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# Communication Networks and Protests: Investigating the "Occupy Movement" in the United States

Recife,
2016

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Dissertação apresentada ao Programa de Pós-graduação em Economia da Universidade Federal de Pernambuco como requisito para obtenção do título de mestre em Ciências Econômicas, sob a orientação do Professor Breno Ramos Sampaio.

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“Even places traditionally more muted, such as Japan and Singapore, have seen demonstrators in the streets. Social inequalities and political discontent have spurred citizens to gather. Resistance can be co-ordinated with greater ease than ever in the age of the smartphone.”

**The Economist, Dec 23rd, 2013.**

**Resumo**

Este artigo investiga a influência que o acesso à rede de Internet banda larga pode exercer na ocorrência de eventos de inquietação civil, através de uma argumentação teórica e de evidências empíricas. Primeiro, expandimos um recente modelo de decisão sobre o ato de protestar, considerando a hipótese de que a Internet define um ambiente para comunicação e troca de informações que aumentaria a insatisfação coletiva contra políticas injustas. Em seguida, utilizamos dados recolhidos sobre os locais das manifestações relacionadas ao Movimento Occupy nos Estados Unidos em 2011 para estimar o impacto que um provedor de serviços de Internet a mais exerceria sobre a probabilidade de evidenciar protestos em um determinado local. Para identificar o efeito do fornecimento de banda larga, usamos uma abordagem de variável instrumental utilizando elevação topográfica como fonte de variações exógenas no custo de construção e manutenção de infraestrutura de Internet a cabo. Como abordagem alternativa, também realizamos identificação através de heterocedasticidade, que não depende de restrições de exclusão. Em concordância com nossas previsões teóricas, nossos resultados mostram que a disponibilidade de serviços de banda larga durante a época dos protestos do Movimento Occupy esteve fortemente associada com a ocorrência de tais eventos.

**Palavras-chave:** *Internet; Engajamento Civil; Protestos; Movimento Occupy.*

**Abstract**

This article investigates the influence of broadband Internet availability in the occurrence of events of civil unrest, both with theory and empirical evidence. We first expand a recent model of protests considering the hypothesis that the Internet sets an environment for communication and information exchange that boosts collective dissatisfaction towards unfair policies. We then use collected data on the locations of 2011's Occupy Movement in the United States to estimate the impact of one extra Internet Service Provider on the probability of evidencing protests in a given location. To identify the effect of broadband provision, we use an instrumental variable approach based on topographic elevation as a source of exogenous variations in the cost of building and maintaining cable infrastructure. As an alternative approach, we also use identification through heteroskedasticity, which does not rely on exclusion restrictions. In accordance with our theoretical predictions, our results show that the availability of broadband services during the time of the Occupy protests was greatly associated with the occurrence of such events.

**Keywords:** *Internet; Civic Engagement; Protests; Occupy Movement.*

# Contents

# 1 Introduction

Episodes of civil unrest have been remarkably present in many tracks of societies' formation throughout history, on a spectrum that ranges from small and peaceful demonstrations to political clashes that ultimately led to grievous outcomes. In such spectrum, the act of protesting as a channel of political participation is one that has been receiving growing attention from media and academic literature in recent years. Not without reason, the past decade has showcased various acts of protesting around the world, as well as a perceptible rise in the number of such events each year - an increasing trend as documented by Ortiz et al. (2013) in the time period between 2006 and 2013.

At the same pace, this last decade (and the one before) have also witnessed a huge change in another important aspect of social interactions: the communication revolution. The introduction of dial-up Internet, its upgrade to broadband and Wi-Fi connections, the inception of mobile and smartphone usage, the increasing accessibility to personal computers and the popularization of social networks, have all drastically changed the way human beings produce, acquire and share information with one another. Not only that, it may have set the path on how our society will jointly evolve from now on,[1] which is not at all a strong statement, if we consider how Information and Communication Technologies (ICT, hereafter) have contributed, for instance, to the process of global homogenization of the western culture (Beynon, J. and Dunkerley, D., 2000) and to new breaths towards democratization in countries from the Arab world (Hussain, M. and Howard, P., 2012). In terms of figures, it is estimated that Internet usage and mobile phone subscriptions have increased worldwide at a rate between 2.78% and 7.4% per year, respectively, in the course of this last decade.[2]

The combination of these two facts led many researchers in social and technological sciences to wonder about the role that the Internet and social media may have played in the course of recent popular movements. Many argue that the advent of the Internet was the key factor that allowed such movements to develop in a more spontaneous and anarchic sense. However, actual evidence on the relation between the Internet and protests is scarcely available beyond anecdotal facts, hindering any causal claim between the two. The main objective of this study, therefore, is to provide empirical

[1] See McChesney (2007) for a more in-depth essay on the "communication revolution".

[2] Data from 2005 to 2013; Source: World Bank.

evidence of how the development of ICTs have positively influenced the incidence of events of civil unrest, by studying the influence that broadband Internet had on the so-called “Occupy movement” in the United States.

Inspired by recent waves of social unrest, like the Arab Spring and the Spanish “Indignados”, and sparked by an embryonic version called Occupy Wall Street (the first “Occupy” demonstration, initiated on September 2011 in Zuccotti Park, New York City), the Occupy movement refers to the series of protests that spread throughout the U.S. territory in late 2011, eventually becoming one of the most relevant episodes of mass protesting in recent years. Its core purpose was to raise awareness about the control that financial systems and big corporations exert in society in a way to disproportionately benefit a minority share of the population, and how this may undermine the proper functioning of a democratic society. Evidence of demonstrations held as part of the movement can be traced to hundreds of U.S. cities, but the movement also had international presence with demonstrations being held in many places outside the U.S. Its main motto, “we are the 99%” - a reference to the income and wealth distribution inequality between the wealthiest 1% and the rest of the population - was widely disseminate by the worldwide media.

The choice of the Occupy movement as a case study for the upcoming analysis is justified by a number of particular features to this event that may ease the isolation of the raw relationship between broadband availability and protesting. First, it is well known that the U.S. is one of the most solid democratic communities today. The First Amendment to the United States Constitution specifically allows its citizens to engage in peaceful demonstrations and guarantees their freedom of assembly as part of a measure to facilitate the redress of their grievances. In fact, many of the actions taken by protesters during the movement were in the form of peaceful sign-holding marches, rallies and pickets. Real acts of trespassing were more notably observed in the bigger cities, where protesters “occupied” public squares by organizing sit-ins and/or camping communities, and only in a few of these places - considering that such demonstrations were observed in more than 800 cities - protesters encountered severe repression from the police in the early phase of their installments. Such an environment could have signaled a low opportunity cost to engage in protests, enough to diminish the psychological threshold preventing individuals who felt aggrieved from going to the streets.

Second, despite the striking proportions achieved by the movement, outdoor demonstrations did not last long: the bulk of the collected data of Occupy-related protests is mainly concentrated to the months of October and November 2011, with very few episodes registered outside this time frame. This fact turns out to be of great convenience to our analysis since, by having observations restrained to a window of only two months, possible strong sources of bias such as changes in climate, in macroeconomic conditions and in other possible unobservable variables are unlikely to be of great impact to our estimates. Yet we may treat the data as cross-sectional without adding any substantial prejudice.

A third feature concerns the observed motives of the Occupy protests. Despite the declared general request to separate politics from financial corporations, as disseminated by most of the mainstream media that covered the protests, there was not, indeed, a unifying demand among its participants that could characterize the movement as a whole. Castells (2012) gives further evidence in favor of this statement: "The movement demanded everything and nothing at the same time. In fact, given the widespread character of the movement, each occupation had its local and regional specificity: everybody brought in her own grievances and defined her own targets." The author later points that the list of most frequently mentioned demands debated in various of the Occupy-related events and campsites was of extraordinary diversity, ranging from positions against economic austerity, government corruption and other financial and political subjects to concerns about health care, student loans, global warming, sexism, and animal rights. This supports the idea that mass movements of social unrest, in their most contemporary forms, could be a phenomena arising from the increased possibility of information acquisition and collective action through the Internet network, which would possibly be playing a significant causal role by bringing together unsatisfied citizens from a much diverse pool of complaints.

To identify the sought causal relationship between broadband and the Occupy protests, we therefore address the problem of endogeneity within the determinants of protests with an instrumental variable approach, using topographic elevation as an exogenous determinant to the provision of the Internet. The use of physical geographic elements, such as weather and topography, as a means for identification frameworks is common in many empirical studies because of the generally random and predetermined nature they possess, as we see for example in Miguel et al. (2004), Hidalgo et al. (2010) and Yanagizawa-Drott (2010). In addition, Jaber (2013) has introduced the use of terrain elevation specifically as an instrument to broadband Internet in the U.S., since it captures some of the costs of building and maintaining cable infrastructure - the most used technology for signal distribution in the U.S. We argue, based on evidence from this research, that low-lying areas are more prone to floods and exhibit higher summer temperatures, and that such climate conditions played some role in today's deployment of broadband infrastructure.

