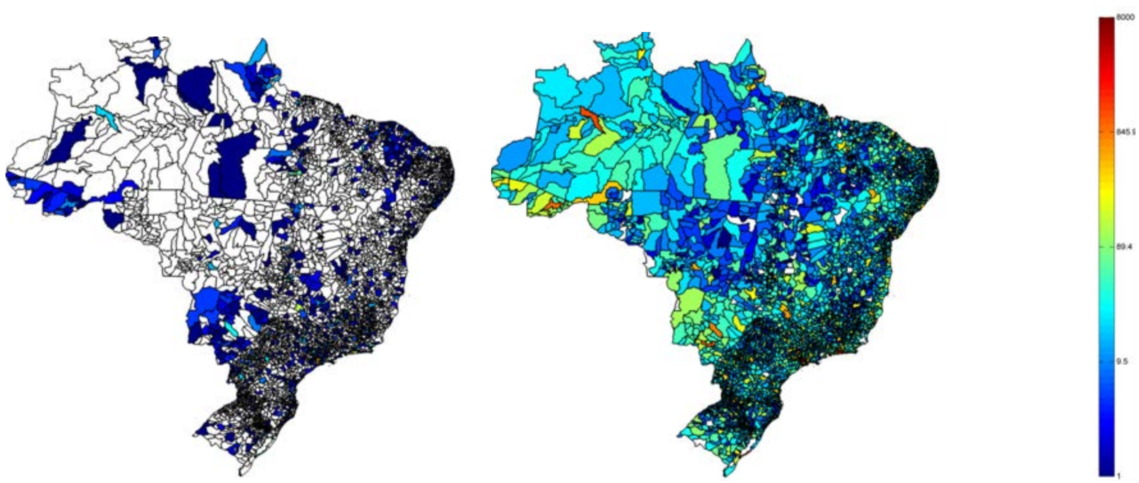
Tables and Figures

Figure 1: 3G internet rollout over time and Facebook use across the Brazilian territory

Panel A. 3G rollout

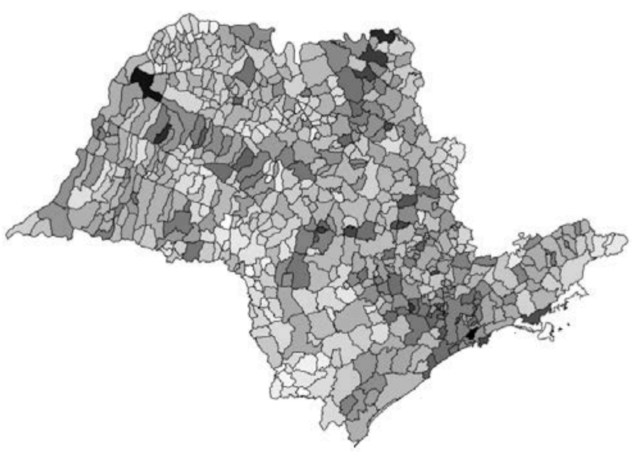
Panel B. Mention to municipalities on Facebook



Notes: Panel A: Roll-out of 3G coverage across municipalities in Brazil prior to 2011, after 2014 and for the intermediary years. *Source:* Teleco. Panel B: Number of times in 2011 and 2014 that municipalities are mentioned on Facebook, computed over the posts of all elected politicians in the log scale.

Figure 2: Spatial distribution of the vote share of the two best-voted politicians from São Paulo state

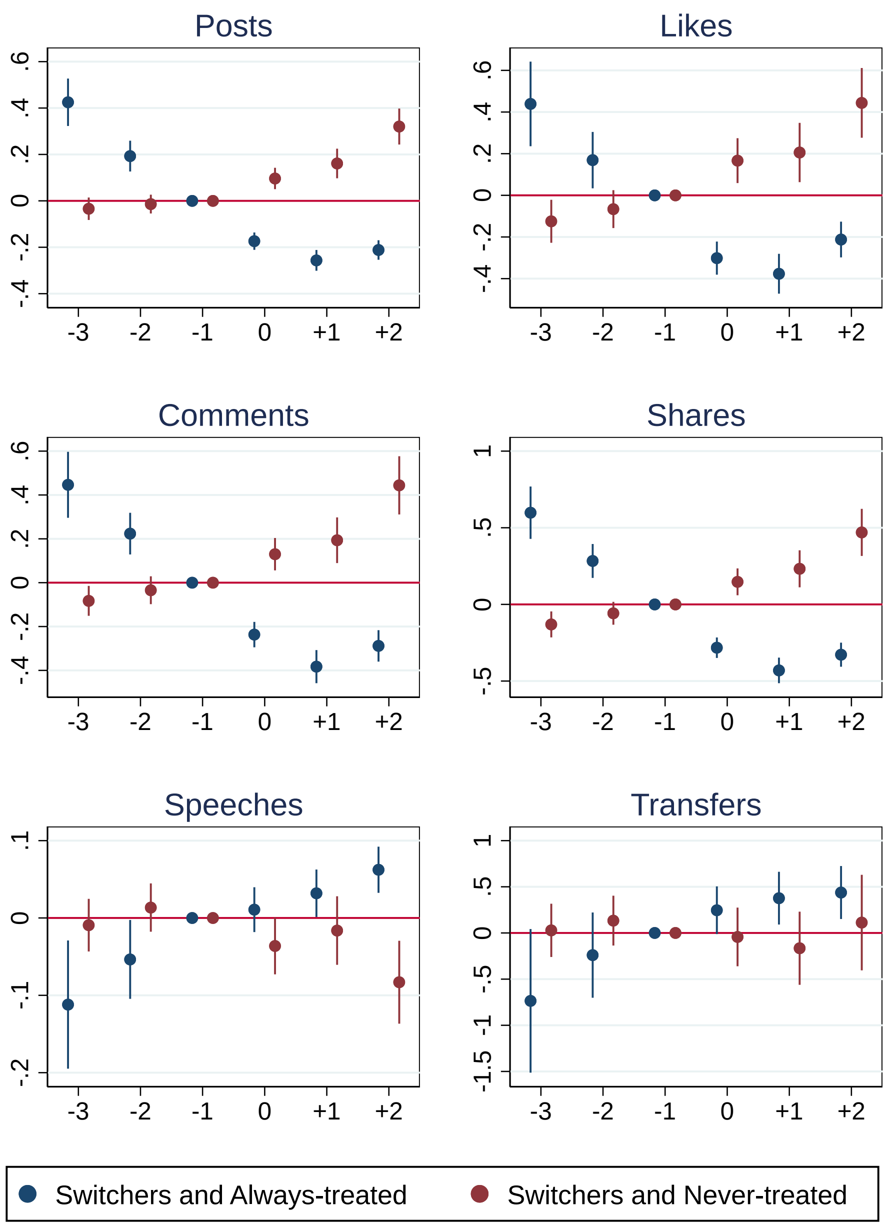
Tiririca (1.3m votes)



Gabriel Chalita (560k votes)

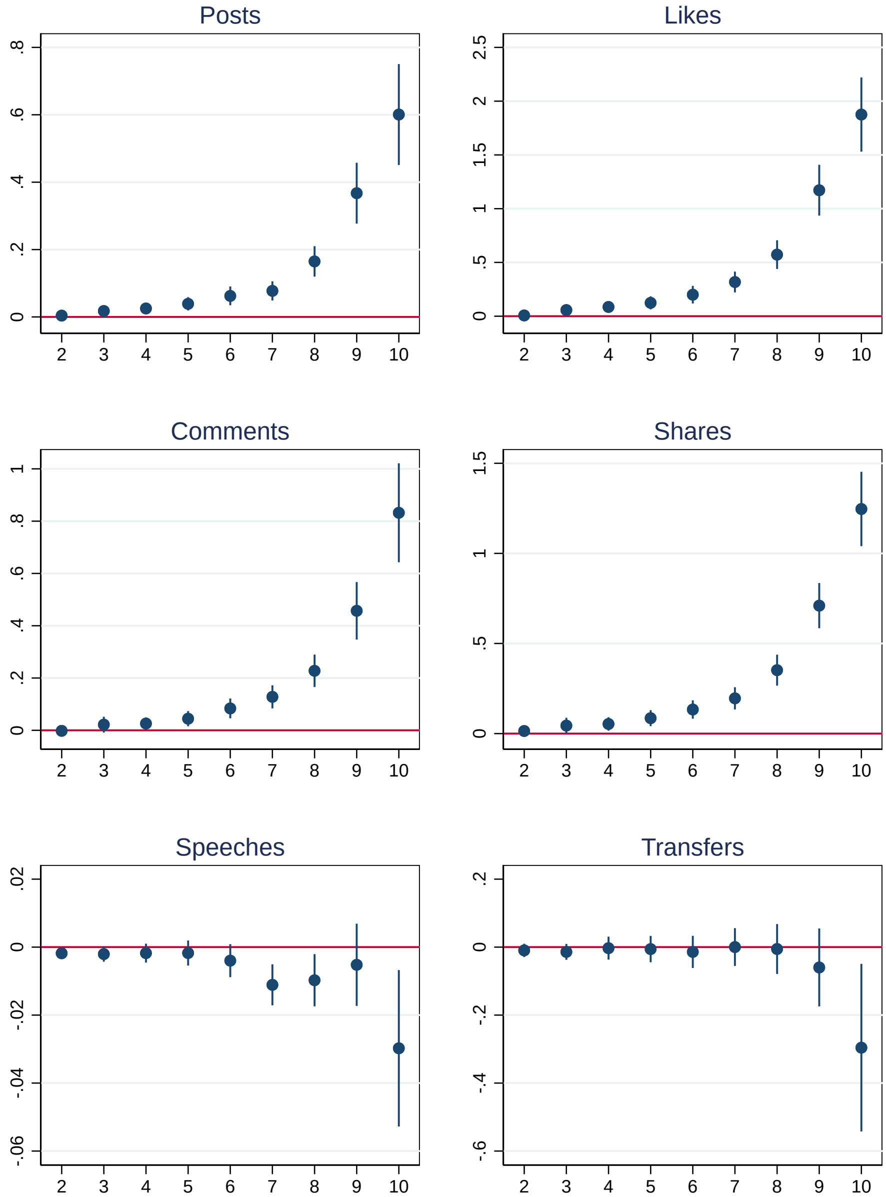
Notes: Vote shares per municipality of the two best-voted politicians from the state of São Paulo: Tiririca (1.3m votes) and Gabriel Chalita (560k votes). Vote shares are computed as the votes for the candidate in a municipality divided by the candidate's total number of votes. Light colors represent low vote shares. Black colors represent the highest vote share for each candidate. *Source:* Tribunal Superior Eleitoral (TSE).

Figure 3: Pre-intervention trends for different groups of municipalities



Notes: Coefficient plots for pre-trends specifications in Equation (6). Regressions of the dependent variable on leads and lags of 3G introduction at the municipality and year levels, with municipality and year-state fixed effects. "Switchers" refers to the set of municipalities that obtained 3G internet access between 2012 and 2014, inclusive. "Always-treated" obtained 3G internet access before 2012, and "Never-treated" obtained 3G internet access after 2014. "Switchers and Always-treated" refer to the estimates of Equation (6) using the "Always-treated" as the control units; equivalently, "Switchers and Never-treated" refer to the estimates using the "Never-treated" as the control units. Dependent variables are the inverse hyperbolic sine transformation of the number of posts citing the municipality, likes, shares and comments those posts obtained, congressional speeches citing those municipalities, and number of transfers targeting them. Clustered standard errors at the municipality level.

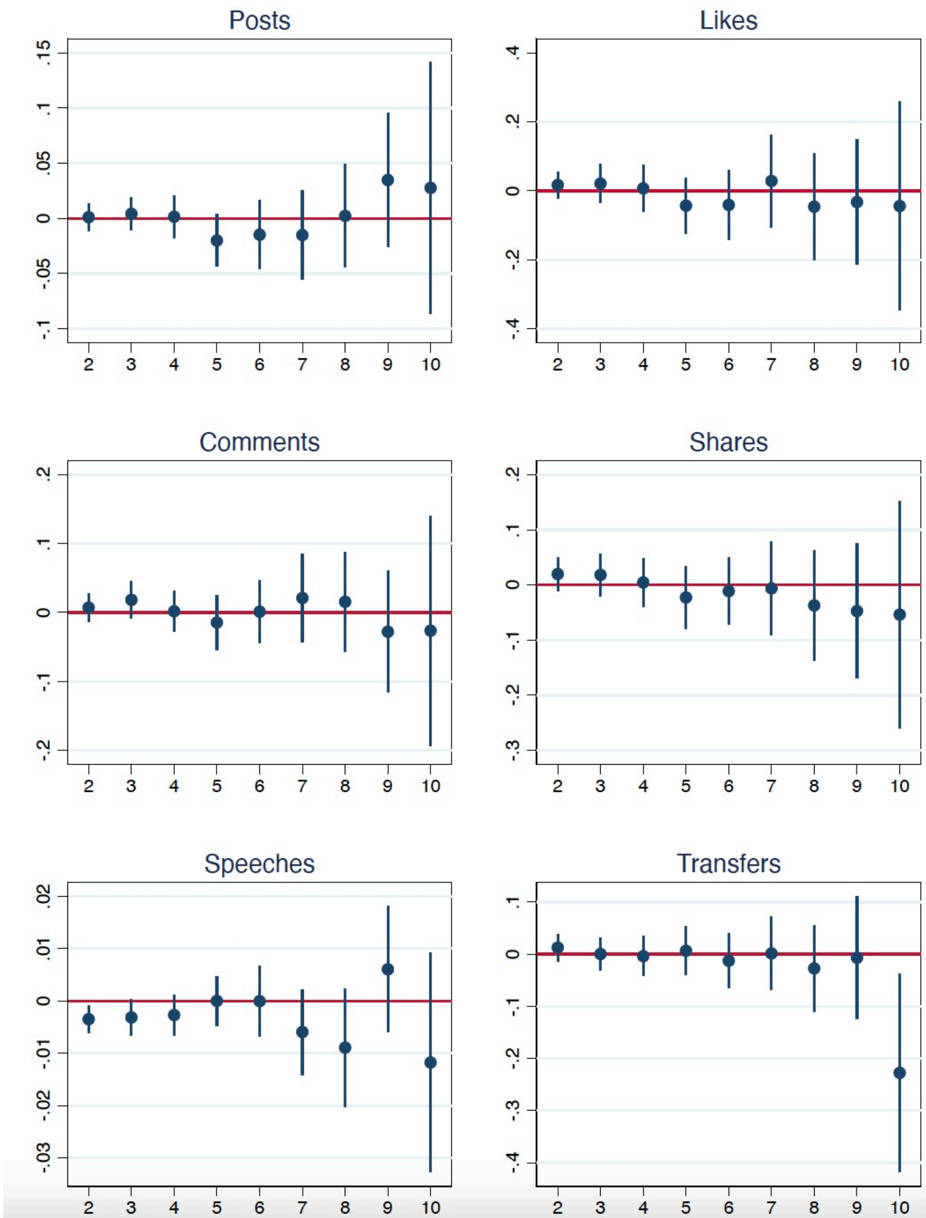
Figure 4: Effect of 3G entry on online and offline behavior



Notes: Panel regressions at the municipality-politician by year levels. In the top-left figure, the dependent variables is the inverse hyperbolic sine transformation of the number of politicians' posts mentioning a municipality in a given year, explained by presence of 3G dummy variable (treatment) interacted with the importance of the municipality for the politician (vote shares decile, along the horizontal axis) in the 2010 elections. Point estimates in circles, and the corresponding 95% confidence intervals in bars. All specifications includes municipality-time, municipality-politician, and politician-time fixed effects. The figures labelled as "likes", "comments", and "shares" use the inverse hyperbolic sine transformation of the number of likes, comments and shares that those posts obtained. "Speeches" refers to the inverse hyperbolic sine transformation of the number of politicians' speeches in Congress mentioning a municipality in a given year. Finally, "transfers" refers to the inverse hyperbolic sine transformation of the value of the earmarked transfers proposed by the politicians. Transfers in Brazilian Reais. Two-way clustered standard errors at the municipality and politician levels.

