Digital access, political networks and the diffusion of democracy

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ABSTRACT

We examine the effects of digital access on the prevalence of democracy and its diffusion via trade, geographical and migration networks across 189 countries between 2000 and 2010. We find that different digital technologies may have varying impacts on freedom while affecting its diffusion via different political networks, and that related changes in civil liberties can be affected by both media freedom and internal political institutions. Our analysis suggests three key mechanisms linking information technology with democratic change and highlights the importance of a country's "susceptibility" to political influence that is triggered by greater digitally induced visibility.

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1. Overview and motivation

On January 14, 2011, President Zine El Abidine Ben Ali stepped down as the president of Tunisia, reacting to a localized series of protests that had begun in the central Tunisian town of Sidi Bouzid 4 weeks earlier. Over the next 10 days, thousands of people in neighboring Egypt demonstrated for the resignation of their president Hosni Mubarak, an Egyptian Facebook page was set up to coordinate protests in Cairo, and there were widespread revolutionary activity in other regional countries including Yemen and Algeria. These protests soon fanned out across the region, and by early February, 11,000 Syrians had joined a Facebook page called The Syrian Revolution, over 20,000 Yemenese had participated in "A Day of Rage" in their capital, citizens of Jordan, Morocco and Oman were participating in rallies, and the government of nearby Kuwait had made key interior government changes toward pre-empting demonstrations. The short-term culmination of these events was the series of protests at Tahrir Square and the resignation of Hosni Mubarak on February 11, 2011, which in turn spawned a civil war in Libya and continued intensive political unrest in Yemen.

The extent to which these revolutions have led to sustained political change has been mixed. However, regional diffusion of this kind is not unprecedented. Many writers have drawn a parallel between this recent "Arab Spring" and the Spring of Nations of 1848, which began in Sicily in January, was first noticed in France in February, then spread through much of Europe (and parts of Latin America) over the year (Evans and Strandmann, 2000).[1] One theme of the ex-post analysis of the 2011 events in Northern Africa has been a focus on the role that information technologies and social media may or may not have played in diffusing and sustaining the revolution. While concurrent press coverage frequently emphasized the role of the Internet, even going so far as to label these "Twitter Revolutions" or "Facebook Revolutions", more substantive analyses appear more cautious in ascribing any causal role to social media technologies, highlighting, however, two differing aspects of information technologies – providing access to information and providing a means for coordination – that could account for their catalyzing effect on democratic change.[2] For example, writing for Foreign Affairs in January 2011, Clay Shirky notes that:

> "The safest characterization of recent quantitative attempts to answer the question, Do digital tools enhance democracy? is that these tools probably do not hurt in the short run and might help in the long run – and that they have the most dramatic effects in states where a public sphere already constrains the actions of the government. Despite this mixed record, social media have become coordinating tools for nearly all of the world's political movements, just as most of the world's authoritarian governments (and, alarmingly, an increasing number of democratic ones) are trying to limit access to it." (Shirky, 2011)

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[1] These revolutions were largely suppressed by the end of the year and it is generally believed that they did not lead to a great deal of reform beyond the abolition of serfdom in Austria and Hungary.

[2] This is not the first new technology has been connected to the diffusion of revolution; there is also conjecture that while the information transparency facilitated by the emergence of newspapers played a role in sustaining the 1848 Spring of Nations revolution within each country (Zakaria, 2011), there were no technologies for coordinating revolutionary activity across the neighboring countries (Evans and Strandmann, 2000).

Adopting a more neutral position, Fareed Zakaria summarizes his view about how information technologies might affect democratization:

"It's too simple to say that what happened in Tunisia and Egypt happened because of Facebook. But technology – satellite television, computers, mobile phones and the Internet – has played a powerful role in informing, educating and connecting people in the region. Such advances empower individuals and disempower the state. In the old days, information technology favored those in power, because it was one-to-many. That's why revolutionaries tried to take over radio stations in the 1930s – so they could broadcast information to the masses. Today's technologies are all many to many, networks in which everyone is connected but no one is in control. That's bad for anyone trying to suppress information." (Zakaria, 2011)

It is indeed still too early to assess whether the revolutions in Northern Africa will lead to longer-run political reform, or whether information technologies will play a pivotal role in sustaining either the activism or any subsequent democratic change. Nevertheless, these events frame the broader question we investigate in this paper: Is access to digital technologies related to the emergence of democracy within a country and the diffusion of democracy across countries? Our belief is that the effects that digital technologies may have on democracy and freedom can be more far-reaching than the effect social media might or might not have on fostering revolution. The question we pose is thus broader in its scope and timeframe than one that asks, say, whether social media technologies foster the emergence and diffusion of political participation (Bond et al., 2012), or social or political revolutions (Centola and Macy, 2007).

The importance of our research question stems for at least two points. First, while the democratizing effects of digital access have been discussed extensively (more on this later), we believe that there is still no clear empirical evidence of these effects, nor is there any study which examines the mediating roles that political networks or existing political institutions might have on the impact of digital technologies. Further, there is also really no guarantee that the adoption of digital technologies will lead governments in a democratic direction. For example, Medina (2011) documents the attempts by Chilean President Salvador Allende to create an IBM-based computer system in the early 1970s which would facilitate a more efficient planned economy; while this "Project CyberSyn" was only partially successful, there is some evidence that it was instrumental in thwarting a 1972 labor strike by 40,000 truck drivers in Santiago. This form of centralized control may seem less likely in today's world of the Internet and open IP technologies; however, Lessig (2006) makes a compelling counter-argument in his discussion about the Internet and architectures of control. Ironically, the trend of *digital convergence* over the last decade may exacerbate the potential use of the Internet as a technology of control; as citizens of a country become more reliant on a single network for accessing textual information/news, video information, as well as for person-to-person voice and data communication, the potential for governments to exercise (anti-democratic) control through digital technologies grows.[3] Paradoxically, while digital access has grown dramatically over the world in the last decade, there has been a slight lowering, on average, of civil liberties during this period.

We have organized the rest of this paper has follows. Section 2 provides some background and our theoretical basis, making the idea of "democracy" more precise, describing three different mechanisms by which we believe "digital access" affects the emergence of democracy, and describing the different networks over which diffusion, if it exists, might occur. Section 3 provides a detailed description of our data. Section 4 presents our analysis and results based on two families of empirical models: dynamic panel models which uses the Arellano–Bond estimator, and structural models of the co-evolution of democracy, digital access and political networks implemented using the SIENA software package. Section 5 concludes and provides directions for future work.

2. Background literature and theoretical basis

Although the term "democracy" is generally associated with direct participation, political equality and popular sovereignty (O'Loughlin et al., 1998), it has a number of different conceptions. Some relate to measured *outcomes* which are determined in part by the form of government. Others relate to the specific form of government itself and how it is chosen. We focus on outcomes rather than the structure of government, although we control for measures of the latter. Our approach is motivated by prior arguments that defining democracy as "meaning 'a good government' renders it analytically useless" (Zakaria, 1997). Zakharia further suggests that defining democracy merely based on how a country chooses its government may be too narrow, citing the emergence of a number of "illiberal democracies," countries whose governments might be chosen using democratic procedures, but whose citizens lack basic liberties of speech, assembly and religion. A similar contrast is drawn by Diamond (2008) between "thick" and "thin" democracies.

In arguing against the use of definitions of democracy based on outcomes and in favor of definitions based on how the government is chosen and functions, O'Loughlin and his co-authors suggest that economic freedoms and political freedoms must be treated as distinct, and when confounding a definition of democracy with its desired outcomes, one risks losing analytical leverage. This issue notwithstanding, our objective in this paper is to study the effects of digital access on democracy itself, rather than the effect of democratic institutions on their intended outcomes. A middle ground might be to include measures which reflect both the form of government and its outcomes, such as *political rights* and *civil liberties*. We are particularly interested in changes in civil liberties that relate to freedom of expression, the right to associate freely, and personal autonomy, since intuitively, these are not merely central to economic development, but also most likely to be altered directly by changes in citizens' digital access. We also consider a third measure of democracy, namely *media freedom*, since it is possible that the path via which digital access leads to a change in civil liberties or political rights is through its impact on freedom of the media; indeed, there is a long-standing belief that a free press is an essential pre-cursor to a strong democracy (McChesney and Nichols, 2010).