We also perform robustness tests and discussions to validate the hypothesis of the exclusion restriction, which requires the measure of land elevation to influence the incidence of protests only through its effect on Internet infrastructure. Furthermore, we use a recent estimator developed by Lewbel (2012) that exploits heteroskedasticity for identification and does not rely on any exclusion restrictions. Estimates obtained from both methods were very similar, thus providing us with robust evidence that the studied effect of broadband Internet on the occurence of protests is strong and positive.

There are a few other contemporaneous studies that investigate the causal effect of broadband Internet on corruption (Andersen et al. 2010), on labor market outcomes (Atasoy, 2011) and on voting behavior both in the U.S. (Larcinese and Miner 2012, Jaber 2013) and in other countries (Czernich 2012, Miner 2013, Falck et al. 2013, Campante et al. 2013), via an instrumental-variable approach, as well as a growing body of empirical (Machado et al. 2011, Esteban et al. 2012, Voth 2012, Yanagizawa-Drott 2010, Aguilar and Ferraz, 2014) and theoretical (Shadmer and Bernhardt, 2011; Shadmehr, 2014; Passarelli and Tabellini, 2015; Little, forthcoming) research on the determinants of events of social unrest. In this paper, we contribute to both literatures by focusing on protests as a political outcome for broadband penetration. Likewise, many other studies have been conducted on the political economy of traditional media, such as in the effects of newspapers on government responsiveness (Besley and Burgess, 2002); newspapers on reducing corruption (Reinikka and Svensson, 2004); newspapers on federal spending in a district (Stromberg, 2004); newspapers on electoral politics (Gentzkow et al., 2011); newspaper on civic attitudes and economic development (Cagé and Rueda, 2014); television on voter turnout (Gentzkow, 2006); television on presidential elections (DellaVigna and Kaplan, 2007); and radio on political violence (Yanagizawa-Drott, 2010).

To shed some light on the mechanisms behind the studied effect, we pave the way to our empirical analysis with a theoretical section in which we propose small adjustments to the theory of determinants to political unrest developed by Passarelli and Tabellini (2015), incorporating a role to broadband availability into the model. The theory is motivated by the following argument: By having fair accessibility to broadband services through technologies such as ADSL (Asymmetric Digital Subscriber Line), cable and Wi-Fi, people are able to fully utilize several devices that are today the principal means of digital intercommunication, such as computers, tablets and smartphones. Those technologies have become better alternatives in terms of cost and communication dynamics for short and long distance data exchange between two - or a group of - people, in comparison to, for example, direct phone calls or Short Message Services (SMS). Besides its wide use for entertainment and personal subjects, the possibility of such broad intercommunication, powered up by different platforms within the Internet service such as forums, communities, blogs, social networks and on-line News, allows for an accessible and unprecedented networked environment for information sharing, factual transparency and free expression.

We define a protest as a political resource for an individual (or a group of individuals) to publicly express a discontent provoked by situations, policies or events for which an entity that holds some form of power in society - be it economic, political, military, ideological or cultural - is assumed to bear responsibility. The engagement in a protest is for every agent a decision based in the threshold between costs and benefits he perceives from the act of protesting. This relation is strongly based in variables such as: how the individual is affected by this discontent, how large is the group set to protest together with him and what kind of repression might he face in doing so. In this context, the use of such a network for communication, made possible by broadband infrastructure, would improve an agent's perception on how these entities have a part on their aggrievement and also serves as a tool for collective coordination between members of a group. In a similar reasoning, Castells (2012) says that communities, including Internet-based ones, improve a psychological sense of togetherness, and togetherness is a fundamental force to overcome fear: the fear of confronting violence and repression with the act of protesting.

After this introduction, the remainder of this paper is organized as follows. Section 2 develops the theory behind the investigated effect. Section 3 presents the data. Section 4 contains the empirical framework, in which we present our identification strategy. Section 5 presents the results, alongside some robustness checks. And section 6 presents our concluding remarks.

## 2 Theoretical Foundation

In this section we explicitly model the mechanism discussed previously, through which broadband availability can positively influence individual participation on social movements given a propitious environment for protesting as a mean for political participation. We present such mechanism as an addendum to the theory of how political unrest is motivated by public policy, presented by Passarelli and Tabellini (2015), which we make a simplified exposition here. For didactic purposes, the role of the entity towards which social movements target their actions, referred to as a more broadly defined concept in the previous section, will be assigned to a single institution on societies' organization, namely, the government. Its actions, by means of policy, have the power to interfere in the lifes of individuals in personal, professional, financial and even cultural spheres. Furthermore, we set the stage in a static economy consisting of $N$ sectors/groups, indexed by $i$, of size $1 > \lambda_i > 0$ with $\sum_{i=1}^{N} \lambda_i = 1$. Individuals of group $i$ share a similar perception regarding government's actions and similar preferences on what they consider to be fair public policies.

We argue that broadband infra-structure influences social unrest through its improvement on communication, primarily between agents of a same group. We define two main effects that arise from Internet usage upon each different group:

- An *information effect*, from the reduction of possible asymmetry of information between government and individuals; and
- A *coordination effect*, from the use of Internet as a tool for collective action and coordination of individuals within the same group.

The first comes from the possibility of broader information acquisition from sources like News websites, political blogs and social networks, which could bring consequences to an individual's perception of what are the costs and benefits associated to different government policies. The second, from the use of communication platforms such as social networks, which could make individual participation in collective activities less hierarchical, could help monitoring compliance and, in general, could facilitate coordination of a group towards a single objective, independent of its size.

The decision whether to engage or not in social movements is based on a simple relation of costs and benefits that the act of protesting may represent to an individual $j$ of group $i$. The benefits are assumed to be purely emotional: a psychological reward for joining other group members in a public display of discontent towards government's policy. It is measured by an expression that contains: a term denoting the aggrievement caused by such policy to members of group $i$, $a_i$, times a term related to the size of group $i$, $\phi_i$, weighted by the proportion of other group members also participating in the demonstration, $p_i$. The costs are modeled as the sum of two components: $\mu+\epsilon_{ij}$, in which $\mu$ is a positive parameter, common to all groups, that represents the amount of repression power in service of the government and $\epsilon_{ij}$ is a random variable that captures different perceptions of costs and benefits for different agents. It has distribution $F_i(\cdot)$ and it is proposed to be of common knowledge, continuous, with density $f_i(\cdot)$, and with support on both sides of 0. Joining the previous assumptions together, individual $j$ of group $i$ is assumed to join the protests if:

$$p_i\phi_i a_i - \mu - \epsilon_{ij} \geq 0. \tag{1}$$

Equation 1 is equivalent to $\epsilon_{ij} \leq p_i\phi_i a_i - \mu$. The fraction of individuals in group $i$ who participate is thus given by:

$$p_i = Pr(\epsilon_{ij} \leq p_i\phi_i a_i - \mu) \equiv F_i(p_i\phi_i a_i - \mu). \tag{2}$$

In the case where $\epsilon_{ij} \leq -\mu$, which occurs with probability $F_i(-\mu)$, individual $j$ in group $i$ draws positive utility from engaging in a protest, even if nobody participates (i.e. $p_i = 0$).

At this point we can identify two ways in which participation in protests could increase: either by changing the shape of $F_i(\cdot)$ or the boundary relation set by $p_i\phi_i a_i - \mu$. As argued before, $F_i(\cdot)$ is known and defined for a group $i$ and $\mu$ is an external parameter, taken as given. To set our investigation forth, we develop specifically the terms regarding the effects of agrievement $a_i$ and of group size $\phi_i$.

The group's indirect utility as an outcome of government policies is represented by the function $V_i(q, \theta)$ where $q$ is the present policy and $\theta$ is a state variable. Let $\hat{q}_i = Q_i(\theta, \gamma_i)$ be the policy that is deemed fair by group $i$ in state $\theta$ given the availability of broadband Internet, $\gamma_i$ (henceforth the entitled policy). Also, $\gamma_i = \Gamma_i(\gamma)$, where $\gamma$ is the general availability of broadband in the economy, so that

$$\hat{q}_i = Q_i[\theta, \Gamma_i(\gamma)] \equiv Q_i(\theta, \gamma) \tag{3}$$

Implied in this assumption is the sense that entitled policy is given both by state $\theta$ and, no less important, by the group's perception of that state, formed, among other ways, from information acquired through usage of Internet. Based on this reasoning, the mechanism through which the magnitude of $\gamma$ exerts the aforementioned *information effect* is made evident.