Figure 5: Effect of 3G entry on online and offline behavior

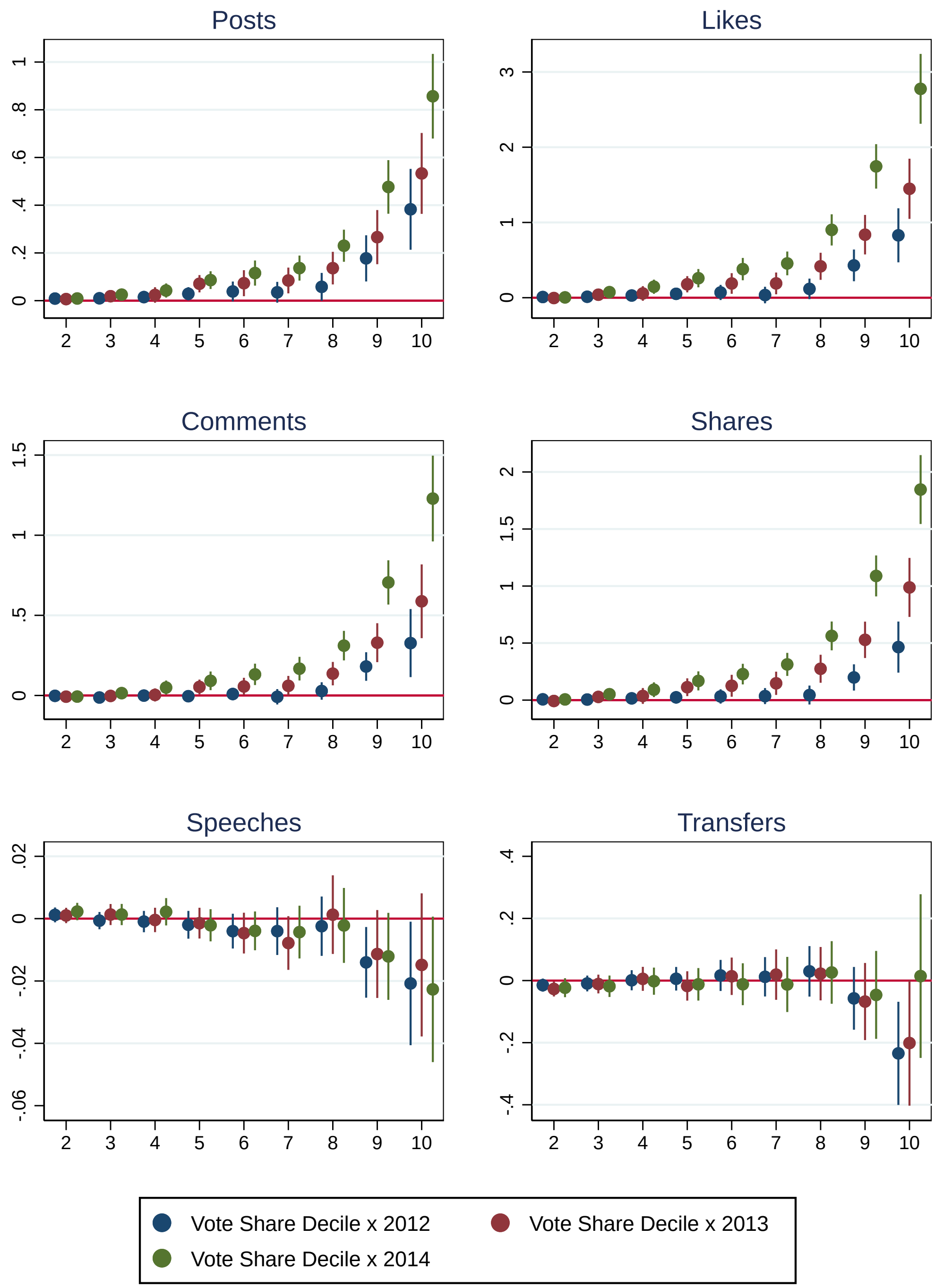
Unpacking the variation: 3G



Notes: Panel regressions at the municipality-politician by year levels. In the top-left figure, the dependent variables is the inverse hyperbolic sine transformation of the number of politicians' posts mentioning a municipality in a given year, explained by presence of 3G dummy variable (treatment) interacted with the importance of the municipality for the politician (vote shares decile, along the horizontal axis) in the 2010 elections. Point estimates in circles, and the corresponding 95% confidence intervals in bars. All specifications includes municipality-time, municipality-politician, politician-time, and vote share-time fixed effects. The figure shows the 3G x Vote Share Decile. The figures labelled as "likes", "comments", and "shares" use the inverse hyperbolic sine transformation of the number of likes, comments and shares that those posts obtained. "Speeches" refers to the inverse hyperbolic sine transformation of the number of politicians' speeches in Congress mentioning a municipality in a given year. Finally, "transfers" refers to the inverse hyperbolic sine transformation of the value of the earmarked transfers proposed by the politicians. Transfers in Brazilian Reais. Two-way clustered standard errors at the municipality and politician levels.

Figure 6: Effect of 3G entry on online and offline behavior

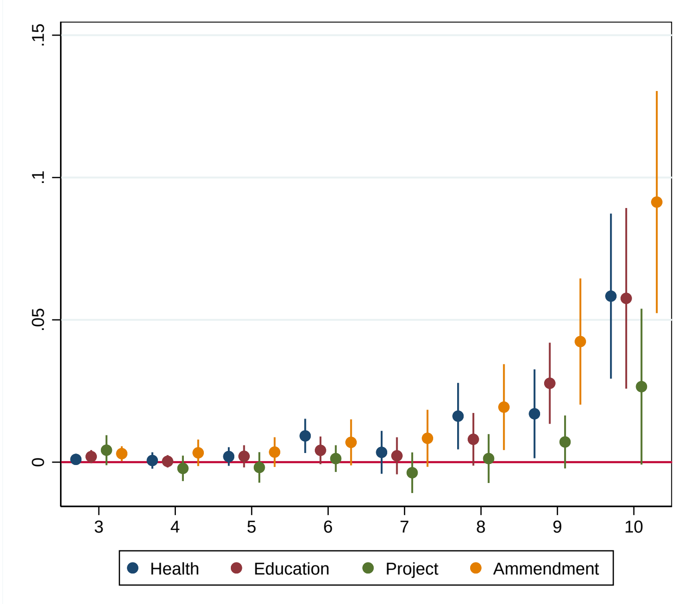
Unpacking the variation: Year Effects



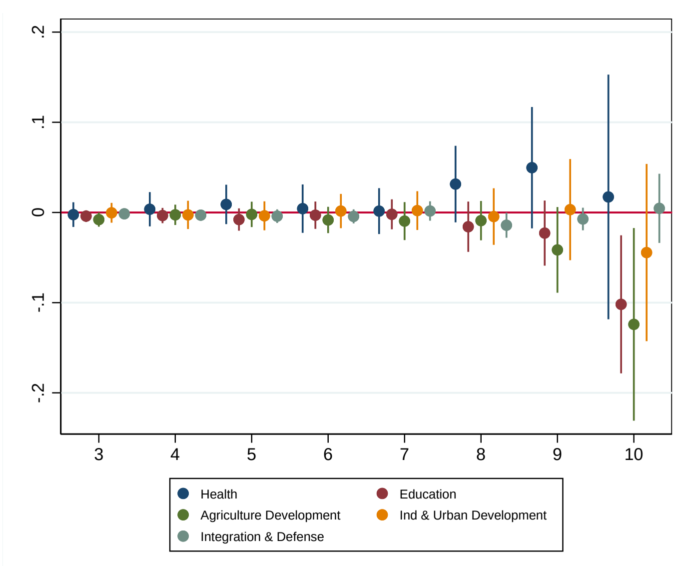
Notes: Panel regressions at the municipality-politician by year levels. In the top-left figure, the dependent variables is the inverse hyperbolic sine transformation of the number of politicians' posts mentioning a municipality in a given year, explained by presence of 3G dummy variable (treatment) interacted with the importance of the municipality for the politician (vote shares decile, along the horizontal axis) in the 2010 elections. Point estimates in circles, and the corresponding 95% confidence intervals in bars. All specifications includes municipality-time, municipality-politician, politician-time, and vote share-time fixed effects. The figure shows the vote Share Deciles interacted with the 2012, 2013 and 2014 indicators. The figures labelled as "likes", "comments", and "shares" use the inverse hyperbolic sine transformation of the number of likes, comments and shares that those posts obtained. "Speeches" refers to the inverse hyperbolic sine transformation of the number of politicians' speeches in Congress mentioning a municipality in a given year. Finally, "transfers" refers to the inverse hyperbolic sine transformation of the value of the earmarked transfers proposed by the politicians. Transfers in Brazilian Reais. Two-way clustered standard errors at the municipality and politician levels.

Figure 7: Topics cited in Facebook by the politicians and types of transfers

Panel A. Topic modelling



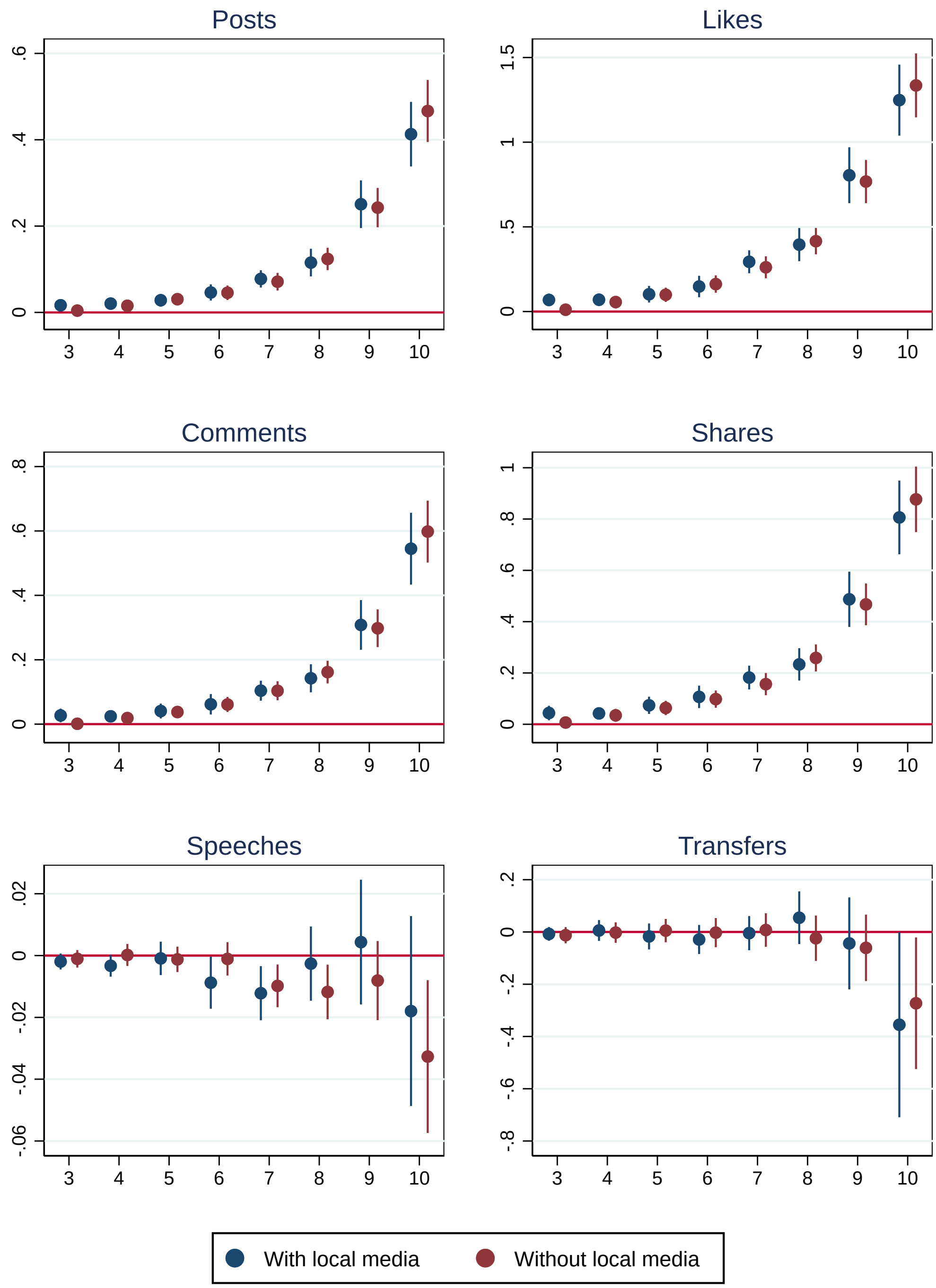
Panel B. Destination of funds



Notes: Panel regressions at the municipality-politician by year levels. In Panel A, dependent variable is the inverse hyperbolic sine transformation of the number of politicians' posts mentioning a municipality in a given year a and topic, explained by presence of 3G dummy variable interacted with the importance of the municipality for the politician (vote shares decile, along the horizontal axis) in the 2010 elections. In Panel B, the dependent variable is the inverse hyperbolic sine transformation of the count of the keywords "health", "education","project"and "amendment". Point estimates in circles, and the corresponding 95% confidence intervals in bars. All specifications includes municipality-time, municipality-politician and politician-time fixed effects. Two-way clustered standard errors at the municipality and politician levels.

Figure 8: Effect of 3G entry on online and offline behavior

Heterogeneous effects by presence of local media



Notes: Panel regressions at the municipality-politician by year levels. In the top-left figure, the dependent variables is the inverse inverse hyperbolic sine transformation of the number of politicians' posts mentioning a municipality in a given year, explained by presence of 3G dummy variable interacted with the importance of the municipality for the politician (vote shares decile) in the 2010 elections. The figure plots the coefficients of the interaction with (blue) and without presence local media (red), and the corresponding 95% confidence interval. Presence of local media is defined as municipality having AM, FM or community radio, or TV station. All specifications includes municipality-time, municipality-politician and politician-time fixed effects. The figures labelled as "likes", "comments", and "shares" use the inverse hyperbolic sine transformation of the number of likes, comments and shares that those posts obtained. "Speeches" refers to the inverse hyperbolic sine transformation of the number of politicians' speeches in Congress mentioning a municipality in a given year. Finally, "transfers" refers to the inverse hyperbolic sine transformation of the value of the earmarked transfers proposed by the politicians. Transfers in Brazilian Reais. Two-way clustered standard errors at the municipality and politician levels.

Table 1: The rise and adoption of mobile Internet and Facebook in Brazil

	2011	2012	2013	2014
Panel A. Internet adoption				
municipalities with 3G	1,542	2,994	3,429	3,720
% municipalities with 3G	.278	.539	.617	.670
% households with Internet use	.366	.403	.480	.549
% households with mobile Internet use	–	–	.536	.804
Broadband Internet subscriptions per 100 inhabitants	7.17	8.98	9.53	10.55
Mobile subscriptions per 100 inhabitants	100.1	118.0	123.8	133.9
Panel B. Facebook adoption				
% use Facebook (*Latinobarometer*)	.135	–	.428	–
% use Facebook (*Ibope Nielsen Online*)	.228	.243	–	–
% use Facebook (*Facebook*)	–	–	–	.450
Panel C. Google Trends interest index for Facebook, Orkut and Twitter				
Facebook	20.96	65.09	85.85	67.79
Orkut	22.06	14.91	2.67	1.00
Twitter	5.79	3.74	2.21	1.42

Notes: Panel A: "% municipalities with 3G" refers to the share of municipalities with 3G access in Brazil across regions (*Source:* TELECO), "% households with (mobile) Internet use" is the share of households that report using (mobile) Internet (*Source:* Pesquisa Nacional por Amostra de Domicílios, PNAD). Broadbrand Internet (mobile) subscriptions per 100 inhabitants (*Source:* World Bank). Panel C: "% use Facebook" is the share of Facebook users in the population (*Sources:* Latinobarometer, Ibope Nielsen Online survey and Facebook, available at https://www.facebook.com/business/news/BR-45-da-populacao-brasileira-acessa-o- Facebook-pelo-menos-uma-vez-ao-mes, accessed Jan 30th 2019). Panel D: Google Trends index for searches for Facebook, Orkut and Twitter in Brazil from 2011 and 2014. Numbers of Google searches are normalized with respect to the largest valued observed over time and across all series (*Source:* Google Trends).

Table 2: Descriptive statistics of politicians' online and offline behavior

	2011	2012	2013	2014	2011-2014 total, per pol.	2011-2014 total, all pol.
Panel A. *Politicians' online behavior*						
% open FB profiles	.173	.406	.657	.809	–	–
Posts	24.48	143.85	245.24	484.17	897.74	460.54k
	(37.01)	(303.52)	(492.93)	(1,004)	(1,517)	
Posts (*citing any municipality*)	4.44	44.85	102.55	177.56	329.1	168.98k
	(17.74)	(117.67)	(212.67)	(266.71)	(523.85)	
Likes (*from above*)	26.57	819.37	3,307.7	29,398.7	33,465.4	17.21m
	(98.21)	(3,022.8)	(9,159.6)	(146.31k)	(151.98k)	
Shares (*from above*)	4.15	296.57	1,107.5	11,617.2	12,937.7	6.64m
	(16.94)	(1,010.2)	(2,971.3)	(143.52k)	(144.47k)	
Comments (*from above*)	7.52	146.60	367.40	2,513.1	3,034.6	1.56m
	(30.42)	(530.63)	(1,083.2)	(20,906.2)	(21,284.8)	
Panel B. *Politicians' offline behavior*						
Speeches	24.06	20.38	26.09	17.74	87.91	45.28k
	(42.69)	(44.22)	(60.24)	(45.16)	(179.26)	
Transfers	5.68	4.95	4.81	6.56	21.81	11.28k
	(7.76)	(7.33)	(8.08)	(7.85)	(24.23)	
Transfers (R$)	R$ 5.54m	R$ 5.35m	R$ 4.12m	R$ 6.73m	R$ 21.74m	R$ 11.21b
	(R$ 5.74m)	(R$ 6.04m)	(R$ 5.52m)	(R$ 6.49m)	(R$ 20.42m)	
Number of targeted municipalities	6.32	5.34	5.52	6.99	9.47	3504.4
	(8.02)	(7.58)	(8.50)	(7.74)	(10.39)	

Notes: Panel A: "% open FB profiles" is the share of politicians per year that had opened their Facebook profiles. We defined a Facebook profile open from the moment of the first post. "Posts" are the number of posts on Facebook by politician. "Posts (*citing any municipality*)" is the subset of Facebook posts in which at least one Brazilian municipality was cited. "Likes", "shares" and "comments" are number of likes, shares and comments that those posts obtained. Panel B: "Transfers" is the average number of earmarked transfers proposed by politicians, per year. "Transfers (R$)" is the average value of earmarked transfers in Brazilian Reais, at the time of proposal. "Number of targeted municipalities" is the number of municipalities that were targeted through earmarked transfers by the politician in a given year. "Speeches" is the total number of speeches delivered in Congress that cited at least one municipality. Standard errors are calculated across politicians. Along the columns, "2011-2014, total, per pol." is accumulated values per politician across the 2011-2014 time period. It equal to the sum of for the 2011-2014 period, except for the "number of targeted municipalities" since the politician might repeatedly target them over time. "2011-2014, total all pol." is the number across all politicians, in all time periods. Standard errors in parenthesis. *Sources:* Facebook data from politicians' public Facebook profiles; transfers and value of transfers obtained from Brazilian Senate's database of amendments to the *Lei Orçamentária Anual*; speeches from Congress' database.