There is a healthy history of discussion about the connection between digital access and democracy (Groshek, 2010; Howard, 2010; Stodden and Meier, 2009; Schmidt and Cohen, 2010). For example, Faris and Etling (2008) provide an excellent and detailed analysis of the different ways in which digital access might contribute both positively and negatively to democracy. A recurring theme in many examples of digital democratization is of the technology in question playing one or both of two roles: increasing *information flows and transparency*, and facilitating the *coordination of activities* between geographically dispersed citizens. We describe these in some detail in the following two subsections, after which we examine a third effect related to both of these – the external *visibility* induced

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[3] This does not have to take the form of a complete Burma or Egypt-style Internet shutdown. Rather, control of the kind practiced by the Chinese government, wherein only specific kinds of Web-based information are available to its citizens, can be equally detrimental to democracy. In a future where Internet-based news is the only available news, this form of control can be quite powerful, and since Web browsing creates the illusion of user control, even more so.

by technologies. We conclude our background discussion by motivating the different political networks we consider as the basis for diffusion of democracy across countries.

2.1. Information flows and transparency

The most striking recent example of information technology's effect on the information transparency of government can be found by examining the myriad documents that have been made available by Julian Assange's WikiLeaks, a site that is feasible owing to a network of servers on the (traditional) Internet. A related kind of transparency is facilitated by the network of mobile phone users on the Usha Hidi platform, which has been instrumental in documenting information about ethnic violence in Kenya and making this information more accessible. As the cost of information acquisition and distribution continues to fall over time (Dhar and Sundararajan, 2007), citizens are bound to be able to create and access increasingly novel information sources of this kind. These new repositories of information are made possible by the information aggregation properties of digital media, which enable collecting and disseminating information from diverse and geographically dispersed sources, subsequently allowing individuals to acquire deeper knowledge about their government, and thus providing another means to increased transparency and accountability. The qualities of "good governance" as defined by the UN are all related to this discussion (Speth, 1997). Increased transparency may lead to greater accountability of the government to the citizens, or may encourage good governance practices by amplifying the transparency of existing mechanisms, but unless it also influences the internal workings of the government bodies, long-run political changes are unlikely.

We highlight this effect of visibility and transparency because of its contrast in part with much of the current literature about the Internet's effect on coordination and political communication, which focuses on how IT shapes processes such as campaign communication and protests. Granted, these event-driven effects from digital access are fascinating. However, there is also possibly a more gradual change induced by incremental increases in access to information and communication technologies, one that reshapes the structure and policies of the government as well as the relationship between government and citizens over time.

These information aggregation, dissemination and transparency effects of digital access also further motivate the inclusion of measures of media freedom in our analysis. A free press is a strong pre-cursor to democracy precisely because the press traditionally sets the information agenda for the country's citizens. The media can inform citizens about government abuses as well as spur politicians into action via increased scrutiny on their behaviors. Digital technologies can complement this traditional role of the press: for example, the ability of bloggers to set a political agenda may also spur the media into tackling different and more controversial issues pertinent to the citizenry (McChesney and Nichols, 2010).

However, this discussion also highlights the double-edged sword of the impact of digital access on democracy, since, as was noted succinctly by Brin (1999), the beneficiaries of the Internet's increased ability to record, aggregate, and distribute information on individual activities may well depend on who is "behind the cameras". If government leaders aggregate information on their citizens to further their ends, this may led to a reduction in civil liberties and personal freedoms. For example, the government's proclivity toward intrusion and oppress may lead to a reluctance of its citizenry to discuss sensitive issues online as citizens believe they are being monitored (Hill and Hughes, 1999). Conversely, if the citizens aggregate information on their leaders to hold their leaders accountable, then civil liberties may increase (Faris and Etling, 2008; Nissenbaum, 2010). Thus, information aggregation may

benefit authoritarian governments just as much as it might benefit a democratic citizenry: governments may well be monitoring citizens while citizens believe they are monitoring the government.

2.2. Digital access, coordination and communication

Access to information and the ability to coordinate are familiar as the underlying transformative effects of information technologies on organizations and markets (Gurbaxani and Whang, 1991). The Internet facilitates low-cost, immediate, and interactive connections among geographical disparate citizens, which might initially suggest that over time, universal digital access could herald a return to an Athenian style of democracy, with direct participation by citizens and the elimination of the need for representative government. The political coordination effects and community visible during the events in Northern Africa in 2011, while impressive, were far removed from this idealistic notion. However, they may reflect the more realistic future path of impact for digital technologies on democracy. This has been particularly noticeable in the event-driven coordination of campaign processes and political protests. For example, Goldstein (2007) documents the use of mobile 'phones and web-based discussion boards in fostering the Orange Revolution of 2004 in Ukraine; Faris and Etling (2008) and Wang and Nagaraja (2007) discuss the how the Burmese government shut down the Internet in their country for two weeks toward quashing the 2007 "Saffron Revolution". In trying to mirror this strategy partially, the Egyptian government made numerous attempts to shut down protestor communications technology in 2011, blocking Twitter and mobile usage on January 25th, blocking Facebook, shutting down Blackberry and cutting network access at Tahrir Square on January 26th, and eventually shutting down all Internet services on January 27th. This reflects the emergence of a new "digital public square" – lower communication costs enable the Internet to supplement or substitute "built space" public square gatherings in which individuals realize their collective beliefs and opinions (Chwe, 2003; Zhuo et al., 2011).

Put differently, social media may increase the confidence of citizens that others share their opinion, motivating collective action by countering pluralistic ignorance while enhancing a sense of community. Moreover, the revolutions affected by this coordination capability of digital access need not be aimed at radical political change; a similar role has been conjectured for decentralized digital technology in changing the course of elections in South Korea in 2002 and the United States in 2008. Furthermore, as argued by Zhuo et al. (2011), it seems important to look beyond the explicit effects that social media may or may not have on events like the resignation of Mubarak; implicit effects like fostering "networked individualism" may actually have a greater effect on longer-run and more permanent democratic change.

Digital access may also shape political processes by altering the ease and model of communication between a country's citizens. For instance, telephone communication, whether mobile or fixed, provides one-to-one communication that facilitates deepening of existing relationships. Early research on this point indicates, for instance, that a nation's position in the international communications network can be predictive of its level of democracy (Sun and Barnett, 1994). More importantly, the Internet also facilitates many-to-many dialog, a shift from the one-to-many paradigm of broadcast media (Weare, 2002). For a vast majority of the industrializing world, the mobile Internet will be the only Internet, and mobile 'phone adoption' is a precursor to broader digital access.

However, capturing these effects empirically can be challenging. The effect of communication technologies on the political processes may be quite heterogeneous because the technologies' designs may

embed certain values and politics into their use (Nissenbaum, 1998; Winner, 1988). Further, communication technologies are known to exhibit network effects, so the marginal effect of Internet-based and mobile telephones on political processes may not be constant; after a certain level of adoption by the citizenry, the interactive media increases its attractiveness and the effect of the internet may be amplified (Markus, 1987). The latter point partially motivates our use of both continuous measures of access and a binary threshold model.

2.3. Digital technologies and "external" visibility

Coordinating superior political organization and increasing easily accessible information both clearly have the potential to reshape the relationship between a government and its citizens. However, what may be a key (and perhaps overlooked) aspect of importance is that both social media and information technologies provide externally visible platforms for citizens to air their grievances, advance their agenda, coordinate political activities and garner support. For example, communication technologies may increase scrutiny of the pre-existing practice of public disclosure from government officials (Faris and Etling, 2008). More importantly, the information distributed online about government oppression may amplify the effects of existing channels for international pressure toward freedom; foreign media coverage and international sanctions being two common sources of such pressure. In nations with human rights violations, the ability to disseminate pictures and real-time stories has a powerful ability to constrain official misconduct and empower individual citizens. Thus, the lowered cost of information distribution may also influence the political process as international awareness of government oppression and violations may spur the international community into action. As government awareness of their citizens' ability to document abuses and quickly protest increases, there could be a chilling effect on oppressive behavior. It is in this context that the role of *mobile technologies* may be of particular importance. Their portability collocates them with the exact geographic areas where events of consequence occur; their ability to capture and disseminate audio, pictures and video makes the external visibility of these events far greater and more compelling.

It is possible, however, that political organizations with investment in the status quo may utilize the same technologies to maintain the existing political structures. Therefore, the usage of "digital access" must be considered both from the perspective of average citizens as well as from powerful political and corporate interests (Rethemeyer, 2007). For example, as digital access becomes more widespread, a government that controls access to these technologies can leverage this control to dampen the ability to coordinate protests (Faris and Etling, 2008). Governments can also shut down, monitor, or aggregate information technologies like the Internet, leading to censorship and constriction of outbound information flows, perhaps in a manner that exceeds their ability to control similar outflows due to the presence of an externally funded international press. A recent example has been the March 2012 government shut down of the commenting services for microblogs run by the Sina Corporation and Tencent Holdings (which each have 300 million registered accounts in China), following rumors of a coup and photographs of military vehicles entering Beijing being posted in a manner visible to foreign media. Such censorship may temper the effectiveness of the international community as foreign political leaders may not have the knowledge, political will, or internal backing to tackle the government's misconduct. It is also quite likely that some countries are also more susceptible to international pressure than others, a point we explicitly return to in our empirical analysis.