Entitled policy implies an entitled utility, $\hat{V}_i(\theta, \gamma) = V_i(\hat{q}_i, \theta)$ which represents an expected level of welfare that is deemed fair by members of group $i$. Individuals feel aggrieved if and only if they perceive their actual utility to be below $\hat{V}_i(\theta, \gamma)$, so, we assume that the measure of aggrievement denoted as $a_i$ is given as a well-defined outcome from a comparison between both levels of utility, that is:

$$a_i = \begin{cases} 0, & \text{if} \quad \hat{V}_i(\theta, \gamma) \leq V_i(q, \theta) \\ \frac{w_i}{2}[\hat{V}_i(\theta, \gamma) - V_i(q, \theta)]^2, & \text{if} \quad \hat{V}_i(\theta, \gamma) > V_i(q, \theta) \end{cases} \equiv A_i(q, \theta, \gamma) \tag{4}$$

where $w_i > 0$ and $\frac{\partial \hat{V}_i}{\partial \gamma} = \frac{\partial \hat{V}_i}{\partial \hat{q}_i} \frac{\partial \hat{q}_i}{\partial \gamma} > 0$, following the previous argument with respect to $\hat{q}_i$.

As previously stated, the variable $\phi_i$ is defined as a function of group $i$'s size, $\lambda_i$, subject to a coefficient $\psi_i > 0$. This coefficient has the property to attenuate the strength that the size of the group transmit in favor of a protest. Olson (1965) explains that groups tend to loose efficiency on achieving its common goals the larger they get due to problems like free riding and loss of individual representativity. The Internet may play a powerful role in negatively influencing this attenuation by serving as a tool for individual participation, collective coordination and activity monitoring among members. The larger the availability of the Internet, $\gamma_i$, to members of group $i$, or, analogously, to the economy as a whole, $\gamma$, the smaller will be the interference of an attenuation $\psi_i$ to the potential power of a group's size to protests, that is, $\psi_i = \Psi(\gamma)$ and $\frac{\partial \psi_i}{\partial \gamma} < 0$. The variable $\gamma$, in this context, improves incidence of protests through its *coordination effect*:

$$\phi_i = \lambda_i[1 - \lambda_i \cdot \Psi(\gamma)] \equiv \Phi(\lambda_i, \gamma) \tag{5}$$

The functional form of $\phi_i$, as suggested above, is depicted in Figure 1 for a clearer exposition.

Another important driver effect on protests derived from Internet availability, though in its nature more subjective than the other two modeled so far, concerns the observed heterogeneity between

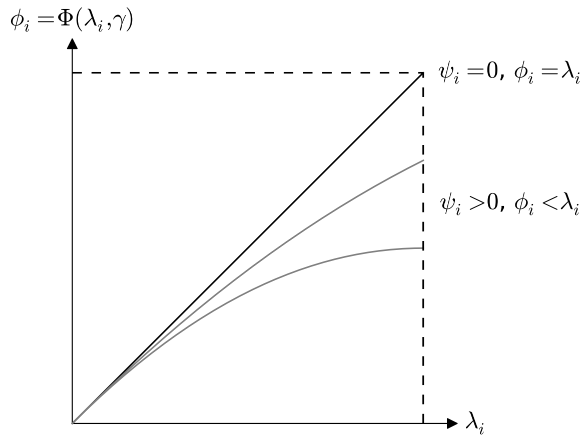


**Figure 1**: Effect of attenuation $\psi_i$ on group's size $\lambda_i$. The black line represents the outcome $\phi_i$ when $\psi_i = 0$ and the grey lines represent $\phi_i$ when $\psi_i > 0$. The higher the value of $\psi_i$, the stronger is its effect over $\phi_i$.

members of a same group. This effect, which we will name *psychological effect*, would be eminent through changes in the shape $f_i(\cdot)$ since, as in the original development by Granovetter (1978), this is the function that describes a single agent's threshold to join a protest, based on the costs and benefits he observes. We abstain from explicitly modelling the effect of $\gamma_i$ on $f_i(\cdot)$, since doing so would involve arbitrage thinking about a single individual's mind apart from its behavior as part of a group. Nevertheless, intuition suggests that we could expect less heterogeneity within a group and an enlargement of $f_i(\cdot)$, with more people becoming more inclined to engage in social movements due to better recognition of the impacts of policy and of actions taken from its peers towards possible aggrievements from policy.

To assure the possibility of a unique equilibrium, Passarelli and Tabellini (2015) establish the following lemma, for which proof will be omitted to preserve the simplicity of this exposition.

**Lemma 1** *Suppose there is a number of individuals willing to protest even if they expect to do it alone, such that* $F_i(-\mu) > 0$*, and there is also a number of individuals that will not join the protests even if the group is expected to participate, such that* $F_i(\phi_i a_i - \mu) < 1$*. Then an equilibrium participation rate,* $0 < p_i^* < 1$*, exists. Furthermore, if there is enough heterogeneity within the group such that* $\phi_i a_i \cdot f_i(p_i^* \phi_i a_i - \mu) < 1$ *around the equilibrium participation rate* $p_i^*$*, then this equilibrium will be unique.*

Figure 2 exhibits a graphical portrayal of the conditions described above.

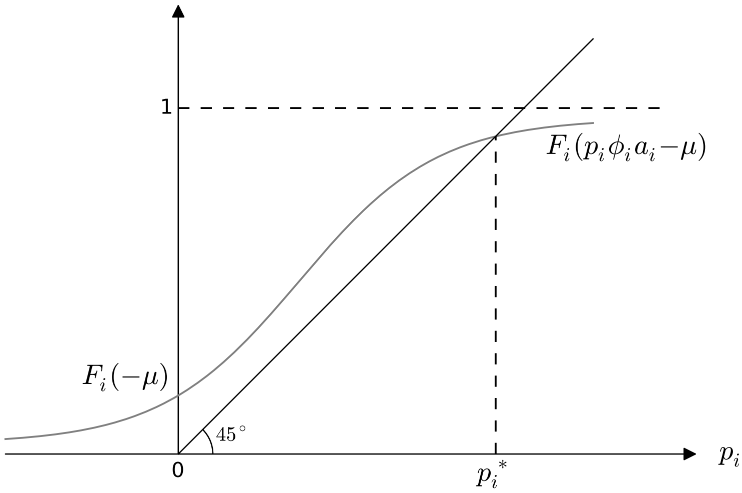


**Figure 2**: Equilibrium participation rate, adapted from Passarelli and Tabellini (2013).

From this Lemma, it is possible to express the equilibrium participation rate $p_i^*$ as a function of group aggrievement $a_i$ and, indirectly, of Internet availability $\gamma$:

$$p_i^* = H_i(a_i) = H_i(A_i(q, \theta, \gamma)) \equiv P_i(q, \theta, \gamma) \tag{6}$$

Differentiating equation (2) with respect to $a_i$ yields:

$$\frac{\partial p_i^*}{\partial a_i} \equiv H_{i,a} = \frac{\phi_i p_i^* f_i(\cdot)}{1 - a_i \phi_i f_i(\cdot)} > 0 \tag{7}$$

With (7) we reach to some interesting conclusions. Participation in protests will be more sensitive to aggrievement the larger the realizations of $p_i^*$,$\psi_i$, $f_i(\cdot)$ and $a_i$. That is, the more people are already involved in protests, the greater the perception of aggrievement by the agents and the greater the natural propensity of participation of each agent, the higher will be the effect of aggrievement on the occurrence of protesting events.

Reviewing what we argued in this section, Internet availability, $\gamma$, plays its role on these variables through: an *information effect*, making agrievement $a_i$ more sensible to policy q; a *coordination effect*, making the effect of size $\phi_i$ less susceptible to attenuation $\psi_i$; and, as shown but not developed, a psychological effect, possibly by reshaping individuals' participation probability density function, $f_i(\cdot)$. Overall, we then expect that the effect of Internet will positively influence the occurrence of protests and the participation of civilians in such.

## 3 Data

To assess the availability of broadband Internet over the US territory, we rely on data from the Federal Communications Commission (FCC). On a semi-annual basis since late 1999, all Internet Service Providers (ISPs, hereafter) are required to report to the FCC all zip codes in which they have at least one high-speed Internet customer. A high-speed line, or broadband, was defined as one that provides a connection speed exceeding 200 kilobits per second (Kbps) in at least one direction, and includes technologies like Cable Modem, DSL, and wireless. Such information has since been subsequently summarized in state, county and zip code-level measurements and made publicly available in the FCC's website. We specifically utilize the data spreadsheet from the FCC Form 477 of December 31st, 2011, since it is the one which was assembled most closely to the time of the Occupy protests.[3]

Our main measure of broadband availability, $ISP_i$, is the number of ISPs operating in a county $i$.[4] One limitation, however, is that the FCC parameterize this count denoting a unity, "1", to the range of 1 to 3 ISPs. As an approximation, we rescale this number to "2" - the middle of the range between 1 and 3, introducing some degree of measurement error as consequence. To be a good measure of broadband availability, this variable must exhibit a clear link with the share of broadband subscribers in a given county, that is, it must have indeed an effect over the extent of broadband territorial penetration. Although theory on competitive markets and empirical evidence on broadband markets suggest the existence of such a link (e.g. Bresnahan and Reiss, 1991; Aron and Burnstein, 2003; Xiao and Orazem, 2009; Kolko 2010), we provide further empirical support by calculating regression estimates for this relationship, relying on 2011 data only. The results are reported in Table 1.