Table 3: Descriptive statistics of municipalities by date of 3G connection

		3G connection year		
	All	≤ 2011 *Always-treated*	[2012, 2014] *Switchers*	≥ 2015 *Never-treated*
Income per capita	R$ 493.80 (243.34)	R$ 621.42 (272.41)	R$ 491.32 (218.10)	R$ 389.67 (189.65)
Years of schooling	9.46 (1.09)	9.56 (.866)	9.56 (1.11)	9.27 (1.22)
Gini index	.494 (.066)	.498 (.058)	.484 (.068)	.504 (.068)
Population	34,316 (203,274)	93,617 (379,155)	13,929 (12,911)	8,696 (7,663)
% urban population	.638 (.220)	.779 (.197)	.624 (.207)	.537 (.191)
% poor	.232 (.179)	.162 (.151)	.219 (.178)	.306 (.175)
% electricity	.972 (.060)	.988 (.033)	.976 (.052)	.954 (.079)
Area	1.525 (5.612)	1.592 (6.022)	1.024 (3.028)	2.064 (7.308)
Turnout in 2010	.806 (.060)	.816 (.049)	.804 (.060)	.802 (.067)
Municipalities	5,556	1,542	2,178	1,836

Notes: Descriptive statistics of the municipalities in the sample. "Full sample" refers to the all Brazilian municipalities; "≤ 2011" is the subsample of municipalities that gained 3G access before January 2012; "[2012, 2014]" refers to the municipalities gained access between January 2012 and December 2014, thus during the period of analysis; "≥ 2015 " gained access on or after January 2015 and constitute the control group. "Income per capita" at the municipality level, in Brazilian Reais. "Years of schooling", "Gini index" and "Population" refer to the average number of years of schooling, Gini inequality index, and population in the municipalities. "% Urban population", "% poor", "% electricity" refer to the share of urban population, poor (defined as below poverty levels) and with household access to electricity. Area of the municipalities in thousands of square kilometers. Standard errors in parenthesis. *Source:* IBGE 2010 census.

Table 4: The effect of 3G internet rollout using municipality-level variation

	(i) Posts	(ii) Likes	(iii) Shares	(iv) Comments	(v) Speeches	(vi) Transfers
Panel A. Extensive margin, binary dependent variable						
Treat	.005	.013	.040***	.028**	-.024	-.007
	(.012)	(.012)	(.012)	(.012)	(.015)	(.014)
Mean of dep. var.	.535	.521	.467	.433	.348	.189
Panel B. Intensive and extensive margins, IHS of dependent variable						
Treat	.157***	.263***	.255***	.210***	-.039*	-.151
	(.027)	(.060)	(.048)	(.041)	(.020)	(.176)
Mean of dep. var.	3.19	294.9	161.7	30.34	.846	R$ 99,756
Observations	16,056	16,056	16,056	16,056	16,056	16,056
Treated	2,178	2,178	2,178	2,178	2,178	2,178
Control	1,836	1,836	1,836	1,836	1,836	1,836

Notes: Panel regressions at the municipality by year levels, explained by presence of 3G dummy variable, with municipality and state-year fixed effects. In Panel A, dependent variable is binary. In column *(i)*, it is equal to one if a given municipality was cited at least once in Facebook in a given year. Dependent variables in columns *(ii)*, *(iii)* and *(iv)* are equal to one if those posts obtained at least one like, share or comment, respectively. Dependent variable in column *(v)* is equal to one if the municipality was cited at least once on Congressional speeches. Column *(vi)* is equal to one the given municipality was targeted by transfers, and zero otherwise. "Mean of dep. var." refers to the mean of the dependent variable, averaged across the 2011-2014 period. In Panel B, dependent variables are the inverse hyperbolic sine transformation of the number of earmarked transfers proposed to the municipality in a given year, speeches delivered in the Congress and Facebook posts that mentioned the municipality, likes, shares and comments that those posts obtained. “Mean of dep. var.” refers to the raw numbers, without the inverse hyperbolic sine transformation, and averaged across the 2011-2014 period. Transfers in Brazilian Reais. Clustered standard errors at the municipality level.

Table 5: The effect of 3G internet rollout across the politicians' electoral base of support

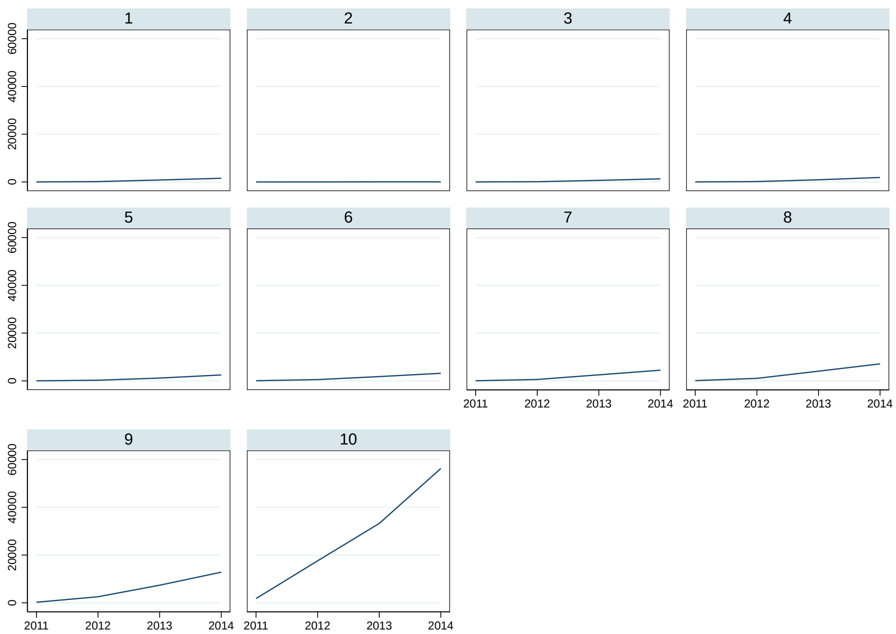
	(i) Posts	(ii) Likes	(iii) Shares	(iv) Comments	(v) Speeches	(vi) Transfers
Panel A. *Extensive margin, binary dependent variable*						
3G x Vote Share	.116***	.132***	.144***	.133***	-.006**	-.005
	(.020)	(.020)	(.021)	(.019)	(.003)	(.004)
Mean of dep. var.	.092	.089	.078	.065	.020	.010
Panel B. *Intensive and extensive margins, IHS of dependent variable*						
3G x Vote Share	.137***	.367***	.249***	.173***	-.013***	-.056
	(.022)	(.062)	(.041)	(.029)	(.005)	(.052)
Mean of dep. var.	.229	21.19	2.18	11.62	.033	3,844.2
Observations	203,107	203,107	203,107	203,107	412,254	412,254

Notes: Panel regressions at the municipality-politician by year levels, explained by presence of 3G dummy variable, and interaction with vote shares of the candidates in the municipalities. Specifications contains municipality-time, municipality-politician and politician-time fixed effects. In Panel A, dependent variable is binary. In column *(i)*, it is equal to one if a given municipality was cited by a politician at least once in Facebook in a given year. Dependent variables in columns *(ii)*, *(iii)* and *(iv)* are equal to one if those posts obtained at least one like, share or comment, respectively. Dependent variable in column *(v)* is equal to one if the municipality was cited by a politician at least once on Congressional speeches in a given year. Column *(vi)* is equal to one the given municipality was targeted by transfers, and zero otherwise. "Mean of dep. var." refers to the mean of the dependent variable, averaged across the 2011-2014 period. In Panel B, dependent variables are the inverse hyperbolic sine transformation of the number of earmarked transfers proposed to the municipality by a politician in a given year, speeches delivered in the Congress and Facebook posts that mentioned the municipality, likes, shares and comments that those posts obtained. "Mean of dep. var." refers to the raw numbers, without the inverse hyperbolic sine transformation, and averaged across the 2011-2014 period. Numbers are relative to the municipalities from the politicians' state of origin. Transfers in Brazilian Reais. Two-way clustered standard errors at the municipality and politician levels.

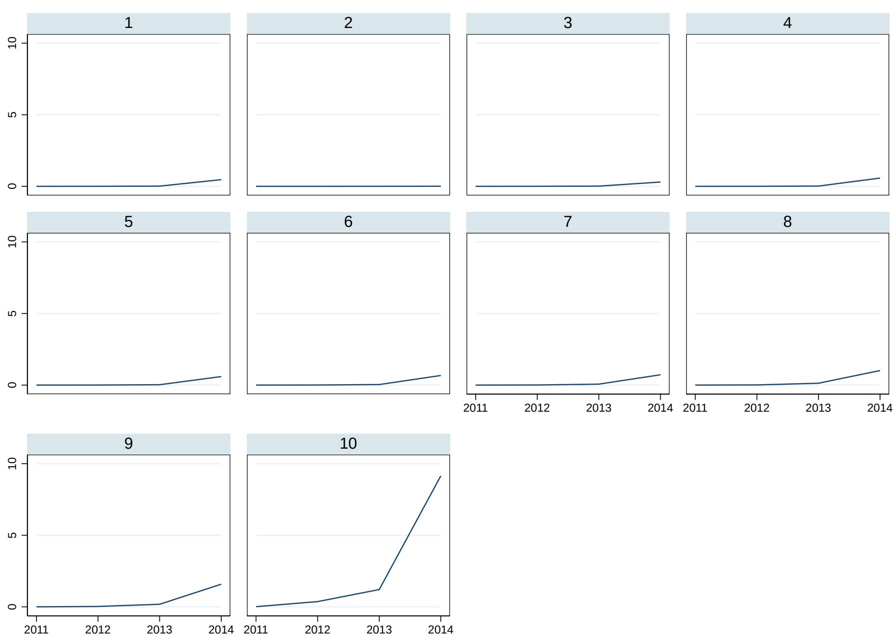
Appendix A Appendix Tables and Figures

Figure A1: Posts and likes by vote share decile, 2011-2014

Posts



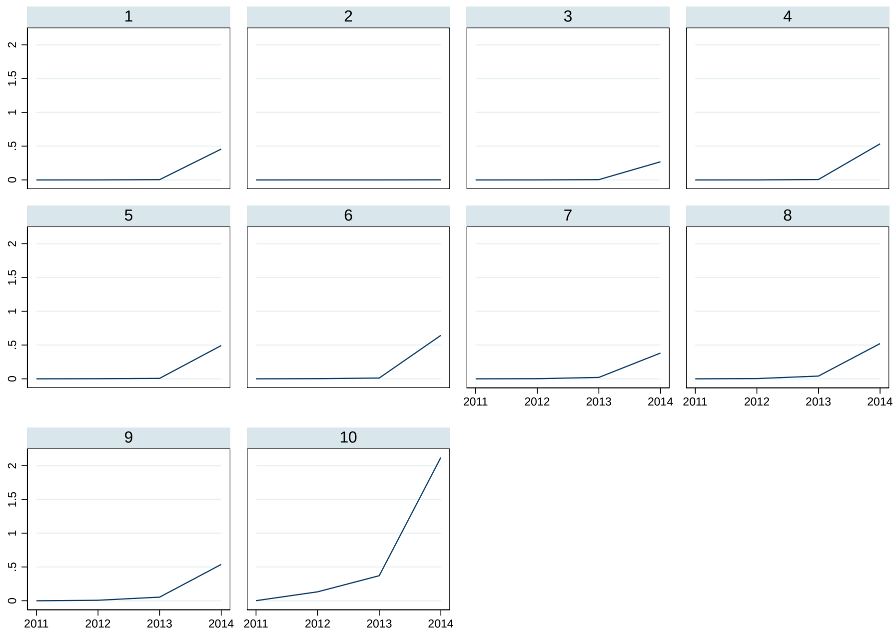
Likes



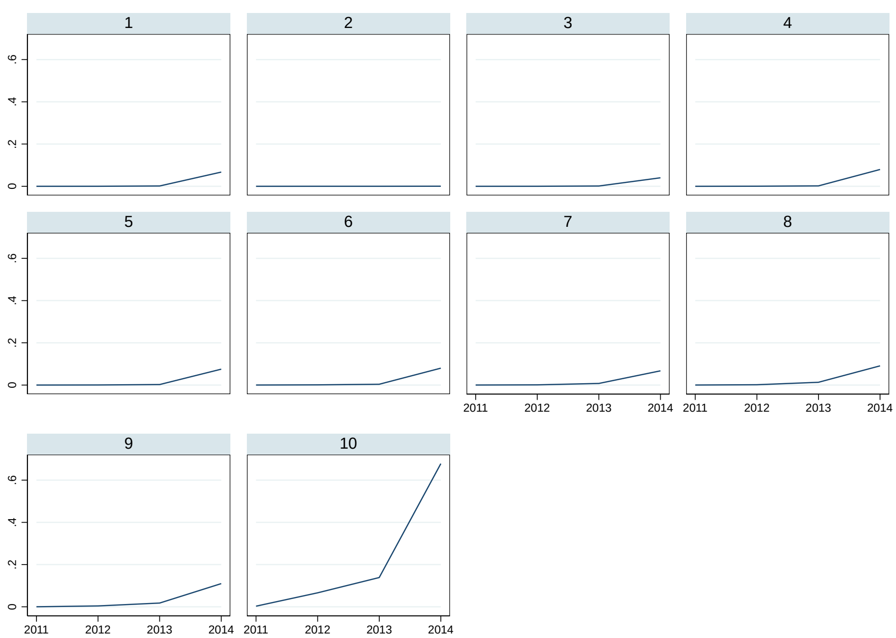
Notes: Posts and likes citing any municipality by decile of politicians' candidate share, for the 2011-2014 period. Likes in millions.

Figure A2: Shares and comments by vote share decile, 2011-2014

Shares



Comments

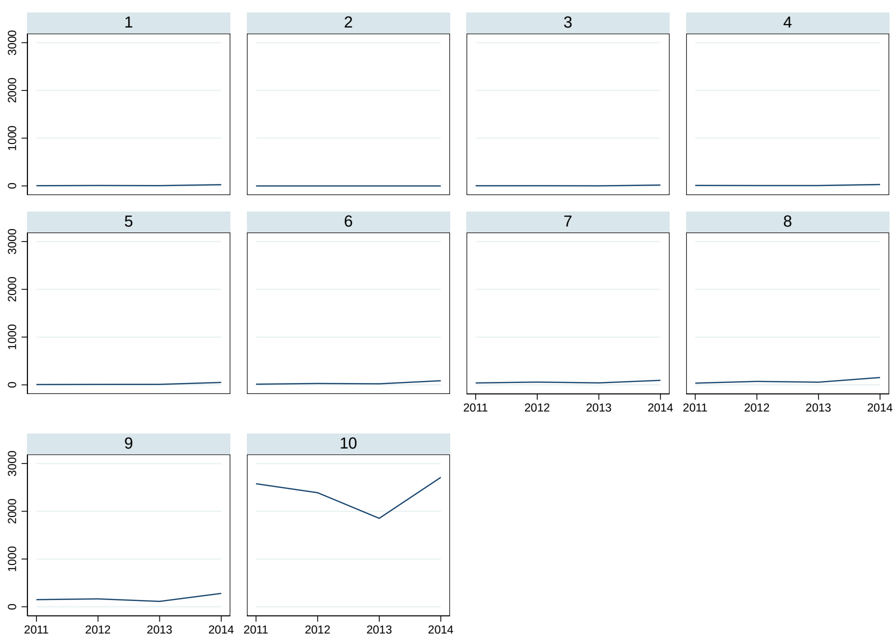


Notes: Shares and comments of posts citing any municipality by decile of politicians' candidate share, for the 2011-2014 period. Shares and comments in millions.