2.4. Networks that mediate the diffusion of information, ideas and influence

This varied susceptibility of countries to international pressure highlights a more general point: modeling inter-nation political networks that capture the relationships between countries is central in understanding how the communication technologies of the Internet and mobile phones will alter democracy. Interactions between countries clearly shape their political, social, and economic agenda, and the importance of these relationships is highlighted well in the following definition of globalization: "the spatial organization of social relations and transactions – assessed in terms of their extensity, intensity, velocity, and impact-generating transcontinental or interregional flows and networks of activity, interaction, and the exercise of power" (Montai, 2004).

There are diverse ways in which different countries are linked to one another. It is conceivable that any one of these networks of links could serve as a long-run conduit for the forces of democracy. Our opening example clearly motivates the role a geographic network might play as a channel of this kind. A similar basis for diffusion was used by O'Loughlin et al. (1998) who find evidence of both temporal and spatial clustering of democracy during the period 1946–1994. Close physical proximity may indicate similar cultures and strong ties of among the nations' political leaders and citizens. Countries with strong relationships and similar cultures are more susceptible to political pressures from each other, so we expect that civil liberties will diffuse spatially. This is consistent with Barnett (2001), who describes the importance of geography, language, and culture in determining network positioning and the strength of the network.

Additionally, the diffusion of democracy across countries, if it occurs, will also be driven by the spread of ideas and information through different human and technological communication channels, and it is thus likely that non-geographic networks that facilitate this spread will play an equally important role. We use a couple of proxies for this kind of "idea" network. One is based on bilateral migration flows between countries. While clearly not mirroring the flow of information or ideology, migration among countries may reflect international communication and connections of inhabitants to their native country, and seem to be a natural conduit via which influence might spread. As friends and family move to different areas of the country, they remain in touch, share information, and demand increased intervention by their new country on behalf on their country of origin. There are numerous examples, both in the United States and beyond, of politicians in countries or states being more responsible and engaged in the politics of immigrants' homeland if these immigrants comprise a sizable voting bloc.

Another conduit for the diffusion of ideas is created by international trade. More generally, the economic relationship among countries seems like a natural mediator of influence on one another, and the bilateral trade network reflects the strength of the economic ties among countries. Previous research has indicated that trade relationships also correspond to international communication volume (Blumenstock, 2011), or that a trade network may effectively capture information exchange among countries. We therefore use two versions of this network, described in greater detail in what follows.

A final network we consider is that created by foreign direct investment (FDI), which potentially encapsulates information about the nature of influence across countries. This network, illustrated in Fig. 1, is especially important in capturing a country's susceptibility to the international pressure (Jensen, 2003). This susceptibility to external pressure seems like a possible mediator of a country's response to "international visibility" via
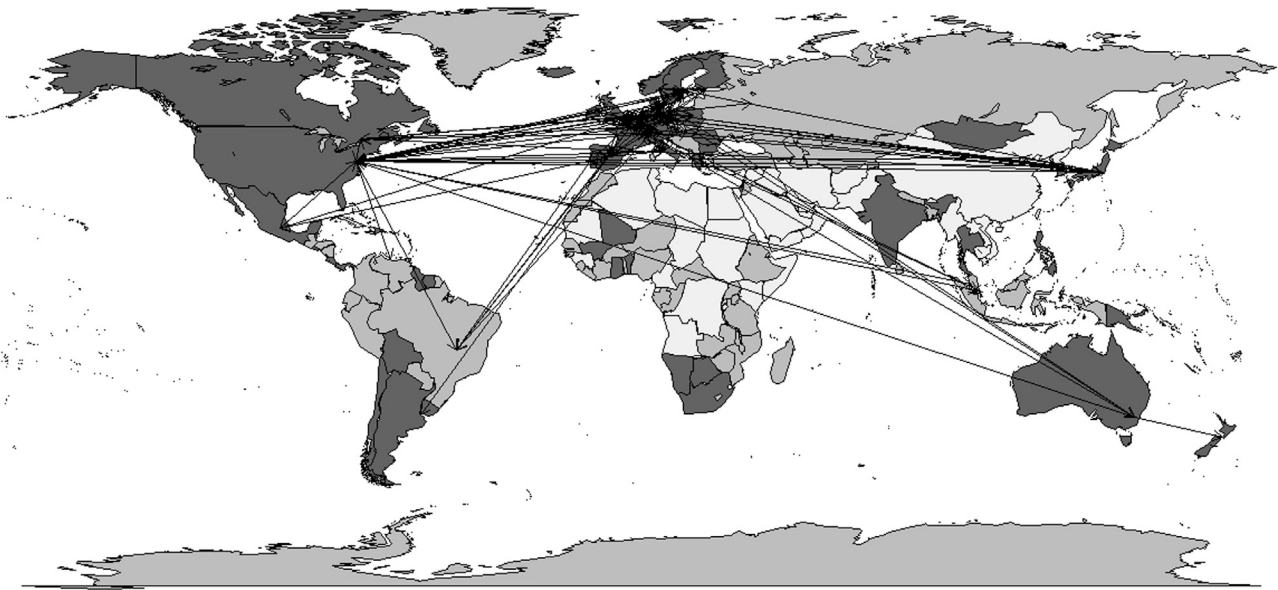
Fig. 1. Illustrates the variation in measured freedom levels and foreign-direct investments across different countries. The countries shaded light gray are those classified by Freedom House to be "not free", those shaded medium gray as "partially free", and those shaded dark gray as "free". The lines between countries reflect foreign direct investment flows; for illustrative clarity, only those investment levels that are a significant fraction of the recipient country's GDP are shown.

digital technologies, because it makes certain countries more receptive of the kind of international influence that could alter civil liberties following the true state of democracy within a country being made apparent through the use of digital technologies.

3. Data

Our analysis uses a panel comprising data about annual measures of democracy, digital access, trade flows, political institutions, and economic development which we construct for 189 countries between 2000 and 2010. The countries we exclude did not report trade data or digital access data for at least one year during the analysis period.

3.1. Democracy

Our three primary measures of democracy are political rights (PoliticalRights), civil liberties (CivilLiberties) and media freedom (MediaFreedom), all of which are obtained from Freedom House (http://www.freedomhouse.org), an independent watchdog organization that specializes in the analysis of the components of freedom. The measures of civil liberties and political rights are obtained from their annual "Freedom in the World" reports from 2000 to 2010. Freedom House rates countries based on a 25-question survey, of which 10 are about political rights and 15 are about civil liberties. The questions contributing to their measures of political rights are designed to assess the electoral process, political pluralism and participation, and the functioning of government. The civil liberties questions assess freedom of expression, rule of law, right to associate freely, and personal autonomy. The survey yields a score between 0 and 40 for political rights and a score between 0 and 60 for civil liberties, which are then converted to normalized scores on a 7-point scale, with countries with the highest civil liberties or political rights receiving a 7 as their respective rating.[4] A summary of the evolution of average assessed civil

liberties is provided in Fig. 2. In addition to political rights scores, Freedom House also publishes an annual list of electoral democracies.

Our measure of media freedom is obtained from Freedom House's annual Freedom of the Press Index which gauges the autonomy of the press across the world. The composite index is created by surveying overseas correspondents and staff members regarding the legal, political, and economic environment and its influence on media content.

3.2. Digital access

Our primary measures of digital access – mobile phone, Internet, and broadband Internet subscribers – were gathered from the World Telecommunications and ICT Indicators database of the International Telecommunication Union, a United Nations agency (http://www.itu.int). The variables we use are:

- *MobileDensity*: The number of subscribers to portable mobile telephone service divided by the de facto population (defined below), expressed as a percentage between 0 and 100. Since subscribers may not be isolated precisely in the ITU data, this number is somewhere between the number of active mobile phone connections and the number of people who own one or more mobile phones.
- *InternetDensity*: The number of Internet subscribers with fixed access to the Internet divided by the de facto population, expressed as a percentage between 0 and 100. This measure includes dial-up, broadband, cable modem, DSL, and any other service provider. Mobile data subscriptions are not included in this measure.
- *BroadbandDensity*: The number of broadband Internet subscriptions divided by the de facto population, expressed as a percentage between 0 and 100.
- *PhoneDensity*: The number of subscriptions to wireline telephone service divided by the de facto population, expressed as a percentage between 0 and 100. Mobile and satellite telephone connections are not included in this measure.
- *HouseholdInternet*: The percentage of households with access to Internet subscriptions in their home.