[3] Subsequent results presented in this paper remain unchanged when using the FCC Form 477 from June 30th, since there is very little variation between the data recorded in both spreadsheets.

[4] The wider range of the count of the number of ISPs in the original dataset, in comparison to the one of residential fixed connections, was a main motivation for such choice. The FCC records broadband penetration by allocating each county into one of six categories based on percentage of households with fixed connections, which are: zero, up to 20%, 20% to 40%, 40% to 60%, 60% to 80%, and greater than 80%. On the other hand, the count for number of ISPs operating in a given county, in our sample, ranges from 1 to 55 (or 2 to 110, after rescaling). This approach was also considered in Kolko (2011), Miner (2012) and Jaber (2013).

**Table 1:** Relationship between broadband penetration and the number of ISPs

| Variable | Dependent variable is % of R.F.C. 200 kb/s + | | | Dependent variable is % of R.F.C. 720 kb/s + | | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Number of ISPs | .53*** | .50*** | .21*** | .62*** | .59*** | .23*** |
| | (.02) | (.02) | (.03) | (.02) | (.02) | (.03) |
| log(pop.density) | | | 3.32*** | | | 4.27*** |
| | | | (.30) | | | (.33) |
| Intercept | 42.28*** | 36.77*** | 29.97*** | 34.52*** | 24.96*** | 16.22*** |
| | (.57) | (1.46) | (1.52) | (.63) | (1.43) | (1.53) |
| State dummies | NO | YES | YES | NO | YES | YES |
| $R^2$ | .19 | .33 | .36 | .21 | .36 | .40 |
| N. of Counties | 3,019 | 3,019 | 3,019 | 3,019 | 3,019 | 3,019 |

Note: Observations are at the county-level. The dependent variable is the percentage of the population with broadband access under two alternative definitions. The FCC divides counties into six groups on the basis of broadband penetration: 1) Zero broadband penetration, 2) $0 <$ broadband $\leq 20\%$, 3) $20 <$ broadband $\leq 40\%$, 4) $40\% <$ broadband $\leq 60\%$, 5) $60\% <$ broadband $\leq 80\%$, and 6) broadband $> 80\%$. For each category, we impute the middle of the range (e.g. 10% penetration for counties in the second category). *** indicates significance at the 1 percent level.

In the first three regressions, we stick with the standard definition of broadband Internet both to set the measures of availability (number of ISPs) and residential penetration (% of residential fixed connections). From specification (1), we see that an additional ISP predicts an approximate increase in residential penetration of 0.53 percentage points. By adding state fixed effects in specification (2) the fit becomes better ($\bar{R}^2 = 0.32$) and the result changes little. If we control for population density, as in specification (3), the fit improves marginally, ($\bar{R}^2 = 0.35$) but the predicted increase in residential penetration decreases to 0.21 percentage points. In the latter three regressions, we use a more conservative definition for broadband residential penetration, only considering connections with speeds of at least 768 Kbps downstream and greater than 200 Kbps upstream. This alternative measure became the FCC's official definition of broadband in December 2008.[5] On specifications (4)-(6), an additional ISP predicts an increase of respectively 0.62, 0.59 and 0.23 percentage points in broadband penetration, again observing a better fit after adding dummies for states ($\bar{R}^2 = 0.35$) and controlling for population density ($\bar{R}^2 = 0.39$). In all cases, estimates are highly statistically

[5] See statement of Chairman Kevin J. Martin on that matter at https://apps.fcc.gov/edocs_public/attachmatch/FCC-08-89A2.pdf. In 2010, a new benchmark was again set to 4 megabits per second (Mbps) downstream and 1 Mbps upstream, according to the Sixth Broadband Progress Report available at https://apps.fcc.gov/edocs_public/attachmatch/FCC-10-129A1_Rcd.pdf. Most recently, in 2015, the definition was updated to speeds of 25 Mbps for downloads and 3 Mbps for uploads. See statement of Chairman Tom Wheeler at https://apps.fcc.gov/edocs_public/attachmatch/FCC-15-10A3.pdf (all previous documents retrieved on May 4, 2015).

significant ($p$-value $< 0.000$), which suggests that broadband availability can be a good proxy for broadband penetration.

Data on the locations of protesting activities during the Occupy movement was compiled from a wide array of sources, namely: three collectively assembled datasets available on the News websites The Guardian, The New York Times and on Wikipedia; an interactive list from the website Occupy Directory - the most extensive list of Occupy protest locations available; event and community directories from social networks such as Twitter and Facebook; and a bulk of online news coverage. Our database accounts the incidence of protest events in 661 of the 3143 counties of the U.S., and one event in the territory of Puerto Rico.

A common limitation of conducting analysis on social events concerns the possible lack of comprehensibility of available data, which in most cases can be scarce and volatile. To our effort of mapping and detailing the whole wave of protests linked to the Ocuppy movement, the quality of data collection depended greatly on how well these protests were covered by local News, and how much publicity they attained through actions of its participants.[6] We conclude that our database traces, with confidence, the locations where each event took place, although the duration and number of participants in many of these events could not be estimated with enough reliability.

Our approach was so to construct two binary variables to signalize that we have, or not, enough evidence of protest activities in county $i$. We consider a different mechanism in each one to accept such evidences from the data, in order to account for a possible over-counting of protest events: with $Protest_i^W$, evidence comes from cross referencing data from the aforementioned collaborative lists and the Occupy directory list, and with $Protest_i^S$ we take a more conservative approach by validating each single reference in $Protest_i^W$ with further references like News coverages, strong social media activity, testimonials, photos and videos (superscripts $W$ and $S$ denote the strength of the evidences inherent to each variable: *weak* or *strong*). Both variables will be used in the subsequent analysis, and their outcomes can be seen graphically in Figure 3.

[6] A widely utilized database for domestic conflicts events is the Cross-National Time Series Data Arquive, a service launched by Professor Arthur S. Banks from the State University of New York in 1968, yearly updated since then. While adequate for many cross-country studies, finer-level data for a single set of events within a country such as the Ocuppy movement is not comprehensively available. In a similar effort, the SPEED project from the University of Illinois at Urbana-Champaign attempted to record and geo-reference every civil unrest event in the world after World War II, but updates to the data are currently discontinued.

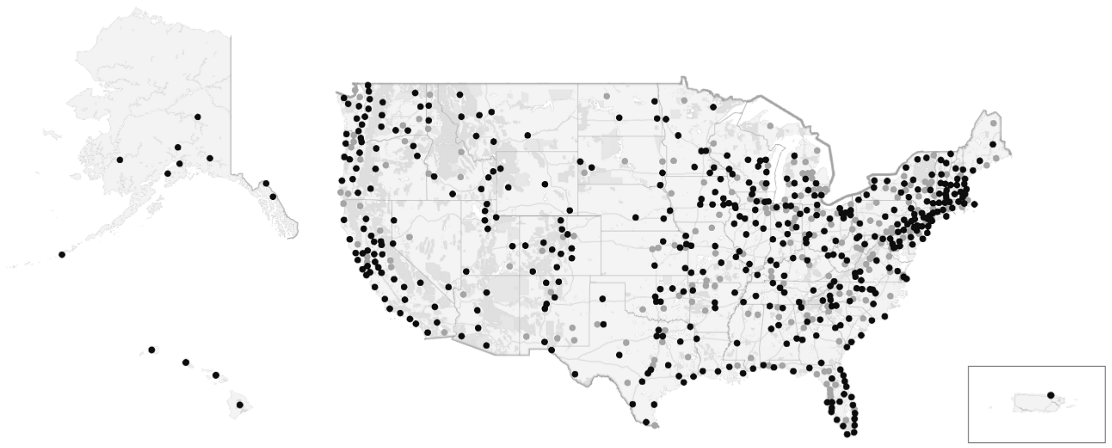

**Figure 3**: Geography of the Occupy movement in the United States and Puerto Rico. All dots (black and grey) correspond to the counties where $Protest_i^W = 1$, but only black dots correspond to the counties where $Protest_i^S = 1$

All dots (black and grey) in the figure correspond to the centroids for the counties where $Protest_i^W = 1$. For our second outcome definition, $Protest_i^S$, we define $Protest_i^S = 1$ for counties with black dots only and zero otherwise. In other words, the black dots correspond to the counties for which we have stronger evidence that public demonstrations have been carried out as part of the Occupy movement.