Figure A3: Speeches and transfers by vote share decile, 2011-2014

Speeches

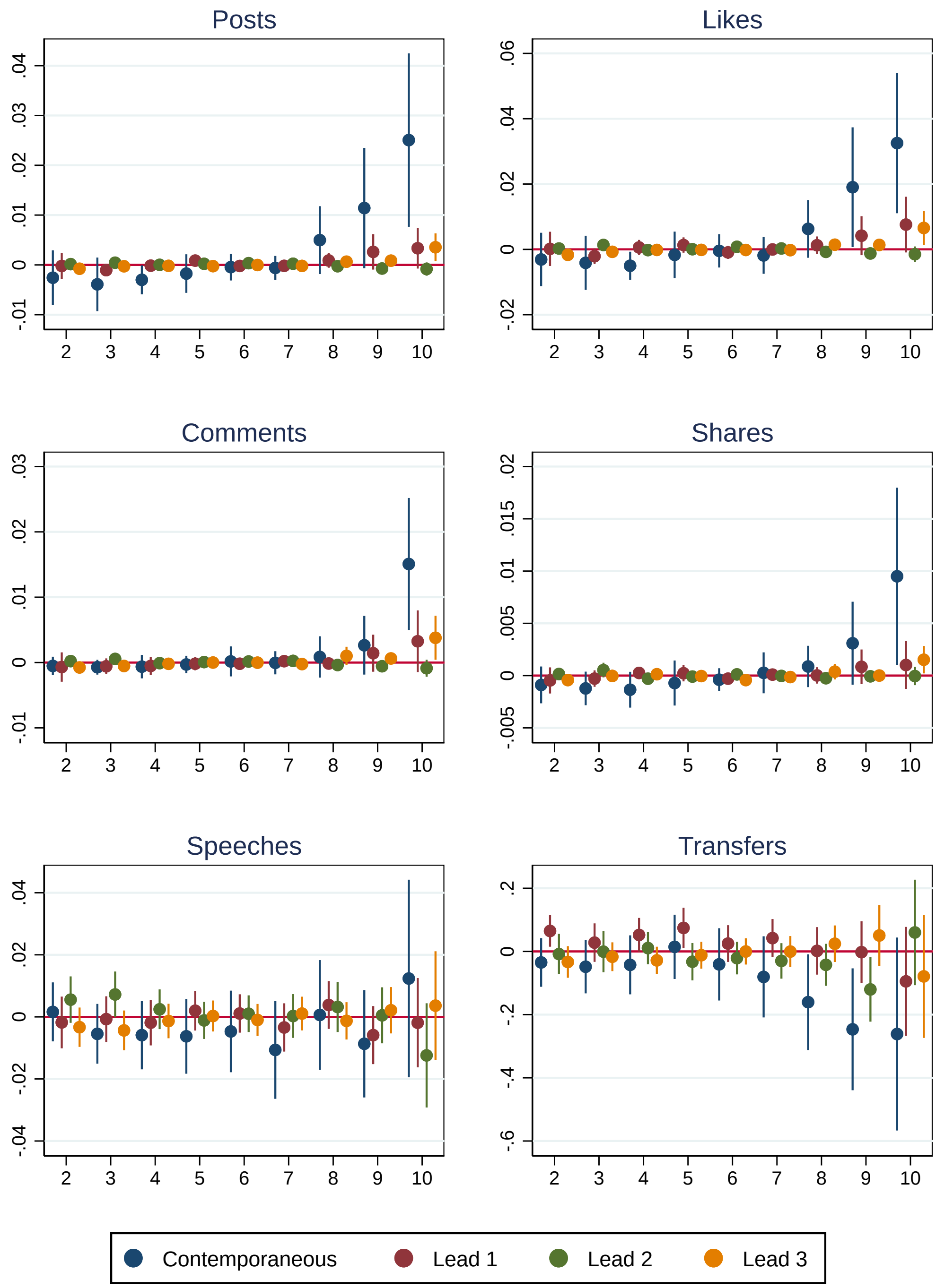
Transfers



Notes: Speeches and transfers citing any municipality by decile of politicians' candidate share, for the 2011-2014 period. Transfers in R$ millions.

Figure A4: Effect of 3G entry on online and offline behaviour

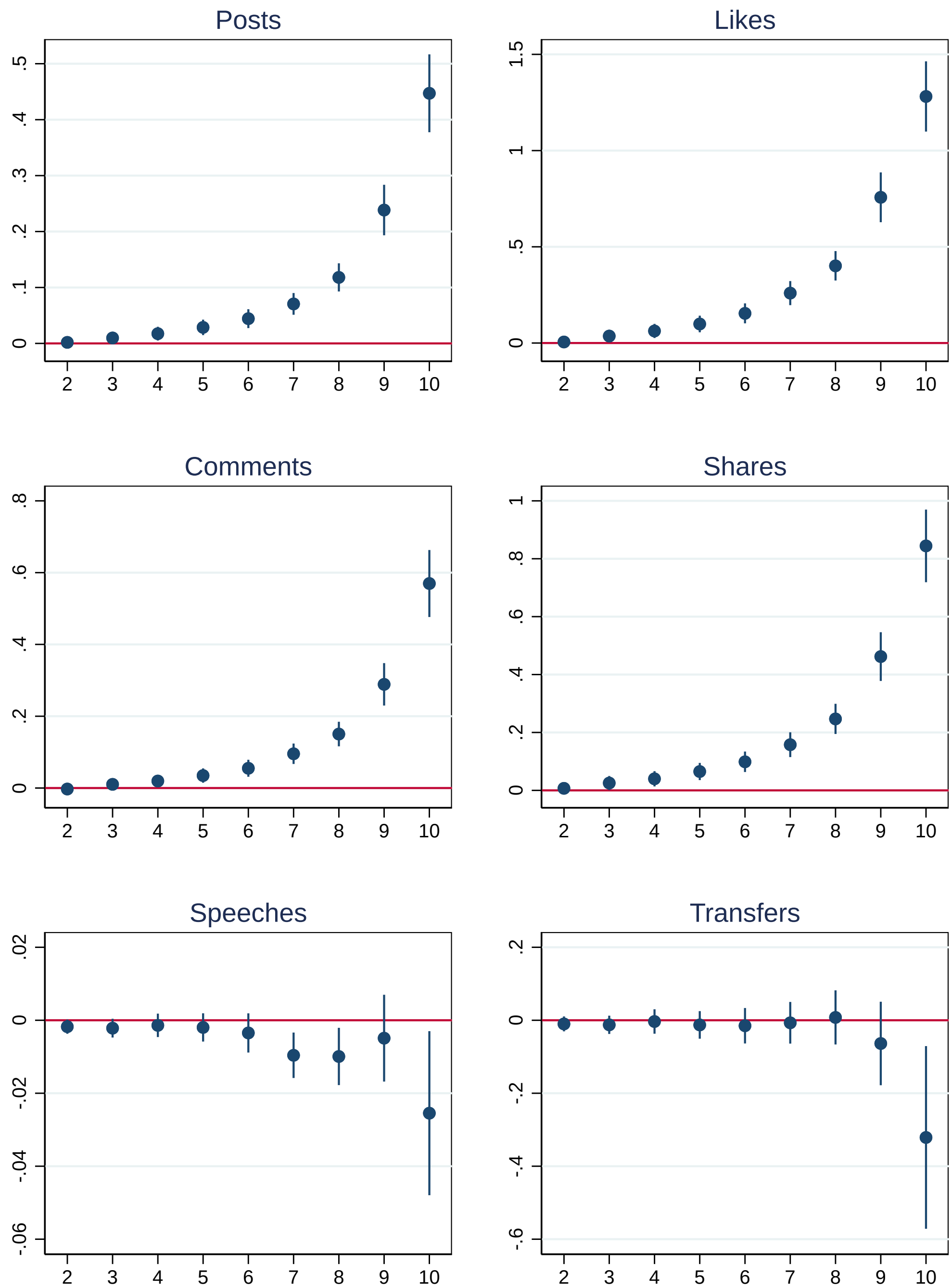
Contemporaneous and leads effects



Notes: Panel regressions at the municipality-politician by year levels. In the top-left figure, the dependent variables is the inverse hyperbolic sine transformation of the number of politicians' posts mentioning a municipality in a given year, explained by presence of 3G dummy variable (treatment) interacted with the importance of the municipality for the politician (vote shares decile, along the horizontal axis) in the 2010 elections. Regressions include contemporaneous and three leads of the 3G introduction. Point estimates in circles, and the corresponding 95% confidence intervals in bars. All specifications includes municipality-time, municipality-politician and politician-time fixed effects. The figures labelled as "likes", "comments", and "shares" use the inverse hyperbolic sine transformation of the number of likes, comments and shares that those posts obtained. "Speeches" refers to the inverse hyperbolic sine transformation of the number of politicians' speeches in Congress mentioning a municipality in a given year. Finally, "transfers" refers to the inverse hyperbolic sine transformation of the value of the earmarked transfers proposed by the politicians. Transfers in Brazilian Reais. Two-way clustered standard errors at the municipality and politician levels.

Figure A5: Effect of 3G entry on online and offline behaviour

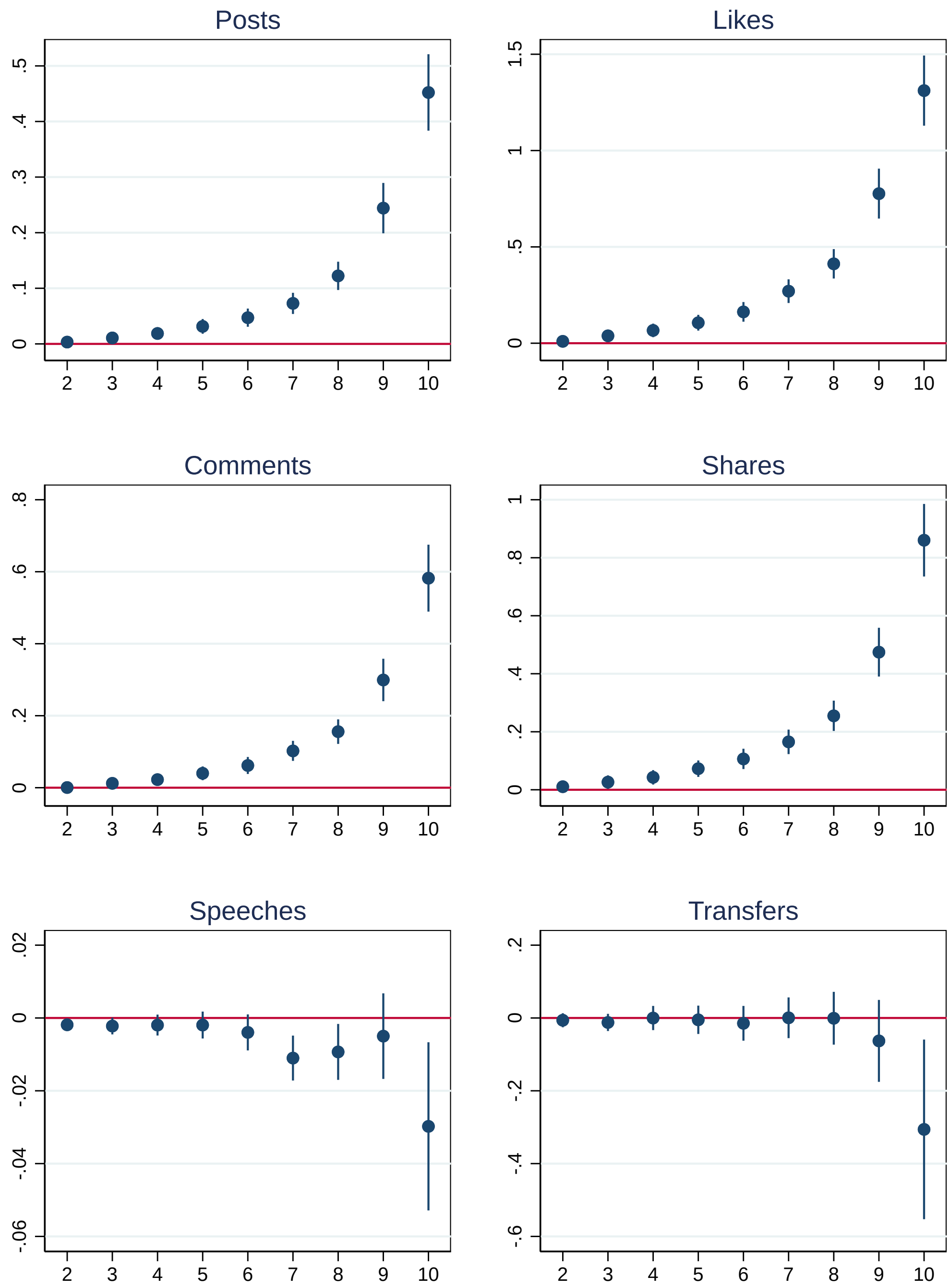
Excluding municipalities neighbouring to those that obtained 3G access



Notes: Panel regressions at the municipality-politician by year levels. In the top-left figure, the dependent variables is the inverse hyperbolic sine transformation of the number of politicians' posts mentioning a municipality in a given year, explained by presence of 3G dummy variable (treatment) interacted with the importance of the municipality for the politician (vote shares decile, along the horizontal axis) in the 2010 elections. The coefficients labelled as "distance cutoff"are computed excluding the municipalities in years without 3G access that are at a 50km or less from municipalities that had obtained 3G at that time. "Integration cutoff"refers to the specifications that exclude conurbated municipalities, and obtained from IBGE (`https://biblioteca.ibge.gov.br/visualizacao/livros/liv99700.pdf`, accessed June 24, 2019). Point estimates in circles, and the corresponding 95% confidence intervals in bars. All specifications includes municipality-time, municipality-politician and politician-time fixed effects. The figures labelled as "likes", "comments", and "shares" use the inverse hyperbolic sine transformation of the number of likes, comments and shares that those posts obtained. "Speeches" refers to the inverse hyperbolic sine transformation of the number of politicians' speeches in Congress mentioning a municipality in a given year. Finally, "transfers" refers to the inverse hyperbolic sine transformation of the value of the earmarked transfers proposed by the politicians. Transfers in Brazilian Reais. Two-way clustered standard errors at the municipality and politician levels.

Figure A6: Effect of 3G entry on online and offline behaviour

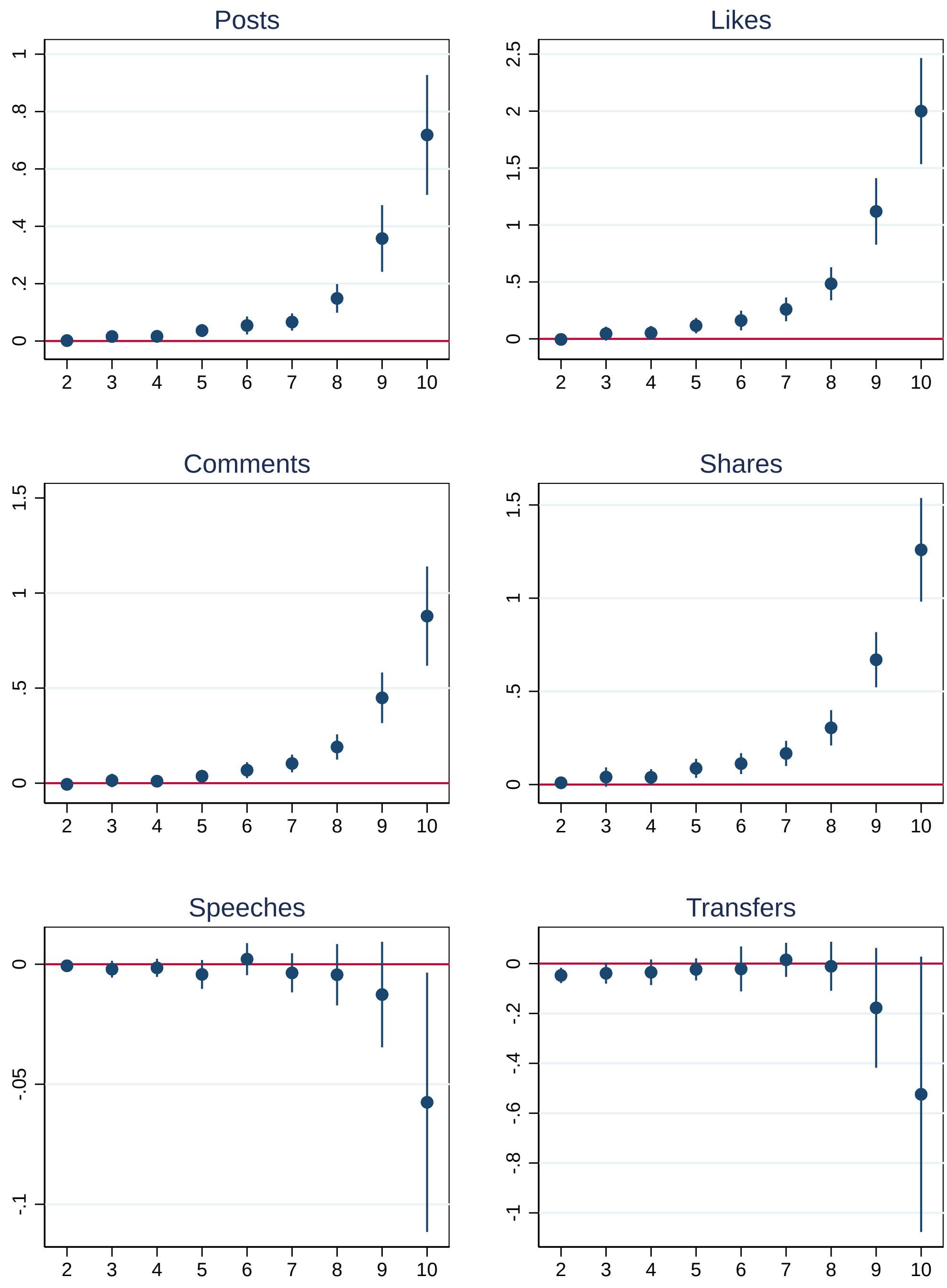
Excluding municipalities neighbouring to those that obtained 3G access



Notes: Panel regressions at the municipality-politician by year levels. In the top-left figure, the dependent variables is the inverse hyperbolic sine transformation of the number of politicians' posts mentioning a municipality in a given year, explained by presence of 3G dummy variable (treatment) interacted with the importance of the municipality for the politician (vote shares decile, along the horizontal axis) in the 2010 elections. The coefficients labelled as "distance cutoff"are computed excluding the municipalities in years without 3G access that are at a 50km or less from municipalities that had obtained 3G at that time. "Integration cutoff"refers to the specifications that exclude conurbated municipalities, and obtained from IBGE (`https://biblioteca.ibge.gov.br/visualizacao/livros/liv99700.pdf`, accessed June 24, 2019). Point estimates in circles, and the corresponding 95% confidence intervals in bars. All specifications includes municipality-time, municipality-politician and politician-time fixed effects. The figures labelled as "likes", "comments", and "shares" use the inverse hyperbolic sine transformation of the number of likes, comments and shares that those posts obtained. "Speeches" refers to the inverse hyperbolic sine transformation of the number of politicians' speeches in Congress mentioning a municipality in a given year. Finally, "transfers" refers to the inverse hyperbolic sine transformation of the value of the earmarked transfers proposed by the politicians. Transfers in Brazilian Reais. Two-way clustered standard errors at the municipality and politician levels.