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[4] Further details and a complete list of these questions for 2010 is available at http://www.freedomhouse.org/template.cfm?page=351&ana_page=362&year=2010.

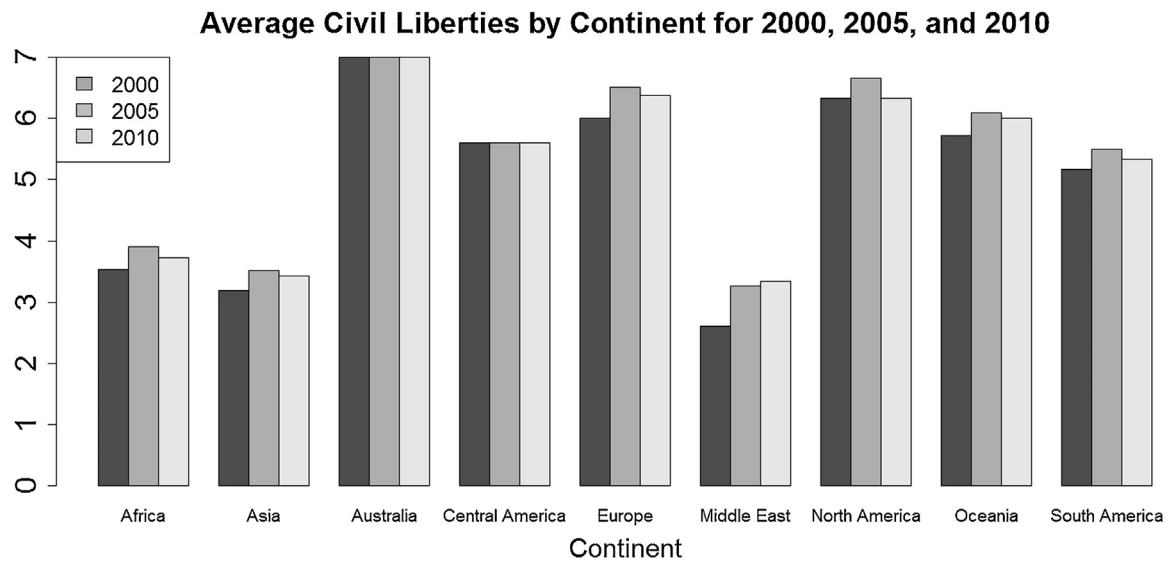## Average Civil Liberties by Continent for 2000, 2005, and 2010

Fig. 2. The evolution of civil liberties 2000–2010.

These communication channels differ in their value for gathering and distributing information. Mobility, and in particular, the digital cameras common to mobile phones, facilitates the gathering of distributed information and potentially making this gathered information externally visible; this promotes transparency to the country's internal condition and invites attention from the international community in response to, for example, human rights violations. In contrast, Internet access and broadcast communication capabilities enable information dissemination within the country (Fig. 3).

3.3. International influence

Countries are heterogeneous in both their susceptibility to outside influence and in their ability to exert influence. In some of our preliminary analyses, we used the inflow of foreign direct investment as a percent of GDP as a proxy for the predisposition of the country's leaders toward international influence. Economic dependency is an important driver of susceptibility to pressure from other countries: more than trade which creates a bilateral dependence, as a country is more dependent on foreign direct investments, it becomes more amenable to such influence.

3.4. Country population, development and economic controls

We use the following controls for the role that demographic, economic and developmental factors may play in mediating the impacts of ICTs:

- *Travel and tourism controls*: International tourism number of departures and arrivals, Air transport passengers carried, Rail lines total route(km), Motor vehicles per 1000 people, Passenger cars per 1000 people.
- *Crime controls*: Intentional homicides government police sources per 100,000 people, battle-related deaths number of people.
- *Economic controls*: GDP per capita constant 2000 US, GINI index, Net foreign assets (current LCU), Foreign Direct Investment (FDI) inflows as a percentage of GDP, Foreign Direct Investment outflows as a percentage of GDP.

- *Population characteristics*: Urban population as a percentage of total population, Population ages 15–64 as percentage of total population, Annual population growth annual, Life expectancy at birth.
- Miscellaneous controls: Daily newspapers per 1000 people, Secure Internet servers per 1 million people.

These controls are obtained from the World Bank Database and the Database of Political Institutions (Beck et al., 2001).

3.5. Network variables

We construct the following networks to analyze inter-country relationships using the lenses of shared geographic proximity, bilateral migration, and economic associations.

- *Geographic network*: A graph in which each country is represented by a node, and the weighted edges are inverse distance among country capitals. We assembled and cross-checked inter-country political borders from a variety of sources, including the CIA World Factbook.
- *Migration network*: A graph in which each country is represented by a node, and two nodes A and B are connected by a directed edge from A to B if Country A is an origin for migrants to their destination of Country B. The edges are weighted by the number of migrants between countries, where the number of migrants from one country to another is obtained from the World Bank's Global Migration Database (Parsons et al., 2013). We used data from the year 2000 since it was the most complete data set available to us.
- *Trade network (1)*: A dynamic graph in which each country is represented by a node and two nodes A and B are connected if they have experienced any import or export relationship during that year. The edges are weighted by the total volume of trade between the nodes. This is a dynamic network which we constructed separately for each of the 11 years 2000 through 2010. Export and import dollar volumes are obtained using the commodities export flows data from the United Nations Comtrade database (http://www.comtrade.un.org).
- *Trade network (2)*: A dynamic graph in which each country is represented by a node, and two nodes A and B are connected by a directed edge from A to B if Country A was one of the

a Average Internet Access by Continent for 2000, 2005, and 2010

b Average Mobile Phone Access by Continent for 2000, 2005, and 2010

c Average Broadband Access by Continent for 2000, 2005, and 2010
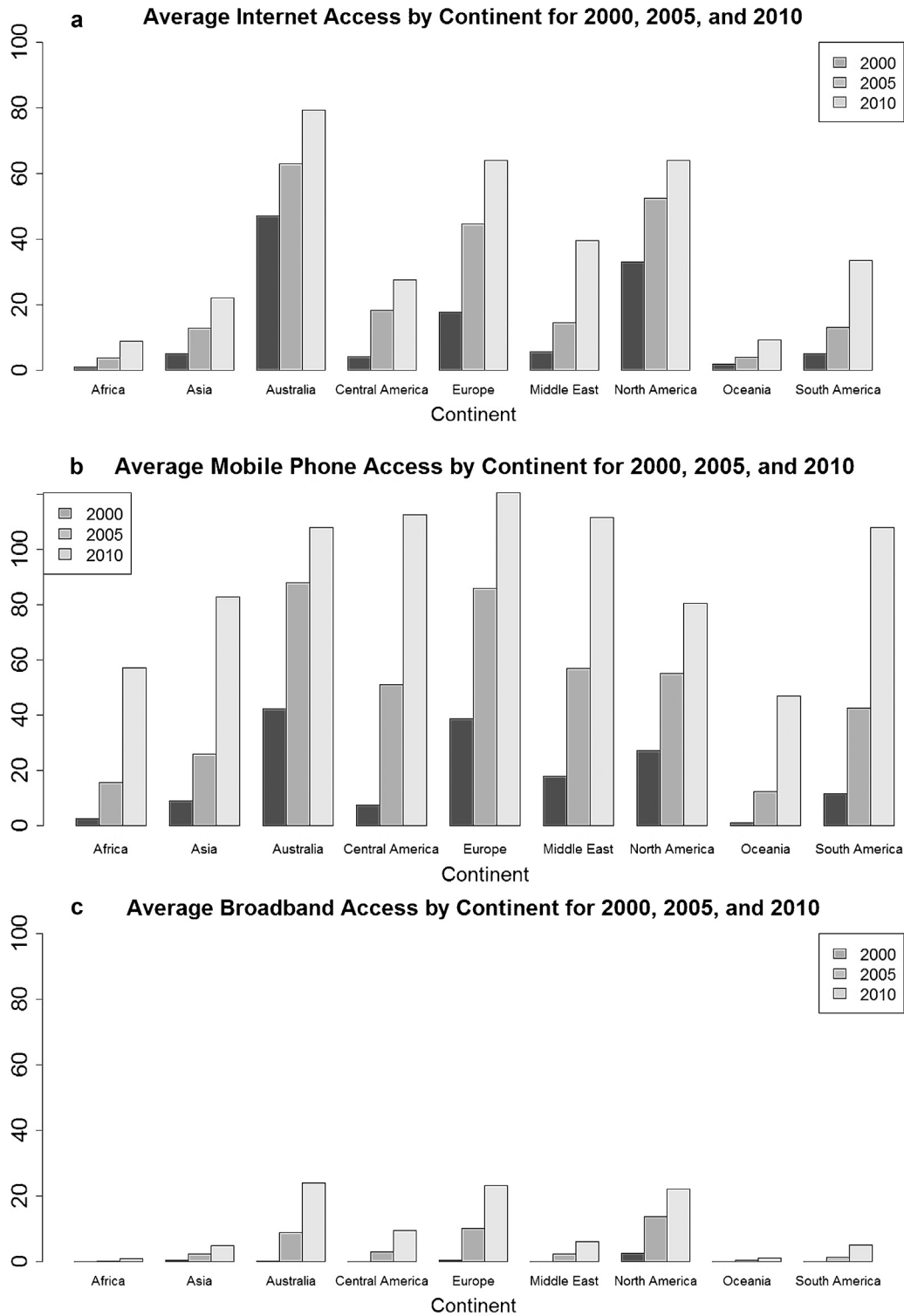
Fig. 3. Three measures of digital access, 2000–2010.