As part of our upcoming identification strategy, we construct the instrumental variable $Elevation_i$: a measure of mean land elevation, in meters, of county $i$, using the software ArcGIS. The raster map we utilized was a 30 arc-second DEM of North America of the GTOPO30 package, this last one created from a collaborative work led by the U.S. Geological Survey's Center for Earth Resources Observation and Science (USGS/EROS).[7]

Finally, to construct our matrix of control covariates $X_i$, we use 2011's 5-year estimate data from the American Community Survey, which are the best estimates available for demographic characteristics between decennial censuses. When any needed information is missing from these estimates, we turn to the Census data of 2010. Our choice of controls reflects the existing state of knowledge in the literature with respect to variables that may influence civil unrest and broadband

[7]Institutions also involved in the mapping of North America's DEM, as cited by the USGS/EROS: National Aeronautics and Space Administration (NASA), the United Nations Environment Programme / Global Resource Information Database (UNEP/GRID), the U.S. Agency for International Development (USAID), the Instituto Nacional de Estadistica Geografica e Informatica (INEGI) of Mexico, the Geographical Survey Institute (GSI) of Japan, Manaaki Whenua Landcare Research of New Zealand, and the Scientific Committee on Antarctic Research (SCAR).

supply and demand. These are: population per square mile, median age, median income, gini index, % high school graduates, % urban households, % male, % white, % black, % Hispanic, % unemployed, % high income (above $150k a year), % below poverty line and % between 18 and 24 years old. We also use additional data from the Census TIGER database to calculate the mean density of roads and highways in every county using ArcGIS and, for additional experiments with the covariates, we use data on climate statistics for the period between October and November 2011 from the North America Land Data Assimilation System (NLDAS) and on the number of votes going towards the Democratic and the Republican presidential candidates in the elections of 2008[8].

## 4 Empirical Framework

To identify the effect of broadband availability on civil unrest, we rely on the facts that broadband availability varies across different places and that the wave of Occupy-related activities in 2011 was expressive in some places but absent in others. Let us now explore this argument a little further.

Broadband demand and supply over the U.S. territory has been in course since the early 2000s, with cable access having dominated as the lead technology: according to an IHS report,[9] broadband market share for cable fixed connections exceeded 50 p.p. (percentage points) in 2013, leading over DSL which had 34 p.p. in that same year. Both technologies, in fact, are largely relied on cable-based infrastructure for signal transmitting (Frenzel, 2013). Other employed but less diffused technologies include fiber-optic cable, satellite, and wireless system.

Broadband provision, as any other market-driven service, varies mainly due to its associated costs and benefits across places. Kolko (2011) firstly notices that provision is mainly determined by demand due to required fixed costs that companies must face in extending service to an area: "Much of the cost to install or upgrade telecommunications infrastructure is required up front, regardless of the number of eventual subscribers served by that infrastructure. Thus, in order to spread the fixed costs across more subscribers, providers are more likely to serve areas with high demand for broadband." Miner (2013) argues that different levels of broadband penetration across states can also be attributed to different regulatory regimes, such as Right-of-Ways (ROW) laws. In addition, broadband availability can vary because of oligopolistic market structure in many areas of broad-

[8]Source: http://usatoday30.usatoday.com/news/politics/election2008/president.htm.
[9]Source: https://technology.ihs.com/468148/broadband-internet-penetration-deepens-in-us-cable-is

band provision, which may affect strategic decisions for both entrants and incumbent companies in extending broadband service in their regions. (e.g. Xiao & Orazen, 2009, 2010)

As for the drivers of political engagement and civic unrest in modern days, recent literature emphasizes dissatisfaction towards economic and political status quo as their main motivators (Machado et al., 2009; Voth, 2012; Ortiz et al., 2013). A survey-based research from the Pew Research Center conducted in 2012,[10] less then one year after the Occupy protests, show that class differences are the prominent provokers of political engagement of all kinds, especially those related to educational attainment, and that there has been a major growth in political activity on social networking sites since 2008. As for the Occupy Movement, the importance of the Internet and mainly of social networks to its unfold is well explored in Castells (2012).

Given the previous discussion, our identification strategy is based on two approaches. First, we attempt to "clean the path" between broadband availability and protests by including a set of control covariates in our main specifications. To account for demographic differences, we add controls for population density, urbanization, median age, wealth and income, education, ethnicity and inequality. We also add controls for road density to capture differences in mobility and transportation infrastructure and a set of state dummies to control for state-specific idiosyncrasy common to all of its counties.

Second, we use average elevation of the local terrain as an instrument for broadband availability. Thus, we are able to tackle important endogeneity issues such as omitted variable, reverse causality and measurement error. To serve as a good instrument, elevation should affect protests only through broadband availability. As broadband infrastructure in the US is cable-based in its majority, we argue that climate differences cause higher elevation areas to be less costly for broadband infrastructure deployment when compared to low elevation areas, characterizing a source for exogenous variation. High-lying areas are less prone to floods, dispensing the necessity of raising barriers to protect broadband facilities, and exhibit lower summer temperatures, which reflects in lower costs of cable maintenance and less need of heat-resistant cable material.[11]

[10] "Civic Engagement in the Digital Age", available at http://www.pewinternet.org/files/old-media//Files/Reports/2013/PIP_CivicEngagementintheDigitalAge.pdf

[11] This argument was originally developed in Jaber (2013). In his unpublished paper entitled "Broadband Internet and Political Behavior: Evidence from the United States", the author draws evidence from a series of urbanistic studies to argue that the link between broadband and elevation should be positive, plausibly due to climate effects. He points out that there is "a strong negative relationship between land elevation and summer temperatures (Willmott and Matsuura, 1995)" and that "low-lying areas are subject to greater flooding of telecommunications infrastructure through storm

The exclusion restriction holds if terrain elevation has no direct effect on protests independent of its relationship with broadband availability. One plausible concerns is that, as we expect the influence of land elevation on broadband availability to be established mainly through its effect over climate, climate itself may have a direct influence on the incidence of protests, with places of milder temperatures and less precipitation, for example, being more prone to receive outdoor demonstrations such as sit-ins and rallies. To handle this potential source of bias, we also include climate controls in some of our specifications to test the consistency of our main results. These controls are records for average maximum and average minimum air temperatures and average precipitation for the months of October and November 2011. Another possible concern is that we could be underestimating some politically oriented effects driving the occurence of protests, so we use controls for 2008's presiential elections outcomes in some specifications to check over this assumption.

Also as part of the identification strategy, we exclude Alaska, Hawaii and Puerto Rico from our sample, focusing therefore on the contiguous U.S. territory only. Their geographic placements make them outliers, which could confound interpretations of the results in our analysis.[12]

Our main empirical specification is constituted by the following set of linear equations, estimated via two-stage least squares (IV-2SLS)[13]:

$$Protest_{is} = \alpha_1 + \beta_1 ISP_{is} + \boldsymbol{\gamma_1}'\boldsymbol{X}_{is} + \delta_{1s} + \varepsilon_{is} \quad (8)$$

$$ISP_{is} = \alpha_2 + \beta_2 Elevation_i + \boldsymbol{\gamma_2}'\boldsymbol{X}_{is} + \delta_{2s} + \eta_{is} \quad (9)$$

The variable $ISP_{is}$ denotes the number of Internet Service Providers in county $i$ located in state

surges and hurricanes (e.g. Michel-Kerjan et al. 2010, Landry and Parvar 2011)". Thus, when built over terrains that are closer to sea level, cable infrastructure is more subject to damages from flooding, high ground temperatures, and excessive precipitation (Zimmerman and Faris 2010), and such challenges "require the use of damage-resistant material and the construction of natural or artificial barriers (Rosenzweig et al. 2011)". He also points that "the reliance on land elevation to capture a multitude of influences at once is not unconventional, since geologists have already shown that land elevation predicts soil characteristics such as water content, crop yields, and vegetation type (Moore et al. 1991, Erskine et al. 2007)". Another challenge associated with building cable infra-structure in a flood-prone area is the difficulty of laying underground cable connections, which, in turn, "may affect the cost of building broadband infrastructure, as overhead poles are in general more susceptible to weather damage (Bascom and Antoniello 2011)".

[12] OLS results are nevertheless robust to the inclusion of these observations.

[13] Non-linear models may seem like the best alternative due to the binary nature of the dependent variable (zero or one). We follow, however, Angrist and Pischke's (2009) advice that linear probability models usually delivers similar results as non-linear regression models while allowing for an easier implementation and interpretation of causal effects. Using a *logit/probit* model also requires an assumption on the distribution of error terms, which introduces an additional bias in case the assumed distribution is incorrect.