Figure A7: Effect of 3G entry on online and offline behaviour

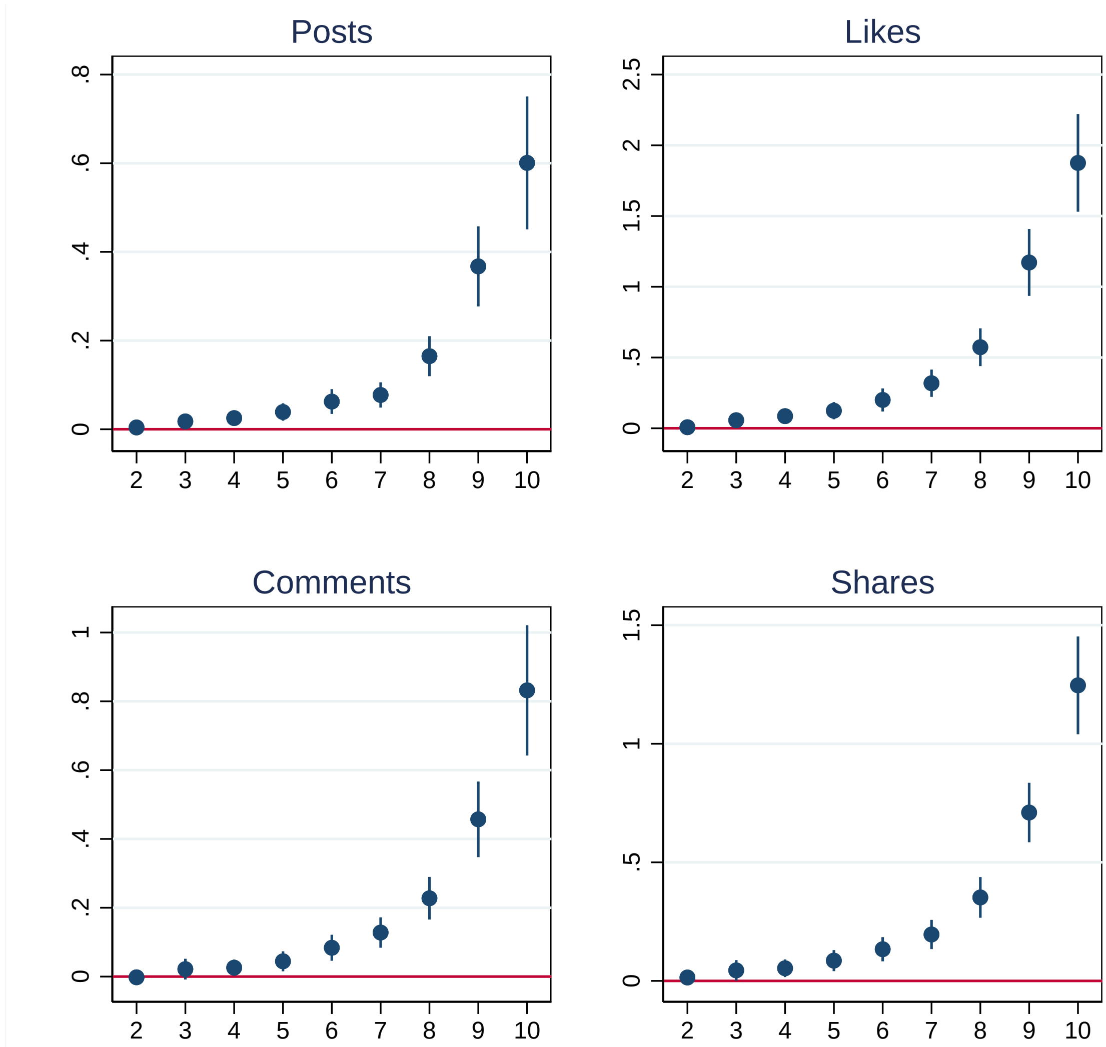
Panel only with politicians who opened their Facebook profile during or prior to 2011



Notes: Panel regressions at the municipality-politician by year levels. Sample restricted to politicians who opened their Facebook profiles during or prior to 2011. In the top-left figure, the dependent variables is the inverse hyperbolic sine transformation of the number of politicians' posts mentioning a municipality in a given year, explained by presence of 3G dummy variable (treatment) interacted with the importance of the municipality for the politician (vote shares decile, along the horizontal axis) in the 2010 elections. Point estimates in circles, and the corresponding 95% confidence intervals in bars. All specifications includes municipality-time, municipality-politician and politician-time fixed effects. The figures labelled as "likes", "comments", and "shares" use the inverse hyperbolic sine transformation of the number of likes, comments and shares that those posts obtained. "Speeches" refers to the inverse hyperbolic sine transformation of the number of politicians' speeches in Congress mentioning a municipality in a given year. Finally, "transfers" refers to the inverse hyperbolic sine transformation of the value of the earmarked transfers proposed by the politicians. Transfers in Brazilian Reais. Two-way clustered standard errors at the municipality and politician levels.

Figure A8: Effect of 3G entry on online behaviour

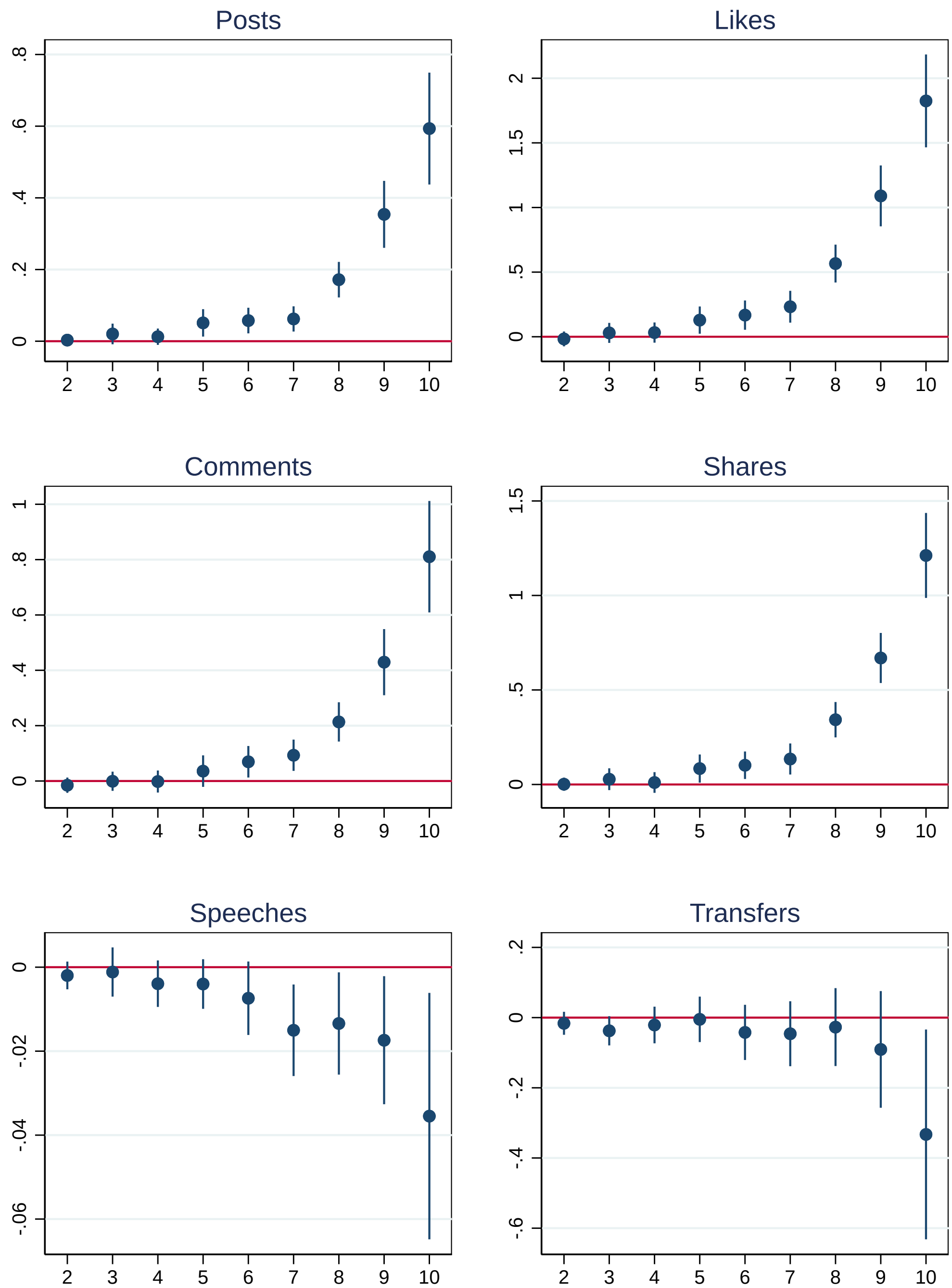
Municipality-politician level regressions, setting Facebook activity to zero if profile was not open



Notes: Panel regressions at the municipality-politician by year levels. Facebook measures set to zero whenever profile was not open. In the top-left figure, the dependent variables is the inverse hyperbolic sine transformation of the number of politicians' posts mentioning a municipality in a given year, explained by presence of 3G dummy variable (treatment) interacted with the importance of the municipality for the politician (vote shares decile, along the horizontal axis) in the 2010 elections. Point estimates in circles, and the corresponding 95% confidence intervals in bars. All specifications includes municipality-time, municipality-politician and politician-time fixed effects. The figures labelled as "likes", "comments", and "shares" use the inverse hyperbolic sine transformation of the number of likes, comments and shares that those posts obtained. Two-way clustered standard errors at the municipality and politician levels.

Figure A9: Effect of 3G entry on online and offline behaviour

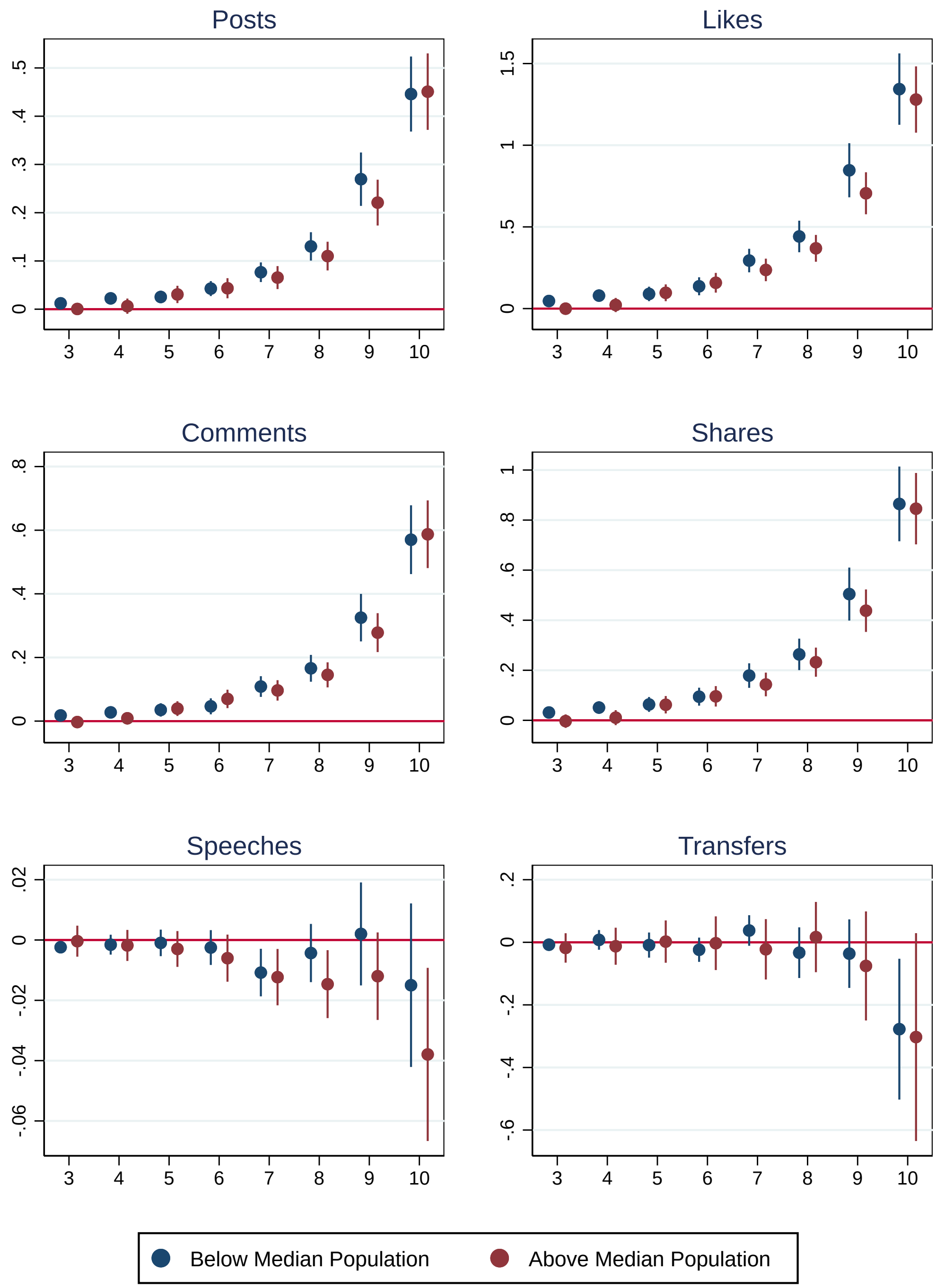
Municipality-politician level regressions, weighted by population



Notes: Panel regressions at the municipality-politician by year levels. Regressions weighted by the municipalities' population. In the top-left figure, the dependent variables is the inverse hyperbolic sine transformation of the number of politicians' posts mentioning a municipality in a given year, explained by presence of 3G dummy variable (treatment) interacted with the importance of the municipality for the politician (vote shares decile, along the horizontal axis) in the 2010 elections. Point estimates in circles, and the corresponding 95% confidence intervals in bars. All specifications includes municipality-time, municipality-politician and politician-time fixed effects. The figures labelled as "likes", "comments", and "shares" use the inverse hyperbolic sine transformation of the number of likes, comments and shares that those posts obtained. "Speeches" refers to the inverse hyperbolic sine transformation of the number of politicians' speeches in Congress mentioning a municipality in a given year. Finally, "transfers" refers to the inverse hyperbolic sine transformation of the value of the earmarked transfers proposed by the politicians. Transfers in Brazilian Reais. Two-way clustered standard errors at the municipality and politician levels.