top exporters to Country B. Since different countries have different import volumes, we define country A as a top exporter to country B if A's level of export flows are at least 5% of the level of export flows of the country that exports the most to country B. We chose to use this cutoff-based approach for computational convenience, and also based on the conjecture that major trade relationships are captured in a succinct way by this binary network, a conjecture borne out in part by the fact that on average, nodes in the trade network have a high GINI coefficient. We experimented with different cutoffs other than 5%, and the 5% number seemed to maximize the information content of the trade relationships. This is a dynamic network which we constructed separately for each of the 11 years 2000 through 2010.

- *Foreign direct investment (FDI) network*: A dynamic graph in which each country is represented by a node and countries A and B are connected if foreign investors from country A have invested in country B according to the International Monetary Fund definition. The edges are weighted by the absolute value of the investment to capture the magnitude of the investors' commitments.

For each network, we construct ten different network variables, for each country:

○ NeighborCivilLiberties
○ NeighborPoliticalRights
○ NeighborMediaFreedom
○ NeighborFixedPhone
○ NeighborMobileDensity
○ NeighborInternetDensity
○ NeighborBroadbandDensity
○ NeighborSMS
○ NeighborGDP
○ NeighborElectoralDemocracy

For example, for the geographic network, NeighborCivilLiberties for country A is the weighted average of the civil liberties of the other countries, weighted by the inverse of the distance between country capitals in the completely connected network. The NeighborCivilLiberties variables for the other three networks are defined analogously. Because each of the networks is weighted, the network variables are all calculated using a weighted average to underscore the preferential treatment placed on some countries. In addition, the annual eigenvector centrality and GINI coefficients for the trade network is included in the empirical analysis although the results are not reported (Table 1).

4. Results

We present our results in two groups. Our results account for temporal aspects of both direct impacts and inter-nation diffusion by using two alternative approaches: estimating a dynamic panel model using the Arellano–Bond estimator in which lagged values are included in the model as an independent variables; and estimating a structural model of the co-evolution of democracy, digital access and the connections that facilitate their diffusion, implemented using the SIENA software package. In the first set of results, we will discuss the Arellano–Bond estimator, and the second set will cover the estimation of the dynamic actor-oriented model.

Before we describe the details of our dynamic models, we first report briefly on the highlights of some fairly extensive static panel data analysis that we had undertaken prior to the analysis we report on in Sections 4.1 and 4.2. Since this static analysis is, in a sense, superseded by the more complete dynamic estimation, we suppress most of their details (which are available from the authors on request). Briefly, we used CivilLiberties as our dependent variable and a wide variety of the independent variables summarized in Section 3. We controlled for unobserved heterogeneity using both fixed and random effects (Agresti et al., 2000; Wooldridge, 2002; Pinheiro et al., 2011). Each of our mixed model specifications specified a random intercept, and random effects that are grouped hierarchically by continent and then by country. Each of our fixed effects specifications grouped the data by country.

Our main findings were:

- There was consistent evidence across all our models that civil liberties are positively correlated with digital access, a finding

which admits the possibility of the causal effect we investigate more thoroughly in what follows.

- Different forms (and measures) of digital access have different magnitudes, and more importantly, different directions of impact on civil liberties. For example, when mediated by the strength of a country's political institutions, mobile access has a positive correlation while broadband and fixed-line Internet access have a negative correlation. We find this compelling, because it suggests an interplay, in changing the level of democracy in a country, between a form of digital access that is portable (MobileDensity) and the strength of a country's political institutions. On a related note, there are differing levels of correlation that the density of Internet penetration and the fraction of households with Internet have on civil liberties, suggesting that the access convenience afforded by digital technologies is another factor of potential importance.
- We find fairly consistent evidence of positive correlations between a country's civil liberties and those of its neighbors, the magnitude of which is highest for the trade network. One explanation for this is a country's greater propensity on average to trade with "like" countries (in contrast with those that are merely geographically proximal). In contrast, lower correlations on the migration network might suggest that, relative to the trade network, diffusions of civil liberties on account of migratory flows may be countered by the fact that people tend to choose to migrate to countries with a level of civil liberties that is different (and generally higher) than their own.

These correlations, while interesting, also further motivate both our use of multiple political networks, as well as our use of methods that account for explanations like selection as alternatives to genuine diffusion as the drivers of assortative mixing in civil liberties across countries.

4.1. Dynamic panel models

We have chosen to use CivilLiberties as the dependent variable across our entire analysis, based on our belief that civil liberties are likely to be affected more rapidly by changes in digital access than political rights, which require more substantive structural changes in the way government is organized. We include media freedom as an independent variable since it is possible that the changes induced by digital access are mediated by changes in media freedom. We have estimated models that include PoliticalRights as a control variable and those which do not, and there are no directionally significant differences in any of the coefficient values. Retaining both ensures that we are not incorrectly ascribing a change in civil liberties to a change in digital access when in fact the former may have been caused by a change in one of these other related measures of political structure or freedom.

Our models are also designed with a recognition that civil liberties may not depend solely on the current state of the nation but on inertia from the existing social and political structures. Since incumbent interests may use technologies to preserve the status quo, the shift of political institutions toward increased civil liberties may lag behind technology adoption. Additionally, rather than being induced by changes in digital access, higher levels of civil liberties may cause individuals to seek greater digital access. It is also possible that countries simply form trade ties with higher export and import flows with others whose civil liberties are similar to theirs, for example, in response to their citizens not wanting to trade with countries with poor human rights records. Thus, changes in civil liberties may cause change in trade ties, rather than the ties inducing a diffusion of the changes in liberties.

Table 1
Summary statistics.

Variable	2000–2010		2000		2010	
	Average	SD	Average	SD	Average	SD
CivilLiberties	4.61	1.86	4.49	1.85	4.75	1.84
PoliticalRights	4.60	2.21	4.57	2.27	4.59	2.16
Media freedom, Legal	16.86	9.16	16.32	9.46	16.62	8.68
Media freedom, Political	22.33	10.97	23.17	10.98	22.01	9.50
Media freedom, Economic	17.78	7.25	19.05	7.10	16.67	6.68
InternetDensity	19.16	23.55	7.38	12.37	31.05	28.36
MobileDensity	34.25	41.64	14.81	21.87	89.27	43.90
BroadbandDensity	2.64	6.75	0.17	0.79	8.40	11.41
PhoneDensity	18.07	18.94	18.41	20.46	18.53	17.11
HouseholdInternet	9.75	19.66	3.94	11.04	24.13	28.98
HouseholdTV	18.13	34.57	10.41	25.79	9.76	28.61
FDIInflows	5.84	25.19	6.94	33.35	5.95	22.00
InternationalArrivals	3,402,836	8,898,881	3,402,083	9,046,309	896,442	4,804,088
Geographic network						
NeighborPoliticalRights	4.84	0.66	4.81	0.66	4.84	0.66
NeighborCivil Liberties	4.85	0.59	4.71	0.58	5.01	0.57
NeighborMediaFreedom	56.39	7.56	57.66	7.57	54.85	6.81
NeighborFixedLines	21.61	6.66	22.27	7.06	21.93	6.12
NeighborMobileDensity	38.59	33.73	16.47	6.07	100.30	15.36
NeighborBroadbandDensity	3.16	4.14	0.24	0.26	10.39	4.22
NeighborInternetDensity	22.49	11.63	8.66	3.43	36.21	10.45
NeighborGDP	7554.00	3,137.00	7,508.00	3,108.00	6,430.00	2,176.00
Migration network						
NeighborPoliticalRights	5.50	1.56	5.55	1.56	5.45	1.59
NeighborCivil Liberties	5.50	1.40	5.28	1.38	5.53	1.42
NeighborMediaFreedom	64.38	17.97	66.35	18.28	62.51	18.11
NeighborFixedLines	35.48	17.19	38.13	19.18	31.75	14.64
NeighborMobileDensity	64.73	32.71	30.70	16.65	99.63	25.96
NeighborBroadbandDensity	9.01	8.41	0.85	0.86	17.36	9.30
NeighborInternetDensity	37.91	22.11	21.19	13.10	53.17	22.62
NeighborSMS	8,680,000,000	19,300,000,000	1,090,000,000	1,420,000,000	21,760,000,000	31,230,000,000
NeighborGDP	17,009.00	9,840.00	16,242.00	9,350.00	15,956.00	9,970.00
Trade network variables						
Degree	139.00	42.02	131.50	40.61	153.57	35.87
NeighborPoliticalRights	5.73	0.81	5.90	0.74	5.44	0.79
NeighborCivil Liberties	5.67	0.71	5.49	0.66	5.51	0.70
NeighborMediaFreedom	66.66	9.96	69.64	8.99	61.52	9.52
NeighborFixedLines	39.56	8.64	42.98	8.65	33.76	6.77
NeighborMobileDensity	72.92	25.01	39.37	9.35	106.60	11.73
NeighborBroadbandDensity	9.93	7.02	0.84	0.47	19.03	4.61
NeighborInternetDensity	32.79	20.62	18.48	10.35	40.30	27.27
NeighborGDP	18,454.45	5,354.21	18,303.92	4,860.74	16,746.49	5,113.12
FDI network variables						
Degree	38.25	49.22	16.64	33.57	49.91	53.85
NeighborPoliticalRights	6.03	2.39	4.69	3.29	6.36	1.96
NeighborCivil Liberties	5.89	2.35	4.38	3.08	6.17	1.92
NeighborMediaFreedom	71.39	28.60	57.22	40.19	72.95	22.98
NeighborFixedLines	46.01	19.31	40.67	28.78	42.25	14.30
NeighborMobileDensity	80.27	38.03	41.25	29.26	107.30	35.26
NeighborBroadbandDensity	14.37	11.32	0.67	0.62	26.78	8.98
NeighborInternetDensity	53.00	26.04	23.38	17.29	71.19	23.18
NeighborGDP	24,532.04	11,805.94	16,524.81	11,960.29	25,454.36	10,663.07