$s$; the outcome $Protest_{is}$ is a binary variable denoting evidence of protest activity in county $i$; $Elevation_{is}$ is the instrumental variable for $ISP_{is}$, denoting average land elevation in county $i$; the vector $\boldsymbol{X}_{is}$ is the set of control variables and $\delta_s$ are state fixed effects. $\alpha_1$ and $\alpha_2$ are the intercepts in each equation, $\beta_2$ is the effect of elevation on $ISP_i$ and $\beta_1$ is the investigated effect of $ISP_i$ on $Protest_i$. Some variables in the control vector $\boldsymbol{X}_{is}$ , as well as the instrument $Elevation_{is}$, are log-linearized so as to convert their variations to percentage points.

# 5 Results

## 5.1 Preliminary Analysis

How strongly the spread of Occupy-related demonstrations in the US can be accounted as an outcome of broadband availability? We start our investigation by analyzing differences in county characteristics conditioned to protests evidence status, to help us trace preliminary assumptions on the differences between profiles of counties that have or have not been stage to demonstrations. Table 2 presents a partition of our sample between counties where $Protest_i^W = 1$ and $Protest_i^W = 0$, with reported means for the collected set of climatic, political and socio-economic characteristics.

As originally presumed, means of indicators for broadband penetration and availability are remarkably higher in the sub-sample where $Protest_i^W = 1$. The difference in the percentage of residences with fixed connections are of 15.52 points for one-way connection speeds exceeding 200 kbps and of 18.21 points for connection speeds of at least 768 kbps downstream, and the average number of ISPs is almost two times bigger. Comparisons on demographics also indicate that this partition is, on average, more densely populated, more urbanized, better served with transportation infrastructure, more educated, wealthier and younger, and that differences in gender predominance, ethnicity and level of unemployment are only slightly perceptible. Also nearly indistinguishable are differences in the Gini index and in the percentage of the population below the poverty line. A curious fact at minimum, considering that awareness to inequality was the main concern in the Occupy movement's declared agenda, and so insurgences in support to it could likewise be sensible in counties where $Protest_i^W = 0$.

Vote shares for the 2008's presidential election suggest that the Republican Party had stronger representation where $Protest_i^W = 0$, an outcome narrowly reversed to the Democrat Party's side in

**Table 2:** Summary Statistics

| | Mean | s.d. | Mean by protest status | | t-stat |
|---|---|---|---|---|---|
| | | | $Protest_i^W = 1$ | $Protest_i^W = 0$ | |
| · FCC Data | | | | | |
| % Residential Fixed Connections (200 kbps +) | 55.27 | 15.91 | 67.56 | 52.04 | -24.07 |
| % Residential Fixed Connections (768 kbps +) | 49.62 | 17.45 | 64.04 | 45.83 | -26.11 |
| Number of ISPs (200 kbps +) | 24.55 | 13.13 | 38.79 | 20.80 | -37.37 |
| · Census/ACS data | | | | | |
| population per square mile (2010) | 261 | 1733 | 845 | 108 | -9.77 |
| median age | 40.14 | 4.97 | 37.71 | 40.78 | 14.42 |
| median income | 40,925 | 17,134 | 46,158 | 39,548 | -8.85 |
| gini index | 0.44 | 0.04 | 0.43 | 0.44 | 1.06 |
| % high school | 83.63 | 7.16 | 87.10 | 82.72 | -14.31 |
| % urban (2010) | 40.61 | 31.49 | 73.11 | 32.05 | -34.81 |
| % male | 49.93 | 2.30 | 49.34 | 50.08 | 7.31 |
| % white | 84.24 | 16.13 | 81.66 | 84.92 | 4.58 |
| % black | 9.04 | 14.58 | 8.80 | 9.10 | 0.46 |
| % Hispanic | 8.10 | 13.09 | 11.10 | 7.31 | -6.59 |
| % unemployed | 4.80 | 1.90 | 5.26 | 4.67 | -7.05 |
| % high income | 4.75 | 3.90 | 7.30 | 4.08 | -19.83 |
| % below poverty line | 15.90 | 6.41 | 14.87 | 16.17 | 4.60 |
| % 18 to 24 years old | 8.94 | 3.77 | 11.24 | 8.33 | -18.44 |
| · Census TIGER data | | | | | |
| mean road density | 3.92 | 2.90 | 5.77 | 3.40 | -19.39 |
| · Elections 2008 data | | | | | |
| % Democratic | 26.63 | 35.46 | 29.03 | 26.00 | -1.94 |
| % Republican | 35.41 | 62.54 | 27.22 | 38.45 | 4.56 |
| % voter turnout | 63.72 | 88.43 | 57.09 | 65.47 | 2.14 |
| · NLDAS data | | | | | |
| average daily precipitation | 2.45 | 1.40 | 2.76 | 2.37 | -6.38 |
| average maximum air temperature | 63.15 | 9.01 | 61.22 | 63.66 | 6.18 |
| average minimum air temperature | 42.87 | 6.66 | 43.22 | 42.78 | -1.51 |
| N. of Counties | 3,109 | | 648 | 2,460 | |

Note: Summary statistics are for 2011 unless otherwise reported. Statistics for the FCC variables are based on value estimates as described in section 2.1 and in Table 1. Mean road density is measured in kilometers of road per square-kilometer ($km^2$). Democratic/Republican percentages denotes the share of votes going towards the Democratic/Republican candidate in the 2008 presidential elections. Percentage in voter turnout is proxied as the ratio between the recorded number of casted votes in 2008's elections and the 2009's ACS 5-year estimates for population (available estimates for 2008 lacks a non-negligible number of counties). Average daily precipitation is measured in millimeters (mm) and average air temperature in Fahrenheit (F). All variables are at the county-level.

the partition where $Protest_i^W = 1$. Interestingly, voter turnout was higher where $Protest1_i = 0$, indicating that the demonstrations happened where political participation through the traditional channel of voting was smaller. Weather and climate data also differs little across both partitions, but is possible to affirm that between October and November 2011 there was less precipitation and higher thermal amplitude where $Protest_i^W = 0$.

A preliminary set of regressions of protests on broadband availability is displayed in table 3. Coefficients are positive and statistically significant at the 1% level across every specification, with robust standard errors reported in parentheses. Let us first consider $Protest_i^W$ as dependent variable. The results from Probit and OLS estimates with no additional controls (specifications 1 and 2, respectively) are fairly similar, supporting the decision of focusing our attention on linear specifications. Adding controls for county-level socioeconomic demographics and dummies for state fixed effects (specification 4) gives us smaller but more reliable results: the presence of one extra Internet Service Provider in the broadband market of a given county is correlated with an increase in the probability of an Occupy-related protest to occur in that county by about 1 p.p. All results remain virtually unchanged when considering $Protest_i^S$ as dependent variable (specifications 5 to 8).

**Table 3:** Broadband penetration and social unrest - Probit and OLS estimates

| | Dependent variable is $Protest^W$ | | | | Dependent variable is $Protest^S$ | | | |
|---|---|---|---|---|---|---|---|---|
| Explanatory variable | Probit | OLS | OLS | OLS | Probit | OLS | OLS | OLS |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| Number of ISPs | .0141*** | .0172*** | .0164*** | .0090*** | .0110*** | .0151*** | .0145*** | .0099*** |
| | (.0005) | (.0005) | (.0006) | (.0009) | (.0004) | (.0005) | (.0006) | (.0008) |
| State dummies | NO | NO | YES | YES | NO | NO | YES | YES |
| County-level controls | NO | NO | NO | YES | NO | NO | NO | YES |
| $R^2$ | - | .31 | .38 | .46 | - | .29 | .36 | .43 |
| $\bar{R}^2$ | - | .31 | .37 | .45 | - | .29 | .35 | .42 |
| N. of Counties | 3,109 | 3,109 | 3,109 | 3,108 | 3,109 | 3,109 | 3,109 | 3,108 |

Note: Probit estimates are reported in terms of marginal effects. County-level controls are consisted of log(road density) and the following county-level demographics: log(density), log(median age), log(median income), gini index, % high school grads, % urban, % male, % white, % black, % Hispanic, %income \$150k+, % income below poverty line, %18 to 24 years old population. *** indicates significance at the 1 percent level.

Table 4 displays our OLS estimates of the effect of terrain elevation on the change in broadband availability and in both protest variables. Controls for county-level demographics and dummies for states are kept in the models, a strategy which we will not lay aside from now on. The estimate in column 1 indicates that a positive variation of 1 p.p. in land elevation predicts the presence of .0121 extra ISP operating in a county. This result corroborates our previous hypothesis that the effect of land elevation on broadband is positive. The estimates in column 2 and 3 indicate that the correlation between elevation and the occurrence of a protest is also positive, a phenomenon we believe to be indirectly driven by the effect identified in column 1. Also here, every coefficient is statistically significant at the 1% level.