Figure A10: Effect of 3G entry on online and offline behaviour

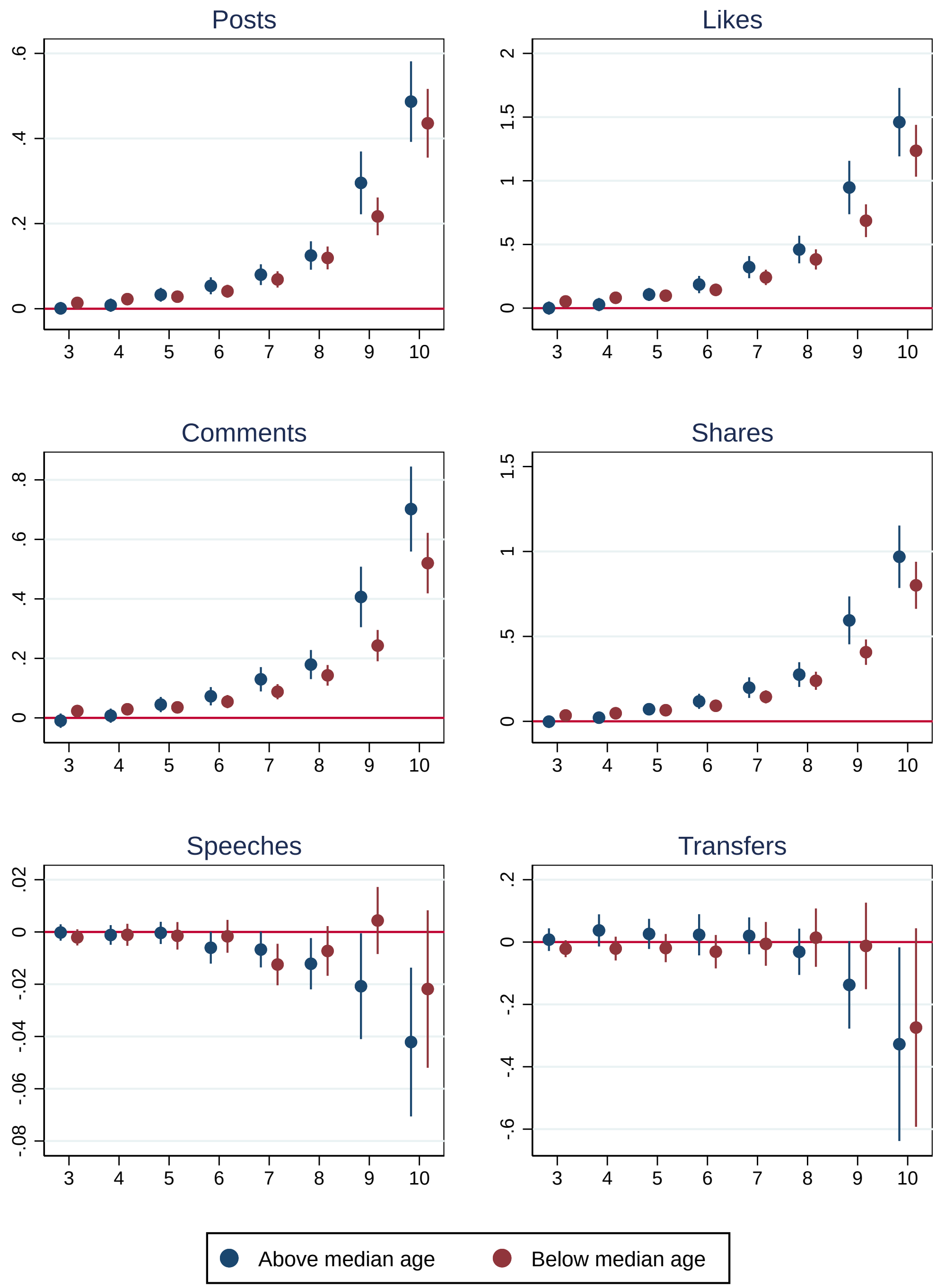
Heterogeneous effects by population



Notes: Panel regressions at the municipality-politician by year levels. In the top-left figure, the dependent variables is the inverse hyperbolic sine transformation of the number of politicians' posts mentioning a municipality in a given year, explained by presence of 3G dummy variable interacted with the importance of the municipality for the politician (vote shares decile, along the horizontal axis) in the 2010 elections. The figure plots the coefficients of the interaction below (blue) and above median population (red), and the corresponding 95% confidence interval. All specifications includes municipality-time, municipality-politician and politician-time fixed effects. The figures labelled as "likes", "comments", and "shares" use the inverse hyperbolic sine transformation of the number of likes, comments and shares that those posts obtained. "Speeches" refers to the inverse hyperbolic sine transformation of the number of politicians' speeches in Congress mentioning a municipality in a given year. Finally, "transfers" refers to the inverse hyperbolic sine transformation of the value of the earmarked transfers proposed by the politicians. Transfers in Brazilian Reais. Two-way clustered standard errors at the municipality and politician levels.

Figure A11: Effect of 3G entry on online and offline behaviour

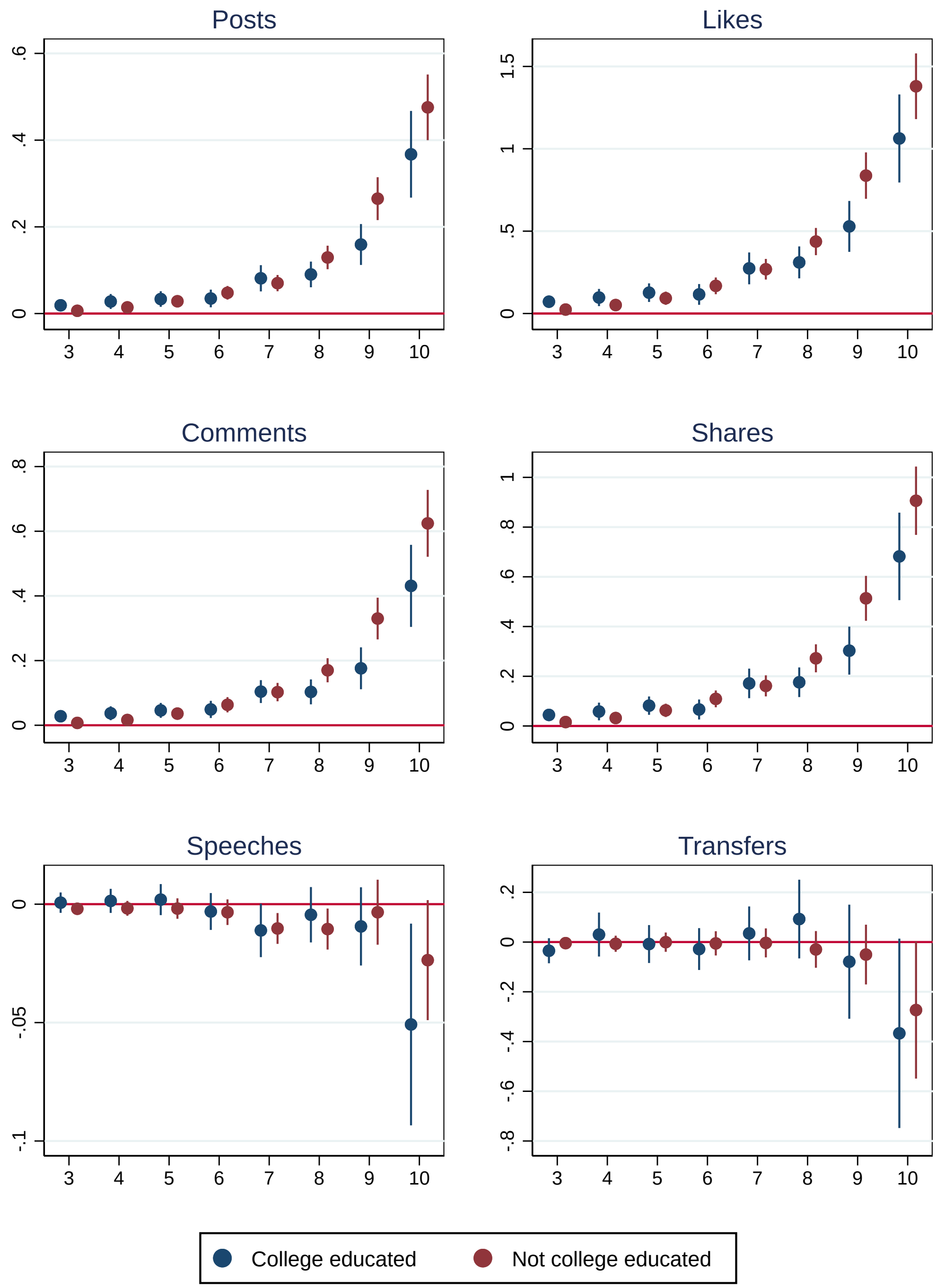
Heterogeneous effects by politicians' age



Notes: Panel regressions at the municipality-politician by year levels. In the top-left figure, the dependent variables is the inverse hyperbolic sine transformation of the number of politicians' posts mentioning a municipality in a given year, explained by presence of 3G dummy variable interacted with the importance of the municipality for the politician (vote shares decile, along the horizontal axis) in the 2010 elections. The figure plots the coefficients of the interaction above (blue) and below median politicians' age (red), and the corresponding 95% confidence interval. All specifications includes municipality-time, municipality-politician and politician-time fixed effects. The figures labelled as "likes", "comments", and "shares" use the inverse hyperbolic sine transformation of the number of likes, comments and shares that those posts obtained. "Speeches" refers to the inverse hyperbolic sine transformation of the number of politicians' speeches in Congress mentioning a municipality in a given year. Finally, "transfers" refers to the inverse hyperbolic sine transformation of the value of the earmarked transfers proposed by the politicians. Transfers in Brazilian Reais. Two-way clustered standard errors at the municipality and politician levels.

Figure A12: Effect of 3G entry on online and offline behaviour

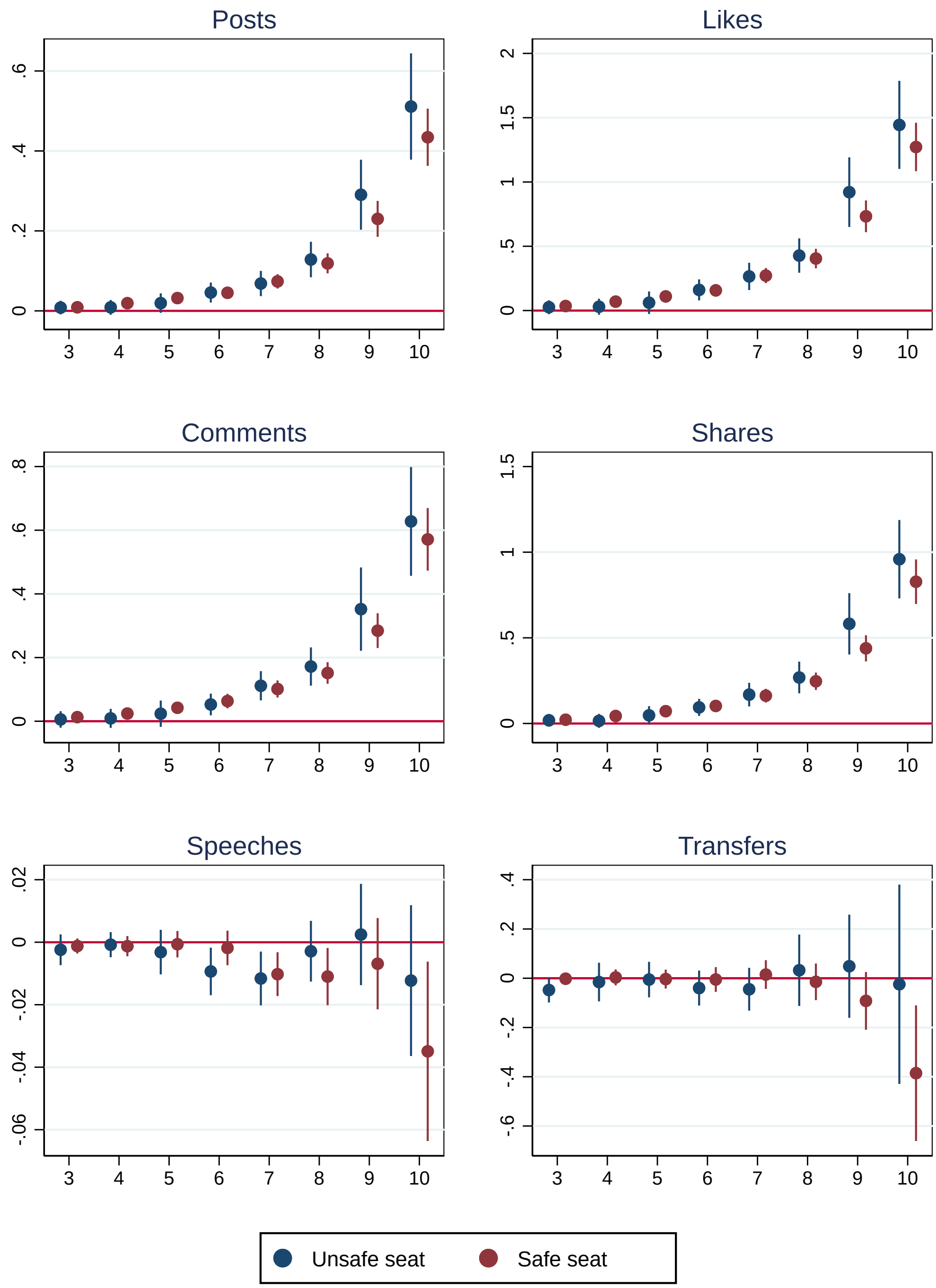
Heterogeneous effects by politicians' education



Notes: Panel regressions at the municipality-politician by year levels. In the top-left figure, the dependent variables is the inverse hyperbolic sine transformation of the number of politicians' posts mentioning a municipality in a given year, explained by presence of 3G dummy variable interacted with the importance of the municipality for the politician (vote shares decile, along the horizontal axis) in the 2010 elections. The figure plots the coefficients of the interaction with (blue) and without college education (red), and the corresponding 95% confidence interval. All specifications includes municipality-time, municipality-politician and politician-time fixed effects. The figures labelled as "likes", "comments", and "shares" use the inverse hyperbolic sine transformation of the number of likes, comments and shares that those posts obtained. "Speeches" refers to the inverse hyperbolic sine transformation of the number of politicians' speeches in Congress mentioning a municipality in a given year. Finally, "transfers" refers to the inverse hyperbolic sine transformation of the value of the earmarked transfers proposed by the politicians. Transfers in Brazilian Reais. Two-way clustered standard errors at the municipality and politician levels.

Figure A13: Effect of 3G entry on online and offline behaviour

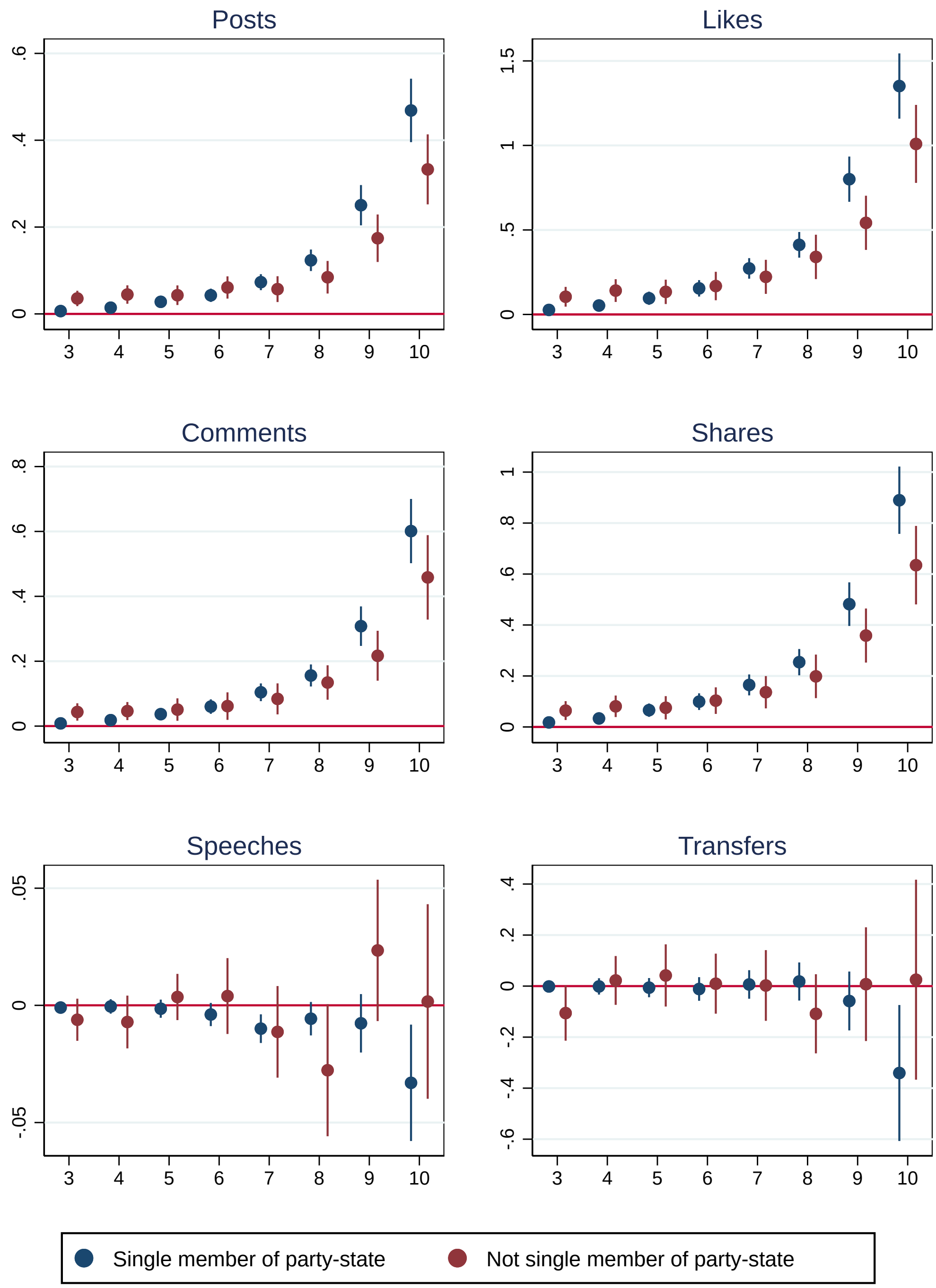
Margin of victory



Notes: Panel regressions at the municipality-politician by year levels. In the top-left figure, the dependent variables is the inverse hyperbolic sine transformation of the number of politicians' posts mentioning a municipality in a given year, explained by presence of 3G dummy variable interacted with the importance of the municipality for the politician (vote shares decile, along the horizontal axis) in the 2010 elections. The figure plots the coefficients of the interaction if Congressman won by below (blue) or above (red) median margin of victory, and the corresponding 95% confidence interval. Margin of victory are defined as the politicians' total number of votes divided by the electoral coefficient in their states of origin. The electoral coefficient is the number of votes required to obtain a seat in Congress. All specifications includes municipality-time, municipality-politician and politician-time fixed effects. The figures labelled as "likes", "comments", and "shares" use the inverse hyperbolic sine transformation of the number of likes, comments and shares that those posts obtained. "Speeches" refers to the inverse hyperbolic sine transformation of the number of politicians' speeches in Congress mentioning a municipality in a given year. Finally, "transfers" refers to the inverse hyperbolic sine transformation of the value of the earmarked transfers proposed by the politicians. Transfers in Brazilian Reais. Two-way clustered standard errors at the municipality and politician levels.