To consider the temporal aspect of digital access on civil liberties, we estimate a dynamic panel model using the Arellano–Bond GMM estimator (Arellano and Bond, 1991) with the plm package (Croissant and Millo, 2008) in which the lagged value for civil liberties (and a range of other variables) is included in the model as an independent variable. This model accounts for endogeneity between civil liberties and the digital access variables, where as we have discussed earlier, the direction of causality may be both ways. This model specification also allows us to explicitly capture the reality that inertia impedes the influence of digital access on political institutions, thus evidence of the impact of digital access is not immediately visible in macro data. The specification considers the annual changes in CivilLiberties and the independent variables, thus controlling for the country-specific and time-specific characteristics being correlated with the explanatory variables.

The estimates from the dynamic panel models are presented in Table 2. We included a number of other variables and lags in the model, and have reported only on those which were significant in at least one of our model specifications. The first column does not include any network variables, and the other columns reflect the inclusion of the geographic, migration, trade, and FDI networks respectively. Lagged CivilLiberties was the single largest determinant of current CivilLiberties. The Sargan test for all these models shows that the model is not conclusively over-specified. Furthermore, although there is AR(1) correlation, as expected, the AR(2) correlation is not statistically significant, so our instruments are appropriate.

Table 2
Arellano–Bond dynamic panel estimation results.

Dependent variable = CivilLiberties Variable	(I) Estimate (SE)	(II) Estimate (SE)	(III) Estimate (SE)	(IV) Estimate (SE)	(V) Estimate (SE)
Civil liberties, Lagged 1	0.511 (0.112)***	0.564 (0.131)***	0.514 (0.110)***	0.500 (0.097)***	0.536 (0.058)***
Political rights	0.081 (0.044)·	0.054 (0.048)	0.072 (0.046)	0.067 (0.048)	0.085 (0.034)*
Political rights, Lagged 1	−0.077 (0.039)*	−0.096 (0.044)*	−0.084 (0.039)*	−0.085 (0.033)*	−0.102 (0.026)***
Internet threshold	0.033 (0.016)*	0.067 (0.080)	0.005 (0.024)	0.042 (0.073)	0.085 (0.054)
Internet threshold, Lagged 1	0.006 (0.017)	−0.196 (0.084)*	0.010 (0.024)	−0.088 (0.072)	−0.147 (0.053)**
Mobile threshold × mobile density	−0.022 (0.009)*	−0.020 (0.041)	−0.021 (0.015)	0.019 (0.035)	−0.024 (0.029)
Mobile threshold × mobile density, Lagged 1	0.022 (0.012)	−0.023 (0.043)	0.004 (0.013)	−0.061 (0.039)	−0.016 (0.029)
Media freedom	0.376 (0.059)***	0.367 (0.062)***	0.336 (0.070)***	0.283 (0.055)***	0.349 (0.039)***
Mobile density	0.033 (0.018)·	0.046 (0.028)	0.035 (0.021)·	0.035 (0.027)	0.030 (0.021)
Mobile density, Lagged 1	−0.019 (0.017)	−0.040 (0.031)	−0.029 (0.021)	−0.018 (0.027)	−0.016 (0.019)
Mobile threshold	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	−0.032 (0.031)	−0.006 (0.024)
Mobile threshold, Lagged 1	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.063 (0.032)·	0.027 (0.025)
Internet density	0.004 (0.010)	−0.025 (0.023)	−0.004 (0.015)	−0.005 (0.020)	−0.016 (0.014)
Internet density, Lagged 1	0.021 (0.016)	0.036 (0.025)	0.040 (0.025)	0.038 (0.019)*	0.044 (0.016)**
Broadband density	0.014 (0.008)·	0.019 (0.013)	0.069 (0.061)	0.016 (0.009)·	0.017 (0.010)·
Broadband density, Lagged 1	−0.005 (0.010)	−0.012 (0.013)	−0.046 (0.048)	0.011 (0.012)	−0.011 (0.010)
Daily newspaper per 1000 people	0.012 (0.005)*	0.013 (0.005)*	0.013 (0.006)*	0.019 (0.006)***	0.016 (0.005)***
Daily newspaper, Lagged 1	−0.004 (0.004)	−0.007 (0.005)	−0.006 (0.004)	−0.005 (0.005)	−0.004 (0.004)

Dependent variable = CivilLiberties Variable Network	(I) Estimate (SE) None	(II) Estimate (SE) Geographic	(III) Estimate (SE) Migration	(IV) Estimate (SE) Trade	(V) Estimate (SE) FDI
Neighbor civil liberties × internet density		0.017 (0.018)	0.004 (0.019)	0.011 (0.011)	−0.025 (0.014)·
Neighbor civil liberties × internet density, Lagged 1		−0.029 (0.024)	−0.037 (0.024)	−0.036 (0.015)*	−0.020 (0.015)
Neighbor civil liberties × mobile density		0.016 (0.016)	0.028 (0.013)*	−0.028 (0.014)*	0.031 (0.010)**
Neighbor civil liberties × mobile density, Lagged 1		0.030 (0.028)	0.002 (0.019)	0.043 (0.015)**	0.027 (0.012)*
Neighbor mobile density		−0.060 (0.061)	0.022 (0.073)	0.003 (0.040)	−0.004 (0.011)
Neighbor mobile density, Lagged 1		0.067 (0.070)	0.001 (0.073)	0.025 (0.038)	0.041 (0.012)***
Neighbor broadband density		0.107 (0.082)	0.061 (0.054)	−0.026 (0.051)	−0.020 (0.016)
Neighbor broadband density, Lagged 1		−0.089 (0.087)	−0.046 (0.054)	−0.056 (0.049)	−0.040 (0.020)*
Neighbor GDP		0.097 (0.049)*	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
Neighbor GDP, Lagged 1		−0.126 (0.056)*	−0.130 (0.061)*	0.000 (0.000)	0.000 (0.000)
Network degree		0.000 (0.000)	0.000 (0.000)	0.045 (0.021)*	0.023 (0.011)*
Network degree, Lagged 1		0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.035 (0.017)*
Neighbor internet density		0.097 (0.049)*	0.007 (0.026)	0.036 (0.032)	−0.006 (0.012)
Neighbor internet density, Lagged 1		−0.126 (0.056)*	0.004 (0.036)	−0.010 (0.034)	0.007 (0.012)

* Significance $p < 0.05$.
** Significance $p < 0.01$.
*** Significance $p < 0.001$.