To check whether our linear specifications in table 4 miss important aspects of the data, we reestimate the effect of variations in mean land elevation on broadband availability and on protest occurrences using nonparametric local polynomial estimators, along the lines of Bruckner and Ciccone (2011). Figure 4(A) presents estimates of the effect of elevation on the number of ISPs, using

**Table 4:** Effects of terrain elevation

| Explanatory variable | Dependent Variable | | |
|---|---|---|---|
| | Number os ISPs | $Protest^W$ | $Protest^S$ |
| | (1) | (2) | (3) |
| Log(mean elevation) | 1.2082*** | .0449*** | .0341*** |
| | (.2217) | (.0091) | (.0088) |
| State dummies | YES | YES | YES |
| County-level controls | YES | YES | YES |
| $R^2$ | .73 | .45 | .40 |
| N. of Counties | 3,108 | 3,108 | 3,108 |

Note: County-level controls are consisted of log(road density) and the following county-level demographics: log(density), log(median age), log(median income), gini index, % high school grads, % urban, % male, % white, % black, % Hispanic, %income \$150k+, % income below poverty line, %18 to 24 years old population. *** indicates significance at the 1 percent level.

a Epanechnikov kernel and choosing the bandwidth that minimizes the mean-square error.[14] With a fair level of precision, this relationship is revealed as monotonically increasing along the whole length of observed variations in mean elevation. Figure 4(B) uses the same approach to obtain estimates of the effect of elevation on protests. This relationship also turns out to be monotonically increasing, although the trend is very imprecisely estimated for large negative variations in mean elevation, since less than 1 percent of observations on mean elevations are to the very left side of the accounted values.

## 5.2 Instrumental Variables Based Identification

Moving on to the IV-2SLS framework, Table 5 provides us the first-stage estimates of our preferred set of specifications, which include state dummies and demographic controls. With no other additional controls (specification 1), the effect of the log-linearized mean elevation on the number of ISPs is shown to be positive and statistically significant at the 1% level, a result we already assessed in specification 1 of table 4. This trend is still preserved with the addition of supplementary controls in specifications 2, 3 and 4: log-linearized mean elevation continues to positively predict the number of ISPs in a given county.

Second stage estimates are also presented in Table 5. Specifications 1-W to 4-W show the correspondent second-stage estimates to specifications 1 to 4 when considering $Protest^W$ as dependent

[14]To choose the bandwidth, we use cross-validation (CV) criteria (see Bowman and Azzalini, 1997)

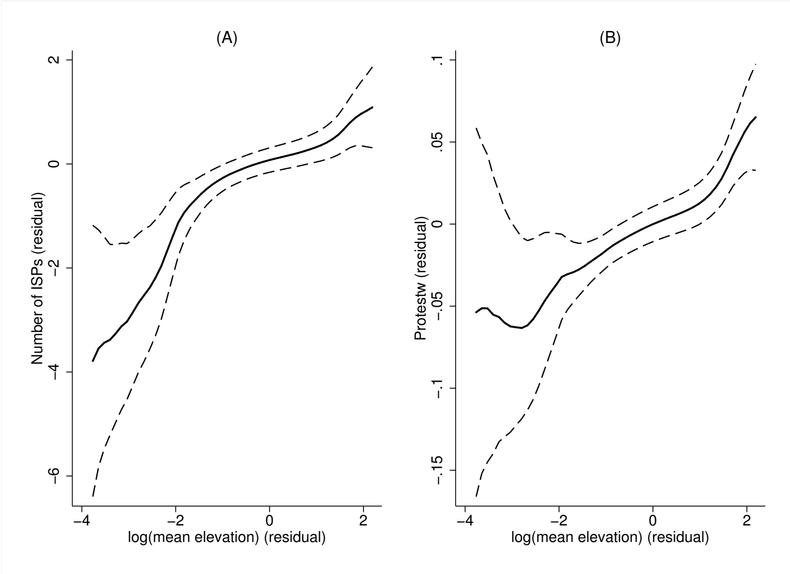


**Figure 4**: (A) log(mean elevation) and Number of ISPs. (B) log(mean elevation) and Protest$^W$. Nonparametric local polynomial estimates are computed using an Epanechnikov kernel. Bandwidth are obtained by cross-validation criteria. Dashed lines indicate 95% confidence intervals.

variable, and specifications 1-S to 4-W show the analogous estimates with $Protest^S$ as dependent variable. Focusing in our main outcome of interest, $Protest^W$, and considering specification 1-W as our benchmark, the effect of broadband on civil unrest is revealed to be considerably big: point estimates indicate that the entrance of one new Internet service provider in the broadband market of a given county would cause an increase in the probability of an Occupy-related protest to occur in that county by about 3.7 p.p. This impact remains high even if we turn to our more conservative outcome $Protest^S$ in specification 1-S, which returns an estimated probability of 2.8 p.p.

Among the factors that could be over-estimating such finding, we highlight the possibility of variations in political engagement and militancy among civilians of different counties. Although the occupy protests were not apparently driven by political interests, we did model protest behavior as a derivative of the relation between civilians and government in Section 2, which is, as discussed, one of the main causes of many other recent demonstrations of civil unrest. Adding a set of political variables as controls in our model (specifications 2-W and 2-S) to proxy for differences in county-level political preferences and behavior, however, does not significantly changes our previous results. As shown in Table 2, these variables are the county-level percentage of voter turnout and the share of valid votes going towards the Democratic and Republican candidates of the 2008

**Table 5:** Broadband penetration and social unrest - IV-2SLS estimates

| Variable | First Stage | | | | Second Stage | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Dependent variable is Number of ISPs | | | | Dependent variable is $Protest^W$ | | | | Dependent variable is $Protest^S$ | | | |
| | (1) | (2) | (3) | (4) | (1-W) | (2-W) | (3-W) | (4-W) | (1-S) | (2-S) | (3-S) | (4-S) |
| log(mean elevation) | 1.2082*** | 1.2443*** | 1.9239*** | 1.9454*** | | | | | | | | |
| | (.1868) | (.1862) | (.2248) | (.2244) | | | | | | | | |
| Number of ISPs | | | | | .0372*** | .0365*** | .0258*** | .0259*** | .0282*** | .0277*** | .0188*** | .0191*** |
| | | | | | (.0085) | (.0082) | (.0058) | (.0057) | (.0075) | (.0072) | (.0051) | (.0051) |
| State dummies | YES | YES | YES | YES | YES | YES | YES | YES | YES | YES | YES | YES |
| County-level controls | YES | YES | YES | YES | YES | YES | YES | YES | YES | YES | YES | YES |
| Political controls | NO | YES | NO | YES | NO | YES | NO | YES | NO | YES | NO | YES |
| Meteorological controls | NO | NO | YES | YES | NO | NO | YES | YES | NO | NO | YES | YES |
| $R^2$ | .73 | .73 | .73 | .73 | .24 | .25 | .39 | .39 | .31 | .32 | .41 | .41 |
| $\bar{R}^2$ | .72 | .72 | .73 | .73 | .22 | .23 | .37 | .37 | .30 | .31 | .39 | .39 |
| N. of Counties | 3,108 | 3,108 | 3,108 | 3,108 | 3,108 | 3,108 | 3,108 | 3,108 | 3,108 | 3,108 | 3,108 | 3,108 |

Note: County-level controls are consisted of log(road density) and the following county-level demographics: log(density), log(median age), log(median income), gini index, % high school grads, % urban, % male, % white, % black, % Hispanic, %income $150k+, % income below poverty line, %18 to 24 years old population. Political controls are the following county-level election outcomes: % Democratic, % Republican, % voter turnout. Meteorological controls for the sample period from October to November 2011 are the following: log-linearized county-level values of average daily precipitation, and average maximum and minimum air temperature. $^{***}$ indicates significance at the 1 percent level.

presidential elections.

Another possible weakness in our empirical strategy is conferred to possible undesired side effects of weather and climate, apart from the discussed effects that link land elevation to broadband infrastructure: meteorological variables such as temperature and precipitation could have directly influenced the occurrence of the Occupy protests, thus violating the exclusion restriction. To approach this issue, we first clarify an important distinction in our argument: the effect of climate on broadband infrastructure is defined by variables observed throughout the whole period that comprises deployment and maintenance of broadband infrastructure, whereas the direct effect of climate on protesting incidence should be driven by variables affecting only the smaller period of the Occupy protests, since it is intuitively plausible that climate records from the past should not influence the willingness of citizens to protest in the present. We therefore add a set of meteorological variables from the observed period of October and November 2011 as controls to our model as an attempt to withdraw these possible effects from the error term in the second-stage equation, reinforcing the assumption of its non-correlation with our instrument while still preserving the effects that determine broadband infrastructure. These variables, also shown in Table 2, are the log-linearized county-level values of average precipitation, average maximum air temperature and average minimum air temperature from that period.