Figure A14: Effect of 3G entry on online and offline behaviour

Single member of party-state

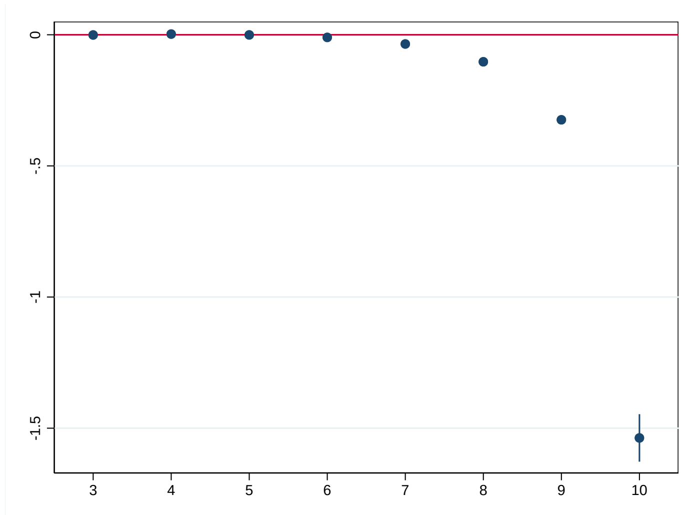


Notes: Panel regressions at the municipality-politician by year levels. In the top-left figure, the dependent variables is the inverse hyperbolic sine transformation of the number of politicians' posts mentioning a municipality in a given year, explained by presence of 3G dummy variable interacted with the importance of the municipality for the politician (vote shares decile, along the horizontal axis) in the 2010 elections. The figure plots the coefficients of the interaction if Congressman is single member of party-state (blue) and if he or she is not (red), and the corresponding 95% confidence interval. All specifications includes municipality-time, municipality-politician and politician-time fixed effects. The figures labelled as "likes", "comments", and "shares" use the hyperbolic sine transformation of the number of likes, comments and shares that those posts obtained. "Speeches" refers to the inverse hyperbolic sine transformation of the number of politicians' speeches in Congress mentioning a municipality in a given year. Finally, "transfers" refers to the inverse hyperbolic sine transformation of the value of the earmarked transfers proposed by the politicians. Transfers in Brazilian Reais. Two-way clustered standard errors at the municipality and politician levels.

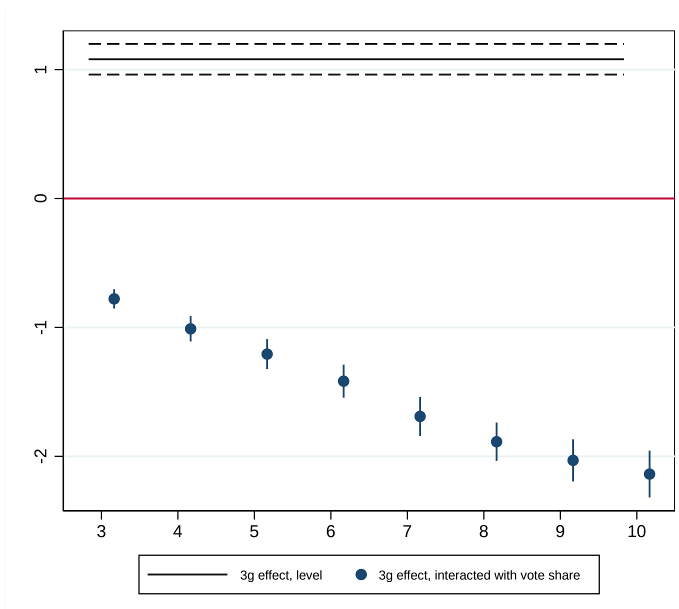
Figure A15: Effect of 3G on 2014 electoral outcomes

Interacted with Facebook use during the 2014 elections

Panel A. Vote share



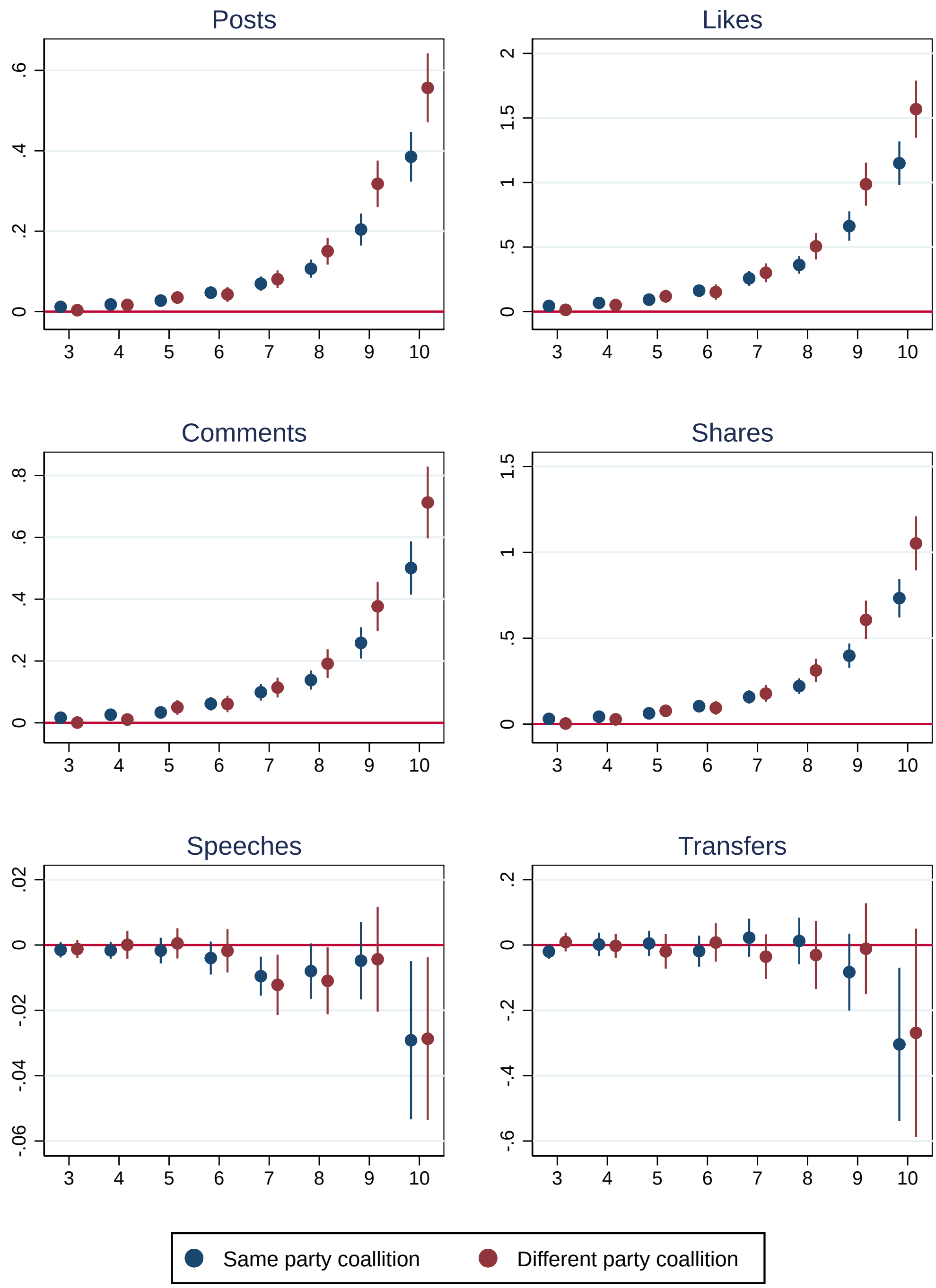
Panel B. Votes share with level effects



Notes: Panel A: Panel regressions at the municipality-politician by year level for the politicians of the 53rd legislature that ran for reelection in 2014. Dependent variable is the *share* of votes that candidates obtained in the 2010 and 2014 elections, explained by presence of 3G dummy variable interacted with the importance of the municipality for the politician (vote shares decile, along the horizontal axis) in the 2010 elections. Coefficients are interacted with the dummy variable which is equal to 1 if the politician cited the municipality in 2014 ("with FB mentions") and zero otherwise ("Without FB mentions"). Point estimates in circles, and the corresponding 95% confidence intervals in bars. Specification includes municipality-time, municipality-politician and politician-time fixed effects. Two-way clustered standard errors at the municipality and politician levels. Panel B: Dependent variable is the inverse hyperbolic sine transformation of the level votes of the Congressman, explained by the 3G treatment dummy (solid line, with dashes representing the 95% confidence level) and 3G interacted with vote share deciles (along the horizontal axis). Specification includes municipality-politician and politician-time fixed effects. Two-way clustered standard errors at the municipality and politician levels.

Figure A16: Effect of 3G entry on online and offline behaviour

Party coallition similarity between Congressman and mayor



Notes: Panel regressions at the municipality-politician by year levels. In the top-left figure, the dependent variables is the inverse hyperbolic sine transformation of the number of politicians' posts mentioning a municipality in a given year, explained by presence of 3G dummy variable interacted with the importance of the municipality for the politician (vote shares decile, along the horizontal axis) in the 2010 elections. The figure plots the coefficients of the interaction if Congressman and mayor are affiliated to the same coallition of parties (blue) and if they are not (red), and the corresponding 95% confidence interval. All specifications includes municipality-time, municipality-politician and politician-time fixed effects. The figures labelled as "likes", "comments", and "shares" use the inverse hyperbolic sine transformation of the number of likes, comments and shares that those posts obtained. "Speeches" refers to the inverse hyperbolic sine transformation of the number of politicians' speeches in Congress mentioning a municipality in a given year. Finally, "transfers" refers to the inverse hyperbolic sine transformation of the value of the earmarked transfers proposed by the politicians. Transfers in Brazilian Reais. Two-way clustered standard errors at the municipality and politician levels.

Table A1: Descriptive Statistics of Vote Share Deciles of the 2010 elections

	Deciles									
	1	2	3	4	5	6	7	8	9	10
Observations	32,987	15,768	15,711	15,731	15,725	15,736	15,732	15,733	15,734	15,733
Mean	0	.0010	.0025	.0053	.0104	.0208	.0442	.1071	.3128	2.7534
Std. Dev.	0	.0003	.0006	.0010	.0020	.0043	.0102	.0299	.1054	7.189
Min	0	.0002	.0016	.0036	.0073	.0143	.0293	.0650	.1691	.5418
Max	0	.0016	.0036	.0073	.0143	.0292	.0650	.1691	.5417	100

Notes: Descriptive statistics of the deciles of vote shares computed as the votes that politician i obtained in municipality m divided by the total votes of politician i, and multiplied by 100.

Table A2: The effect of 3G internet rollout using municipality-level variation

Robustness to population and urban share controls

	(i) Posts	(ii) Likes	(iii) Shares	(iv) Comments	(v) Speeches	(vi) Transfers
<u>Panel A.</u> *Intensive and extensive margins, IHS of dependent variable*						
Treat	.157***	.263***	.255***	.210***	-.039*	-.151
	(.027)	(.060)	(.048)	(.041)	(.020)	(.176)
<u>Panel B.</u> *Controlling for above/below median population interacted with year fixed effects*						
Treat	.066**	.112*	.121**	.091**	-.024	-.013
	(.027)	(.060)	(.049)	(.041)	(.021)	(.177)
<u>Panel C.</u> *Controlling for above/below median urban share interacted with year fixed effects*						
Treat	.144***	.235***	.236***	.190***	-.039*	-.147
	(.027)	(.060)	(.049)	(.042)	(.020)	(.176)
Mean of dep. var.	3.19	294.9	161.7	30.34	.846	R$ 99,756
Observations	16,056	16,056	16,056	16,056	16,056	16,056
Treated	2,178	2,178	2,178	2,178	2,178	2,178
Control	1,836	1,836	1,836	1,836	1,836	1,836

Notes: Panel regressions at the municipality by year levels, explained by presence of 3G dummy variable, with municipality and state-year fixed effects. In all panels, the dependent variables are the inverse hyperbolic sine transformation of the number of earmarked transfers proposed to the municipality in a given year, speeches delivered in the Congress and Facebook posts that mentioned the municipality, likes, shares and comments that those posts obtained. Panel A reproduces Table 4 results. Panel B adds control for above/below median population interacted with year fixed effects. Panel C adds control for above/below median urban share interacted with year fixed effects. "Mean of dep. var." refers to the raw numbers, without the inverse hyperbolic sine transformation, and averaged across the 2011-2014 period. Transfers in Brazilian Reais. Clustered standard errors at the municipality level.

Table A3: Descriptive statistics: elected deputies

	53rd legislature	52nd and 53rd legislatures
% female	.088	.089
% college	.778	.786
% north	.127	.125
% northeast	.294	.300
% centerwest	.064	.060
% southeast	.349	.348
% south	.150	.147
Campaign exp. in 2010	R$ 3.24m	R$ 2.91m
	(R$ 1.87m)	(R$ 1.81m)
Votes in 2010	114.86k	86.21k
	(86.89k)	(85.80k)
Number of deputies	513	744

Notes: Descriptive statistics of the sample of elected deputies of the 53rd legislature (2011-14) and 52rd and 53th legislatures (2009-14). "% Female" refers to the proportion of female deputies. "% College" refers to the proportion of deputies who completed college or university education. "% North", "% northeast", "% centerwest", "% southeast", "% south" refers to region of the deputies' constituencies. "Campaign Expenditures" in Brazilian Reais (R$). "Votes" are the total number of votes obtained by the deputy in the 2010 elections. Standard errors in parenthesis. *Source:* Tribunal Eleitoral Superior (TSE).

Table A4: The effect of 3G internet rollout using municipality-level variation

Robustness to two-way fixed effects estimate of Callaway and Sant'Anna (2021)

	(i) Posts	(ii) Likes	(iii) Shares	(iv) Comments	(v) Speeches	(vi) Transfers
Panel A. Original Estimates						
Treat	.157***	.263***	.255***	.210***	-.039*	-.151
	(.027)	(.060)	(.048)	(.041)	(.020)	(.176)
Municipality FE	yes	yes	yes	yes	yes	yes
State-year FE	yes	yes	yes	yes	yes	yes
Panel B. Dummy treatment and year-fixed effects						
3G Dummy	.179***	.441***	.463***	.391***	-.050***	.112
	(.023)	(.052)	(.045)	(.038)	(.016)	(.136)
Municipality FE	yes	yes	yes	yes	yes	yes
Year FE	yes	yes	yes	yes	yes	yes
Panel C. Two-way FE of Callaway and Sant'Anna (2021)						
3G Dummy	.257***	.578***	.615***	.508***	-.074***	.036
	(.026)	(.050)	(.044)	(.037)	(.018)	(.141)
Municipality FE	yes	yes	yes	yes	yes	yes
Year FE	yes	yes	yes	yes	yes	yes
Mean of dep. var.	3.19	294.9	161.7	30.34	.846	R$ 99,756
Observations	16,056	16,056	16,056	16,056	16,056	16,056
Treated	2,178	2,178	2,178	2,178	2,178	2,178
Control	1,836	1,836	1,836	1,836	1,836	1,836

Notes: Regressions at the municipality by year levels, explained by presence of 3G variable. In Panel A, specification has with municipality and state-year fixed effects, and the treatment variable is the share of months in which the municipality had the 3G signal. In Panel B, the treatment is 1 if the municipality had 3G signal for over six months in the year, and zero otherwise. Panel C has the differences-in-differences of Callaway and Sant'Anna (2021). In column *(i)*, it is equal to one if a given municipality was cited at least once in Facebook in a given year. Dependent variables in columns *(ii)*, *(iii)* and *(iv)* are equal to one if those posts obtained at least one like, share or comment, respectively. Dependent variable in column *(v)* is equal to one if the municipality was cited at least once on Congressional speeches. Column *(vi)* is equal to one the given municipality was targeted by transfers, and zero otherwise. "Mean of dep. var." refers to the mean of the dependent variable, averaged across the 2011-2014 period. "Mean of dep. var." refers to the raw numbers, without the inverse hyperbolic sine transformation, and averaged across the 2011-2014 period. Transfers in Brazilian Reais. Clustered standard errors at the municipality level.

Appendix B Algorithm to detect citations to municipalities in posts

The algorithm works following the steps:

1. Find municipalities names contained in the post string

   Example: "`Congresswoman Iara Bernardi (PT) meets the mayors of` <u>`Capela do Alto`</u>, <u>`Iperó`</u>, <u>`Cedral`</u>, <u>`Cunha`</u> `and` <u>`Arocoiaba da Serra`</u> `to assess the impact of the mining industry in` <u>`Ipanema`</u> `National Forest.`"

   Matched municipalities: Capela (SE), Capela (AL), Capela do Alto (SP), Iperó (SP), Cedral (MA), Cedral (SP), Cunha (SP), Arocoiaba da Serra (SP), Ipanema (MG).

2. Disconsider strings contained in longer strings which were also previously matched;

   Drop matches: Capela (SE), Capela (AL).

3. Duplicate names are kept only if cities belong to the Congressman's state of origin.

   Drop matches: Iara Bernardi was elected in São Paulo (SP), so drop Cedral (MA).