Controlling for the lag in CivilLiberties alters the magnitude of the effects of other variables; nevertheless, these results supplement and advance our preliminary static panel findings. Not surprisingly, civil liberties are positively associated with both political rights and different forms of media freedom, and this relationship is strongly significant and positive for every model specification we have tried, which provides additional support for the importance of a free press in securing civil liberties. An interesting additional finding is the positive relationship between newspaper subscriptions and civil liberties. Newspapers are typically one of the most reliable information sources, so the newspaper volume indicates the availability of journalism.

Notice that a vast majority of the digital access variables, while having positive coefficients on average, are not significant.[5] To test the conjecture that digital access might mediate the diffusion of democracy rather than causing it in isolation, in addition to their direct effects, we also interacted each of the different measures of each form of digital access – Internet, Mobile and Broadband – both current and lagged, with our aggregate measures of the level of civil liberties in the appropriately defined neighboring countries,

Neighbor Civil Liberties. (For brevity, as mentioned earlier, we only report on those variables which are significant in at least one of our model specifications, even though all of the interaction variables were present in each of our estimations.)

We find that when interacted with mobile access, as measured by mobile density, NeighborCivilLiberties has a frequently positive and significant impact on civil liberties. To us, this is suggestive of a more immediate impact that mobile access has on inducing change than traditional Internet access. Mobile technologies inherently have a broader range of activities that they can be integrated into, and are more powerful for coordination and information acquisition owing to their portability; thus, it is not surprising that we find their impact to be consistently more visible than that of fixed-line Internet.

Furthermore, when viewed in light of the different mechanisms we discussed as linking digital access to changes in democracy in Section 2, the results from model (V) which use the FDI network are especially telling. The positive and significant coefficients on both Neighbor Civil Liberties × Mobile Density and Neighbor Civil Liberties × Mobile Density, Lagged 1 support our theory that the *visibility* created by mobile technologies on account of their ability to aggregate and disseminate distributed and previously inaccessible information only has a positive effect on democracy if the increase in mobile access occurs in countries which are then susceptible to pressure from influential FDI partners whose citizens enjoy greater levels of civil liberties themselves. It seems logical that this

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[5] Additionally, the variable measuring wireline telephone access is not statistically significant in any of our models, suggesting that the underlying effect from fixed wireline access may be the increased affluence or economic establishment of countries with extensive wired telephone access.

combination – mobile access coupled with the "right" political network neighbors – is what might actually lead to the diffusion of civil liberties, rather than the existence of the freer neighbors or the mobile access in isolation.

While not visible in the reported results, the interaction between broadband access and Neighbor Civil Liberties was also consistently positive and significant at the 10% level. Broadband offers a greater range of content (audio, video and images) than traditional fixed-line Internet and over time, is likely to lend a greater level of information transparency to a country. It seems increasingly clear that many of the attributes of ICT like videos and pictures require a faster connection than dial-up, so the speed and convenience of ICT may enhance their influence on political structures and government leaders. In addition, convenient access to the Internet may be particularly important for fomenting the perception of freedoms.

There are notable differences between the economic and non-economic international relationships. The lagged GDP of neighboring countries was significantly correlated with Civil Liberties in both the geographic and migration networks, suggesting that proximity to less productive countries is detrimental to a country's civil liberties. This result could indicate that the economic relationships between countries, correlated with country's GDP, is an additional important determinant of democracy. Most saliently, however, the mediating effects of digital access on the diffusion of civil liberties is visible in our data only for the economic networks – (IV) and (V), the trade and FDI networks – and we uncover no evidence of a similar effect for the geographic and migration networks.

To summarize, our analysis points to a theme of democracy possibly diffusing, but more saliently via economic rather than non-economic networks, and only if mediated by appropriate levels of digital access. The evidence we have of this relationship between digital access, networks and the diffusion democracy – that there are spillovers in democracy across connected countries that are amplified by digital access – may have alternative explanations, which we explore to some extent in our next section.

4.2. Dynamic stochastic "actor"-oriented model

It is well know that when considering changes in behaviors across networked individuals, one might also consider the possibility of the co-evolution of these individuals and their networks: changes in the network may cause changes in behaviors, which in turn may induce further changes in individual behavior (Lazer, 2001). A similar dynamic is possible with countries and their levels of democracy: information flows via political networks may induce changes in political rights or civil liberties, and these changes may in turn cause a reconfiguration of the network of trading partners. It could also be that nodes with similar levels of democracy choose to form ties with each other. Put differently, the trade network of countries may display assortative mixing in democracy levels due to "homophily", selection or actual influence-based diffusion.

There are a number of possible approaches that can partially identify and distinguish between these different effects from our longitudinal data sets of networks and behaviors. To supplement our dynamic models of Section 4.1, we investigate our data further using the stochastic actor-oriented approach of Snijders (2005) and Steglich et al. (2006). While we considered using the matched sample framework of Aral et al. (2009), it is better suited for larger networks where node homophily rather than new tie formation is the alternative explanation for influence-based diffusion. In contrast, the SIENA framework lends itself more naturally to our setting of continuous co-evolution of network ties and node "behaviors" in a relatively small network. Our focus in this section is on a single network, the (binary) trade network described in Section 3.

The model underlying SIENA decomposes the evolution of the system into two related processes that unfold in parallel over time: the evolution of the trade network and the evolution of associated "behaviors" and "covariates": digital access, democracy and the political/economic development controls. It is assumed that countries are "actors" (the use of the term 'actor' is thus metaphorical), the "behaviors" (which are our variables of interest) and the network may change at any instant in continuous time, although we, the researchers, only observe the state of the network at discrete time intervals; the remaining "covariates" change only at those time instants that the network is observed. There is a rate associated with each behavior and with the network in each time period (between each observation), which captures the overall propensity of changes in the network/behavior during that period.

For computational reasons, we estimate this model using data from three (rather than all eleven) time periods: 2000, 2004 and 2008, and we restrict our attention to the evolution of three behaviors: political rights, civil liberties and media freedom. In the model whose estimation we report on, we use the following covariates: mobile threshold, internet threshold, GDP (included as the most important control variable) and phone density. The threshold variables are specifically included because of a conjecture that the relationship between InternetDensity and MobileDensity may be non-linear.

The restricted trade network is used in order to perform the analysis. The high GINI coefficient for country-level trade volume supports our decision to truncate the trading relationships into binary indicators. We choose to truncate the trade relationships to ties worth at least 5% of yearly trading volume. This threshold captures the important and influential trade relationships.

During the period 2000–2004 (or alternatively, 2004–2008), each node A of the trade network is modeled as evolving a function of three network characteristics:

- *OutDegree*, the number of existing countries to which country A is a top exporter, which reflects an expectation that forming new trade ties is inherently costly and there is a limit on the number of countries to which one can export sufficiently high volumes to be a top exporter.
- *Reciprocity*, whether each potential neighbor is a top exporter to country A, which reflects an expectation that on average, high volume trade ties tend to be reciprocal.
- *Transitive triplets*, which admits the possibility that if A is a top exporter to B and B is a top exporter to C, this could affect the propensity of A to be a top exporter to C.

In addition, the network is modeled as evolving as a function of each of the three behaviors (the measures of democracy), two measures of digital access, and GDP. The three kinds of effects that these node characteristics are specified as possibly having on trade tie formation are *ego* – the level of democracy or digital access can affect the propensity of a country to form top exporter ties, *alter* – the level of democracy or digital access can affect the propensity of a country to be the recipient of exports, and *similarity* – a country may have a higher propensity to form export ties with other countries which have a similar level of democracy or comparable levels of digital access. Correspondingly, the levels of democracy of a country are modeled as evolving as follows: based on a basic *linear* effect which captures the overall preference for each measure of democracy, a *quadratic* effect which captures the possibility that the current level of democracy may affect the future level of democracy, effects from other measures of democracy which captures the possibility that these democratic characteristics may affect each other, and effects from the levels of digital access – for example, a higher level of mobile access may cause an increase in the level of civil liberties.

Table 3
The co-evolution of digital access, trading ties and democracy.