Results shown in specification 3-W suggest that the effects of temperature and precipitation indeed reduce the magnitude of our previous findings, although they remain high and statistically significant at the 1% level: one extra ISP in a given county accounts for a rise of 2.6 p.p. in the chance of a local protest to happen. In specification 3-S, this estimated effect is of roughly 1.9 p.p. Finally, we run the model considering the set of meteorological together with political controls in specifications 4-W and 4-S. We again do not observe significant changes in our results.

## 5.3 Heteroskedasticity Based Identification

As an alternative approach to identification via instrumental variables that we provide above, we consider recently developed methods that do not rely on exclusion restrictions, but use heteroskedasticity for identification. More specifically, we implement the two-stage estimator proposed by Lewbel (2012) in which identification can be achieved without any exclusion restrictions when there exist some exogenous variables in the structural equation and errors are heteroskedastic.[15]

To briefly present the approach carried out by Lewbel (2012), consider that we dispose of an exogenous variable $Z$, which in our case is $log(mean\ elevation)$. In a triangular system such as the one presented in (10) and (11), where error correlations are due to an unobserved common factor ($U$), identification comes from having regressors uncorrelated with the product of heteroskedastic errors (Lewbel, 2012).

In our case, one may imagine $U$ as an omitted variable which supposedly affects both the endogenous variable $ISP$, and our outcome $Protest$, where $V_1$ and $V_2$ are idiosyncratic errors. Lewbel show that in a system of the form displayed below, one can properly identify the causal effect of $ISP$ on $Protest$, denoted by $\beta_1$, using a modified two-stage least squares (2SLS) or generalized method of moments (GMM). All that is required for identification and estimation are the moments shown in equation 12 along with some heteroskedasticity in $\varepsilon$ and $\eta$, where $Z \subseteq X$ (for a formal presentation, see the Appendix of Lewbel 2012).[16]

$$Protest = \alpha_1 + \beta_1 ISP + \boldsymbol{\gamma_1'} \boldsymbol{X} + \varepsilon, \quad \varepsilon = \delta_1 U + V_1 \tag{10}$$

$$ISP = \alpha_2 + \boldsymbol{\gamma_2'} \boldsymbol{X} + \eta, \quad \eta = \delta_2 U + V_2 \tag{11}$$

$$E[X\varepsilon] = 0, \quad E[X\eta] = 0, \quad Cov[Z, \varepsilon\eta] = 0 \tag{12}$$

Using the residuals from the first stage regression (equation 11), instruments for the second stage are constructed as follows:

$$(Z - \bar{Z})\hat{\eta} \tag{13}$$

where $\bar{Z}$ is the mean of $Z$. Following Lewbel (2012) and Emran and Hou (2013), we implement the Breusch-Pagan test for heteroskedasticity and find that the null for homoskedastic errors is clearly rejected in our first stage regressions, presented in columns 1-3 of table 6 (p-values are all 0.000).

Once again we find positive and statistically significant estimates for all specifications considered with this alternative identification scheme. First-stage estimates of the main specification

[15]Other alternative but similar approaches may be seen in Rigobon (2003) and Klein and Vella (2010), both using also heteroskedasticity for parameter identification.

[16]If $Cov(Z, \varepsilon\eta) \neq 0$ treatment effect bounds on parameters can still be obtained as long as this covariance is not too large.

**Table 6:** Broadband penetration and social unrest - Lewbel (2012) two-stage estimator

| Variable | First Stage | | | | Second Stage | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Dependent variable is Number of ISPs | | | | Dependent variable is $Protest^W$ | | | | Dependent variable is $Protest^S$ | | | |
| | (1) | (2) | (3) | (4) | (1-W) | (2-W) | (3-W) | (4-W) | (1-S) | (2-S) | (3-S) | (4-S) |
| log(mean elevation) | 1.0014*** | 1.0334*** | 1.3957*** | 1.4186*** | | | | | | | | |
| | (.1863) | (.1874) | (.2102) | (.2117) | | | | | | | | |
| Number of ISPs | | | | | .0123*** | .0125*** | .0117*** | .0118*** | .0141*** | .0141*** | .0134*** | .0136*** |
| | | | | | (.0019) | (.0019) | (.0018) | (.0018) | (.0017) | (.0018) | (.0017) | (.0017) |
| Generated Instruments | YES | YES | YES | YES | NO | NO | NO | NO | NO | NO | NO | NO |
| State dummies | YES | YES | YES | YES | YES | YES | YES | YES | YES | YES | YES | YES |
| County-level controls | YES | YES | YES | YES | YES | YES | YES | YES | YES | YES | YES | YES |
| Political controls | NO | YES | NO | YES | NO | YES | NO | YES | NO | YES | NO | YES |
| Meteorological controls | NO | NO | YES | YES | NO | NO | YES | YES | NO | NO | YES | YES |
| Breusch-Pagan test for | 269.29 | 285.15 | 246.78 | 267.55 | | | | | | | | |
| heteroskedasticity | (0.000) | (0.000) | (0.000) | (0.000) | | | | | | | | |
| $R^2$ | .72 | .72 | .73 | .73 | .34 | .35 | .36 | .36 | .32 | .32 | .32 | .32 |
| N. of Counties | 3,108 | 3,108 | 3,108 | 3,108 | 3,108 | 3,108 | 3,108 | 3,108 | 3,108 | 3,108 | 3,108 | 3,108 |

Note: Demographic controls are the following county-level socioeconomic demographics: log(density), log(median age), log(median income), gini index, % high school grads, % urban, % male, % white, % black, % Hispanic, %income $150k+, % income below poverty line, %18 to 24 years old population. Political controls are the following county-level election outcomes: % Democratic, % Republican, % voter turnout. Meteorological controls for the sample period from October to November 2011 are the following: log-linearized county-level values of average daily precipitation, and average maximum and minimum air temperature. *** indicates significance at the 1 percent level.

including state dummies and demographic controls (specification 1) indicate a positive influence of the log-linearized mean elevation on the number of ISPs of a given county. Additional specifications including political (specification 2) and meteorological controls (specification 3) return very similar results. Second-stage estimates show effects of broadband on civil unrest which are smaller in magnitude but equally reliable across all three specifications, considering either $Protest^W$ or $Protest^S$ as dependent variables: the entrance of one new ISP in the broadband market of a given county would cause an increase in the probability of an Occupy-related protest to occur in that county by a measure between 1.1 and 1.4 p.p.

## 6 Conclusion

This paper provides empirical evidence that information and communication technologies can affect collective participation in social and political movements, in particular that broadband Internet played a significant role in disseminating protesting activity related to the Occupy movement in many counties across the U.S. territory. Instrumental variables estimates suggest that the probability of an Occupy-related protest to occur in a county increases by approximately 3.7 p.p. (percentage points) with the addition of one extra ISP, in our preferred specification, and by approximately 1.9 p.p. in our most conservative specification. Heteroskedasticity-based estimates suggest slightly weaker but equally reliable results, with an effect that ranges from 1.1 to 1.4 p.p. across every specification considered.

To assess the magnitude of such findings, we may consider some back-of-the-envelope calculations from sharper variations in the number of ISPs operating between counties. If one extra ISP influences the probability of the occurrence of a protest by 1.5 p.p. (a middle ground between the results from heteroskedasticity-based estimates and from the most conservative IV-estimates), and supposing that a linear relation is not implausible for lower sections of the data, then 20 extra ISPs would, on average, account for an increase in 30 p.p. in that probability, in comparison to a county which have none. In fact, 40% of the counties where protests were weakly evidenced by the available data ($Protest^W = 1$) had more than 20 ISPs by the time of the protests. That share rises to 48% when considering the counties where protests where strongly evidenced by the available data ($Protest^S = 1$).

This paper also theoretically outlines a mechanism by which the improvement in broadband Internet availability influences the observed effects on civil unrest, arguing that it helps individuals get better informed about their social and political environment and also that it helps them with the coordination of their actions with one another. Although it is beyond the scope of this paper to separately estimate the parameters of the model or to derive its equilibrium outcomes, further developments on models of collective behavior involving information/communication constraints should continue to be a productive area for future research.

Although the role of ICTs in the formation and dissemination of social and political movements is an interesting inquiry by itself, in this paper we do not address the possible common aggrievements that drives people to protest in a first place. Global news are constantly covering protests that are comparable to the ones of the Occupy movement still today. In Latin America, for instance, there are ongoing protests against government and bad policies happening in Venezuela since 2014 and in Brazil since 2013. The understanding of what exactly is bringing people to the streets is in most situations a very important subject for policy conduction and for the development of a better agreement between the government and its population, so the growing availability of data from such protests should also make this a fruitful area for future research.

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