4. Citations to dubious names are kept if immediately preceded by term indicating a municipality

   Example: "`Congresswoman Iara Bernardi (PT) meets the mayors of` <u>`Capela do Alto`</u>, <u>`Iperó`</u>, <u>`Cedral`</u>, <u>`Cunha`</u> `and` <u>`Arocoiaba da Serra`</u> `to assess the impact of the mining industry in` <u>`Ipanema`</u> `National Forest.`"

   "Cunha" and "Ipanema" were classified as dubious names. The list in which "Cunha" is contained is preceded by "mayors of", which is not true for "Ipanema". Final matched municipalities: Capela do Alto (SP), Iperó (SP), Cedral (SP), Cunha (SP), Arocoiaba da Serra (SP).

On a sampled evaluation of the performance of the algorithm on 250 posts, 89.09% of the true mentions were identified, and only 2.00% of the posts contained one or more false matches.

Table A5: Performance of the matching algorithm

Number of true mentions in post	Frequency	Correctly classified true mentions	Posts with false matches
0	62.80%	–	1.91%
1	28.40%	87.32%	2.82%
2	6.40%	86.67%	0.00%
3	1.60%	91.67%	0.00%
4 or more	0.80%	92.31%	0.00%
any	100.00%	88.89%	0.00%

Appendix C A Model of Facebook and Pork

Here we present the details of the model discussed in Section 5.

Model Setup

Consider two politicians, $p \in \{a, b\}$, who compete for votes in an election in the municipalities $m \in \{1, 2, ..., n\}$ of a given state. The politicians have two potential instruments to affect voters in a given municipality: communication, $c_m^p \in \mathbb{R}_+$, and earmarked transfers, t_m^p. As for voters, in each municipality there is a continuum of voters of mass 1, indexed by i, each of whom is characterized by an ideological distance from each candidate, $r_{im}^p \sim U[0, 1]$ (i.e., uniformly distributed on the unit interval). Each politician has a given level of overall popularity in each municipality, μ_m^p. We label municipalities such that they are ordered by the popularity of politician a ($\mu_{m'}^a \geq \mu_{m''}^a$ for $m' < m''$), who will be the focus of our comparative statics.

We make three simplifying assumptions, which are not needed for obtaining the key insights, but help sharpen the focus of the analysis. First, we impose symmetry in terms of ideology ($r_{im}^b = 1 - r_{im}^a$) and popularity ($\mu_{m'}^b \leq \mu_{m''}^b$ for $m' < m''$). Second, we model transfers as a binary variable $t_m^p \in \{0, 1\}$, subject to a unitary budget constraint, i.e., $\sum_m t_m^p \leq 1$, implying that the politician can only transfer to one municipality.[33] Finally, we assume that only politician a is currently in office, hence with the option of making transfers – in other words, we will set $t_m^b = 0$ for all m.[34]

The key assumption is in the difference between transfers and communication: we posit that the latter is only effective at reaching voters who already have a substantial idiosyncratic preference for the politician. This captures the idea that it is only voters who are more aligned with a politician who will choose to follow him on Facebook or, more generally, to pay attention to what he says. Formally, we define the "core set" of p in municipality m as $\mathcal{I}_m^p = \{i : \mu_m^p - r_{im}^p \geq 0\}$, which we take to be the set of individuals in m who are sufficiently close to p that his communication efforts exert influence over them. We will refer to them as politician p's "core supporters."[35]

Formally, we model voter i's behavior as follows: she computes the utility from voting on each candidate, and if the highest utility is greater than the opportunity cost of voting, she casts a vote for the corresponding politician, while abstaining otherwise. The utility from

[33]This is meant to capture, in simple fashion, the tight budget that individual politicians have, as illustrated by the fact that, in our data, they target few municipalities (an average of five), relative to the total number of municipalities in each state.

[34]In the Online Appendix, we present a model in which both politicians can make transfers, and show that the key insights carry over, though the complexity of possible strategic interactions between transfers from different politicians substantially complicates the analysis.

[35]More generally, we could model an influence function $h_P(r_i, c)$, such that r, c are super-modular. Under a few additional functional form restrictions on h, we conjecture all results would still hold.

voting for candidate p, given (c_m^p, t_m^p), is given by:

$$U_{im}^p \equiv U_m^p(c,t,r_i) = \alpha t_m^p + I_{im}^p \cdot c_m^p + \mu_m^p - r_{im}^p \tag{7}$$

where $I_{im}^p = \mathbb{1}_{\left[i \in \mathcal{I}_m^p\right]}$, i.e. an indicator of whether voter i is in the core set of politician p in municipality m. We model the opportunity cost of voting as a random variable $\varepsilon_{im} \sim U[0,d]$, independent of r_i.[36] In sum, i votes for p iff $U_{im}^p \geq \max\left\{U_{im}^a, U_{im}^b, \varepsilon_{im}\right\}$.

Taking into account the expected behavior of voters, politicians will choose the optimal levels of the policy tools to maximize:

$$W^p = \sum_m \left[v_m^p - \frac{\gamma_m}{2}\left(c_m^p\right)^2\right] \tag{8}$$

where v_m^p is the share of m's population voting for p, and the cost of communication is a quadratic function parameterized by γ_m. This maximization is subject to the budget constraint on the allocation of transfers.

We further assume:

H1. $1 > \mu_m^a + \mu_m^b > 1 - \alpha > \max\left\{\mu_m^a, \mu_m^b\right\} > 0$

The first part of H1, $\mu_m^a + \mu_m^b < 1$, is the most crucial. It implies that the core sets of both politicians are non-overlapping. This removes the strategic interaction between the communication decisions of the two politicians, and lets us focus on the interplay between transfers and communication. It also implies that there exists a mass of unattached voters in the center of the ideological spectrum who will abstain with probability one in the absence of transfers, which simplifies the analysis by reducing the number of cases to be considered without qualitatively affecting the results. The other conditions in H1 help to rule out corner solutions in our model.

In addition, to focus on interior solutions, we also impose the following conditions on the distribution of the opportunity cost of voting:

H2. (i) $d > \gamma^{-1} \cdot \dfrac{3\mu_m^b - (1 - \alpha - \mu_m^a)}{2\left(\mu_m^a + \mu_m^b - (1-\alpha)\right)}$, (ii) $d > \gamma^{-1} \cdot \dfrac{\mu_m^p}{d - \alpha - \mu_m^p}$, (iii) $d > \gamma^{-1} \cdot \dfrac{3}{4}$

Parts (i) and (ii) guarantee that there is competition for politician b's core supporters and that no voter votes with probability 1. Part (iii) ensures that the problem of politician b is concave.

Main Results

We solve the model in two steps: first, we characterize the optimal communication strategy taking transfers as given, and then solve for the optimal transfers taking into account the communication strategy. (The details of the derivation are left to the Appendix, for the sake of

[36] Note that even though $\varepsilon \perp r$, a voter who is ideologically closer to p has a higher likelihood of voting for p.

brevity.) Our key comparative statics exercise will be a reduction in γ_m, the cost of communication, which we interpret as being the upshot of the entry of municipality m into the 3G network. In other words, the arrival of Facebook to a municipality makes communication to that municipality more effective.

The first key result, characterizing the optimal communications strategy for given transfers, is as follows:

Proposition 1. *Assume H1-H2 hold and t_m^a is fixed for all m. Then, there exists a unique equilibrium which has the following comparative statics: (i) c_m^p is increasing in μ_m^p: a politician's communication efforts towards a municipality are increasing in his popularity in the municipality; (ii) c_m^p is decreasing in γ_m: communication effort is decreasing in the cost of communication; and (iii) the effect of γ on communication is increasing in the politician's popularity, μ_m^p.*

This proposition is rather intuitive: first, politicians will tend to focus their communication efforts in places where they are more popular. This is because their popularity translates into a larger set of core voters, who are reachable by those efforts. Second, a reduction in the cost of communication implies increased communication efforts.[37] This means that a municipality's entry into the 3G network will increase those efforts towards that municipality. The third part of the proposition then establishes that the impact of such entry will tend to be stronger in places where the politician has a bigger set of core voters.

We can then characterize the equilibrium with transfers and the comparative statics in response to the arrival of 3G Internet, as follows:

Proposition 2. *Assume H1-H2 hold, and $\gamma_m = \gamma$. Then: (i) $t_1^a = 1$: politician a will transfer to municipality 1; (ii) If the cost of communication at municipality 1, γ_1, decreases enough, then politician a switches the transfer to municipality 2; and (iii) If the change in γ_1 is small, but enough to trigger the change in transfer, v_1^a may fall, whereas v_2^a will increase.*

This proposition states that, if the costs of communication are the same in the different municipalities, the politician will, intuitively enough, choose to direct his transfers to the municipality that is most important to him. However, if communication targeted to that municipality becomes relatively more effective, he may choose to direct resources *away* from it, to the benefit of other municipalities where he is still popular (even if less so). He is willing to do that even at the cost of losing votes in the former, in exchange for obtaining additional votes in the latter.

[37] Note that H1 is important for this result. If the core sets of the two politicians are overlapping, then communication becomes a strategic substitute across politicians, which makes the comparative statics ambiguous. Intuitively, while a reduction in the cost of communication has the direct impact of increasing a politician's efforts, that increase triggers an incentive for other politicians to reduce their effort, which pushes the equilibrium comparative statics in the opposite direction.

Proof of Main Results

Proposition 1

When transfers are taken as given, the problem for each municipality is independent. We drop the municipality subscript, m, for convenience thereafter. We will also allow for both politicians to have transfers as this will be helpful for extensions of the model. We solve the model from politician a perspective, noting the solution is analogous for politician b.

Let $D_i^p(t^a, t^b) = \mathbb{1}_{\left[U^a(c^a,t^a,r_i)>U^b(c^b,t^b,1-r_i)\right]} \cdot \mathbb{1}_{\left[U^a(c^a,t^a,r_i)>0\right]}$ be the crossing point for politician a. This function measures whether politician a has a shot of receiving the vote of voter i. Also, let $X(t^a, t^b) = \sup\left\{i : D_i^a(t^a, t^b) = 1\right\}$

The expected voting of politician a conditional on transfers (t_a, t_b) is given by by

$$\begin{aligned} v^a(c^a, t^a, t^b) &= d^{-1} \int_0^1 D_i^a(t^a, t^b) \cdot \text{Pr.}\left(U^a(c^a, t^a, r_i) > \varepsilon_i\right) dr_i \\ &= d^{-1} \int_0^1 D_i^a(t^a, t^b) \cdot U^a(c^a, t^a, r_i) dr_i \end{aligned}$$

where the second line assumes no voter votes for a with probability 1, which is guaranteed by H2(ii). The problem for politician a is given by

$$W(c^a, t^a, t^b) = v^a(c^a, t^a, t^b) - \frac{\gamma}{2} \cdot (c^a)^2 \tag{9}$$

We solve the problem for each combination of t^a and t^b.

Case 1. Assume that $t^b = 0$.

Note that $v^a(c^a, 1, 0) = v^a(c^a, 0, 0) + d^{-1}\alpha X(1, 0)$, so politician a's problem becomes

$$W(c^a, t^a, 0) = v^a(c^a, 0, 0) + d^{-1}\alpha X(1, 0) \cdot t^a - \frac{\gamma}{2} \cdot (c^a)^2$$

Because of H1, $X(1, 0) > X(0, 0) = \mu^a$ which implies that $\nabla_c X(1, 0) = 0$. So the FOC of the problem above is given by

$$\gamma c^a = d^{-1} \int_0^1 D_i^a(t^a, t^b) \cdot \nabla_c U^a(c^a, 0, r_i) dr_i$$

or

$$c^a = \frac{\mu^a}{d\gamma} \tag{10}$$

Case 2. $t^a = t^b = 1$. In that case, note that

$$\begin{aligned}
&U^b(c^b, 0, r_i^b) < U^a(c^a, 0, r_i^a) && \iff \\
&U^b(c^b, 0, r_i^b) + \alpha < U^a(c^a, 0, r_i^a) + \alpha && \iff \\
&U^b(c^b, 1, r_i^b) < U^a(c^a, 1, r_i^a)
\end{aligned}$$

Again H1 guarantees that the first expression is true, implying that Case 2 is equivalent to Case 1, and the optimal communication in this case is also given by (10).

Case 3. The potentially more complicated case is when $t^a = 0 < 1 = t^b$. In that case, it is possible that $U_i^b > U_i^a$ for some $i \in \mathcal{I}^a$. Hypothesis H1 and H2(i) guarantee this will be the case.

The utility of the voters in the influence zone $\mathcal{I}_1$ cross at $X(0,1)$, i.e.

$$U_i^a = U_i^b \iff \mu^a - X(0,1) + c^a = \mu^b + \alpha - 1 + X(0,1)$$

solving for $X(0,1)$ yields

$$X(0,1) = \frac{1}{2}\left(c^a + \mu^a - \mu^b - \alpha + 1\right) \tag{11}$$

because we assume the crossing of utilities happens inside the influence zone of 1, $X(0,1) < \mu^a$. Thus, problem (9) becomes

$$W(c^a, 0, 1) = d^{-1}\int_0^{X(0,1)} (c^a + \mu^a - r_i)\, dr_i - \frac{\gamma}{2}\cdot(c^a)^2 \tag{12}$$

The first order condition of this problem is given by

$$0 = \nabla W = d^{-1}X(0,1) + d^{-1}\nabla_{c^a}X(0,1)\cdot(c^a + \mu^a - X(0,1)) - \gamma c^a$$

which solves to

$$c^a(0,1) = \frac{3\mu^a - \mu^b - \alpha + 1}{4d\gamma - 3} \tag{13}$$

As for the comparative statics, items (i) and (ii) from Proposition 1 are straightforward given equilibrium communication (10) and (13). Item (iii) is proven by noticing that the equilibrium communication in cases (10) and (13) is sub-modular in μ^p (politician's p own popularity) and communication cost γ. Because $c(.)$ is twice differentiable, it suffices to notice that $\frac{\partial^2 c}{\partial \mu^p \partial \gamma} < 0$.

Proposition 2

.

Assume that $\gamma_m = \gamma \ \forall m$. First, we prove that politician a transfers to μ_1^a, i.e., the municipality where he is most popular. Politician a will transfer to the municipality m^* such that

$$m^* = \arg\max_m \{v_m^a(1) - v_m^a(0)\}$$

where $v_m^a(t) = v_m^a(c^{a*}, t, 0)$, and $c^{a*} = \arg\max_c W_m^a(c^a, 1, 0) = \arg\max_c W_m^a(c^a, 0, 0)$. Let also $W_m^a(t, 0) = \max_c W_m^a(c^a, t, 0)$.

Claim. $v_m^a(1) - v_m^a(0)$ is increasing in m.

Let $x(1) = x(1, 0)$ and $x(0) = x(0, 0)$. Then

$$v_m^a(1) - v_m^a(0) = \int_{x(0)}^{x(1)} (\alpha + \mu^a - r)dr + \alpha x(0) \tag{14}$$

Taking the derivative with respect to μ_a:

$$\begin{aligned} d \cdot \nabla_{\mu_a}(v_m^a(1) - v_m^a(0)) &= \int_{x(0)}^{x(1)} 1dr + \nabla_{\mu_a}X(1)(\alpha + \mu^a - X(1)) - \nabla_{\mu_a}X(0)(\alpha + \mu^a - X(0)) + \alpha\nabla_{\mu_a}X(0) \\ &= X(1) - X(0) + \nabla_{\mu_a}X(1)(\alpha + \mu^a - X(1)) > 0 \end{aligned}$$

since $X(1) - X(0) > 0$ and $\alpha + \mu^a - X(1) \geq 0$ is the utility of a voter who is indifferent between politician a and politician b inside of politician's b core zone, implying non-negative utility.

Taking now the derivative of refdv with respect to μ_b yields

$$d \cdot \nabla_{\mu_b}(v_m^a(1) - v_m^a(0)) = \nabla_{\mu_b}X(1)(\alpha + \mu^a - X(1)) < 0$$

Thus, for $\gamma_m = \gamma$, the claim above is proved. QED

Remark 1. We solved everything for v, rather than w, because communication of a in equilibrium is independent of t_m^a when $t_m^b = 0$.

Now to prove item 2 of Proposition 2, we just need to show that

$$\nabla_{\gamma_m}(v_m^a(1) - v_m^a(0)) > 0$$

We have

$$\begin{aligned} d\nabla_{\gamma_m}(v_m^a(1) - v_m^a(0)) &= \nabla_\gamma X(1)(\alpha + \mu^a - X(1)) \\ &= -\frac{1}{2}\nabla_\gamma c^b(1, 0) > 0 \end{aligned}$$

Thus, a decrease in γ_m reduces the marginal value transferring to municipality m.

If $\mu_1^a = \mu_2^a$ and $\mu_1^b = \mu_2^b$, any increase in γ_1 leads a to switch the transfer from municipality 1 to 2. Following that rationale, this will also happen for a discrete change in γ if $\mu_1^p = \mu_2^p + \varepsilon$. $\varepsilon \to 0$.

Because the effect of switching the transfer is discrete, if the change in γ_1 leading to the transfer switch is small enough, v_1^a will fall and v_2^b will increase. QED

Remark 2. Our results are valid when $\gamma_m = \gamma + \varepsilon_m$ for $\varepsilon_m \to 0\ \forall m$, because $\mu_m^a c - \gamma/2c^2$ is a continuous function on c.