Variable	Estimate	Standard error	T-Ratio
Network formation			
Rate period 1	6.6637	0.3271	20.37
Rate period 2	8.4256	0.3926	21.46
OutDegree	**−2.7125**	**0.0559**	**−48.52***[***]
Reciprocity	**0.7249**	**0.089**	**8.14**[***]
Transitive triplets	**0.1622**	**0.0061**	**26.59**[***]
Political rights alter	0.0939	0.0703	1.34
Political rights ego	−0.0413	0.0619	−0.67
Political rights similarity	0.0898	0.3571	0.25
Civil liberties alter	−0.0884	0.0975	−0.91
Civil liberties ego	0.162	0.0983	1.65
Civil liberties similarity	−0.4125	0.4934	−0.84
Media freedom alter	**−0.0122**	**0.0043**	**−2.84**[**]
Media freedom ego	−0.0036	0.0046	−0.78
Media freedom similarity	**0.9026**	**0.3605**	**2.50**[**]
Internet threshold alter	0.0374	0.1458	0.26
Internet threshold ego	0.1628	0.1638	0.99
Internet threshold similarity	0.1692	0.1341	1.26
GDP alter	0	31.607	0.00
GDP ego	0	31.607	0.00
GDP similarity	0.5359	0.3183	1.68
Mobile threshold alter	**−0.3657**	**0.136**	**−2.69**[**]
Mobile threshold ego	**−0.5578**	**0.1299**	**−4.29**[***]
Mobile threshold similarity	−0.1699	0.0988	−1.72
Political rights			
Rate period 1	1.2054	0.2983	4.04
Rate period 2	0.6652	0.2355	2.82
Linear	0.3472	0.243	1.43
Quadratic	−0.5688	0.328	−1.73
Effect from civil liberties	1.699	0.9803	1.73
Effect from internet threshold	−4.8645	5.6043	−0.87
Effect from mobile threshold	−0.1036	2.7581	−0.04
Effect from phone density	0.0197	0.0209	0.94
Civil liberties			
Rate period 1	1.2021	0.2353	5.11
Rate period 2	0.6294	0.1701	3.70
Linear	**1.4247**	**0.4069**	**3.50**[***]
Quadratic	**−1.3226**	**0.408**	**−3.24**[***]
Effect from political rights	**1.0516**	**0.5345**	**1.97**[*]
Effect from media freedom	**0.0769**	**0.0329**	**2.34**[**]
Effect from internet threshold	**−8.1274**	**3.0202**	**−2.69**[**]
Effect from mobile threshold	**8.3045**	**3.9009**	**2.13**[*]
Effect from phone density	0.0521	0.0276	1.89
Media freedom			
Rate period 1	96.389	11.7697	8.19
Rate period 2	20.3411	2.968	6.85
Linear	**−0.0669**	**0.0194**	**−3.45**[***]
Quadratic	**−0.0033**	**0.001**	**−3.30**[***]
Effect from civil liberties	**0.1066**	**0.0316**	**3.37**[***]
Effect from internet threshold	**−0.9476**	**0.3559**	**−2.66**[**]
Effect from mobile threshold	−0.0897	0.102	−0.88
Effect from phone density	0	0.0008	0.00

[*] Significance $p < 0.05$.
[**] Significance $p < 0.01$.
[***] Significance $p < 0.001$.

The results of this analysis are summarized in Table 3. (Further discussion of the underlying model is available in Steglich et al., 2010, section 3.) As anticipated, countries with a large number of top-export relationships have a lower propensity to form ties, as evidenced by the negative coefficient on OutDegree. Countries have a higher propensity to form export ties with those they import a lot from, suggested by the positive reciprocity coefficient. Lastly, trade ties tend to be clustered. Interestingly, neither of the alter or ego coefficients are significant, so we uncover very little evidence of selection based on civil liberties or political rights or tie formation based on similarity on level of civil liberties or political rights. Further, as illustrated by the coefficients in Table 3, there was a positive increasing tendency for civil liberties, shown in the positive linear coefficient, which diminished with an increase in the base level,

shown by the negative quadratic coefficient. There was also a negative tendency for media freedom, reflecting global decrease in this measure over the last decade.

The most interesting findings were those that strengthened and altered our documented relationship between digital access and civil liberties. Specifically, mobile access has a strong positive effect on civil liberties in the 2000–2010 time period, even after accounting for all the other selection and reverse causation effects we have controlled for. This is consistent with a conjecture that mobile access improves a citizenry's ability to exchange information and coordinate activities in a manner that results in greater levels of liberty. In a sense, mobile technology plays a greater role in facilitating coordination of the kind described by Michael Chwe (2003), which, rather than transmitting new information about a government and its functioning, or creating greater parliamentary/ideological transparency, simply facilitates the "common knowledge" that is necessary to counter pluralistic ignorance and lead to collective action.

The key additional findings of this SIENA analysis are summarized below:

- Countries with a large number of top-export relationships have a lower propensity to form trade ties with other countries, while countries have a higher propensity to form export ties with those they import a lot from. Furthermore, trade ties tend to be clustered.
- We uncover very little evidence of selection based on civil liberties or political rights, or of tie formation based on similarity on level of civil liberties or political rights.
- There is a positive increasing tendency for civil liberties which diminished with an increase in the base level, and a negative tendency for media freedom, reflecting global decrease in this measure over the last decade.
- Mobile access has a strong positive effect on civil liberties even after accounting for all the other selection and reverse causation effects we have controlled for.

The final finding reinforces the theme of our empirical analysis; that mobile technologies seem to have a unique and persistent impact the emergence and increase in civil liberties, a finding we discuss further in our concluding section.

5. Concluding remarks

We have examined the effects of digital access on the prevalence of democracy and its diffusion via trade, geographical, migration and FDI networks across 189 countries between 2000 and 2010. Our analysis is based on a publicly available data and uses state-of-the-art dynamic econometric and network analysis methods. To our knowledge, our work represents the first attempt to simultaneously examine changes in digital access and the evolution of different measures of democracy while admitting the possibility of inter-country spillovers and trade partner selection effects.

There are a number of different mechanisms that might govern the impact of digital access on the emergence and diffusion of democracy. We have described three broad and sometimes overlapping mechanisms of impact in Section 2 – via the altering of information flows between governments and citizens, through changes to coordination and communication between citizens and due to modifications to the extent a government can control external visibility and accompanying international pressure. Each of these in turn may also shift the extent to which a country's level of democracy is influenced by that of its neighbors', redefining the set of "neighboring" countries whose outcomes potentially diffuse.

Our empirical analysis is a first attempt to capture this complex and interwoven nexus of interactions, bringing together data from a wide variety of sources and examining these data using a range of models and methods.

We believe our analysis and results shed new light on the question we started with: whether access to digital technologies related to the emergence of democracy within a country and the diffusion of democracy across countries? A theme of our findings is that the mechanisms by which digital access can impact freedom can be varied. For example, our results suggest that beyond information access and coordination, the transparency or *visibility* created by mobile technologies on account of their ability to aggregate and disseminate distributed and previously inaccessible information is crucial. This finding adds to a variety of ways by which digital technologies alter choice by altering visibility (Rhue and Sundararajan, 2012). However, this by-product of mobile digital access only has a positive effect on democracy if the country is susceptible to pressure from influential partners whose citizens enjoy greater levels of civil liberties themselves. Although not all of our hypotheses are borne out by the data, our paper moves the discussion of this question beyond its recent focus on the coordination of political movements via IT-based social media, and toward a more general investigation of how information technologies will alter freedom.

Another theme of our findings is that different forms of information technology are likely to impact democracy in different ways, perhaps mediated by different political networks. We are especially interested in encouraging further thought on the impact of mobile and broadband technologies via the third mechanism which we propose, namely the path of increasing external visibility and the resulting foreign pressure it triggers. In particular, the portability of mobile technologies collocates them easily in regions where events of consequence are unfolding and the growing capabilities of such technologies to capture and disseminate audio, pictures and video makes the external visibility of these events far greater and more compelling, a dimension that is only likely to grow in importance as broadband access becomes more widespread. We believe that stronger evidence of this is likely to emerge over time as the true effects of this important mechanism manifest in data at the level of granularity we use. There is also the possibility that a network other than that of foreign direct investments proxies the channels of inter-country influence even better, although we have been unable to find one. This certainly remains an area of active investigation for us.

We have entered an era in which new generations of socially and economically important technologies like mobile computing devices, social media and location-based software get created for and refined by consumers rather than by large enterprises, a trend often referred to as the consumerization of information technologies. This contrasts the "business first" historical pattern of evolution of hardware (from mainframes to minicomputers to PCs) and software (from accounting information systems to enterprise resource planning systems and spreadsheets). The consumerization of IT is not just about a change in the target market for new technologies; it represents a fundamental paradigm shift which gives distributed people new capabilities for human endeavor and freedom, and may lead to information technologies fulfilling their true potential for societal and national transformation. The dominance of the effects of mobile access over traditional Internet access is especially encouraging in this regard, given that this is the device that is at the forefront of the consumerization of IT, and which will be the conduit for digital access for a vast majority of new Internet users over the coming decades.

The impact of digital access on freedom and its diffusion is still in its infancy. The longer-run effect of having a technologically connected world on basic civil liberties and political rights will unfold over the coming decades. Our analysis provides a first empirical step toward uncovering what this impact might look like, and we look forward to participating in and analyzing the continued democratizing effects of digital technologies in the future.

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