SYMPOSIUM

Sensing Service Delivery: Pervasive Computing and Governance in Developing Countries

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Despite having transitioned to democracy, the governments of many developing countries still deliver poor public services as measured by social outcome indicators. Recent literature frames these issues of governance and public service delivery as a two-part principal-agent problem: civil servants are the agents of politicians and politicians are themselves the agents of the voters (Olken and Pande 2011). Much of this literature explores the determinants that drive citizens to demand better services (Pande 2011). Less attention, however, has been paid to understanding the behavior of the agents themselves and the interventions that can lead local politicians and civil servants to deliver better services.

This question is also important for policy formulation and implementation. The Open Government Partnership (OGP) is a 57-member country initiative founded in 2011 and dedicated to high-level aspirational goals around transparency, responsiveness, accountability, and effectiveness (Open Government Partnership 2011). The partnership rests on the assumption that transparency around finance and statistical data will make high-level political leaders more likely to craft inclusive institutions, whereas local performance data related to schools, health clinics, and other public facilities will pressure local politicians and civil servants to deliver better services.

What explains variation in performance among service providers at the microlevel? What leads to performance improvements? Until recently these questions were difficult to answer because of a paucity of data on service provision outcomes and the social context of service provision. However, this has changed in two important ways.

First, development economists have agreed on a set of robust, standardized indicators that measure the quality of services experienced in Africa. To create a picture of the overall service delivery system, service delivery indicators (SDI) measure a number of proxies for the actual experience of citizens at the facility level in the areas of health and education. For example, SDI for health clinics would examine the knowledge of staff at the clinic, how often they are present and providing services, and the level of funding that arrives at the facility from the central government. (Africa Economic Research Consortium and The World Bank Group 2011).

Second, recent developments in both digital technology and network science make it possible for the first time to collect data about how social context shapes the behavior of individuals involved in service provision. The emerging field of pervasive and mobile computing relies on software running in the background of mobile phones to collect an unprecedented amount of data about individual behavior, social network structure, and physical proximity. These same tools make possible experiments outside of a laboratory that may help improve our understanding of how variations in the incentives presented to individuals or groups of individuals are associated with changes in behavior.

In this article, I present two hypotheses from the network science literature which, when combined with these new sources of data, could greatly enhance our understanding of long-standing governance challenges related to service delivery. First, *the positional inequality hypothesis* states that service providers are more likely to perform effectively if their social network contains stronger ties with their colleagues and peers also involved in service delivery. This hypothesis builds on recent findings in the network science literature that a variety of behaviors can be tied to centrality in a social network, ranging from the chances of dying of a heart attack, finding a job, and propensity to pay back a loan all depend on network position (Christakis and Fowler 2011).

Second, *the contagion hypothesis* states that service providers are more likely to deliver high-quality service if their incentives are social; that is, their rewards for high performance are tied to the performance of their colleagues and peers. In network science, the notion of contagion explains how ideas and behavior can spread across networks (Christakis and Fowler 2009; Watts 2003).

In sections that follow, I place each of these hypotheses in the context of the political economy and network science literature and explain how pervasive and mobile computing can help researchers identify behaviors associated with higher performance and incentives that lead to performance improvements. Then, I use the case of health service in Tanzania—a country that is on the steering committee of the OGP and is therefore both an illustrative and a particularly important case—to demonstrate how the positional inequality hypothesis and the contagion hypothesis might be tested in a real-life setting. The last section of the article discusses the current technical limits of pervasive and mobile computing and also reviews some of the ethical questions and risks associated with the approach.

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THE POLITICAL ECONOMY AND NETWORK SCIENCE OF PUBLIC SERVICE DELIVERY IN DEVELOPING COUNTRIES

A growing political economy literature examines the persistence of low levels of public service delivery in new and emerging democracies. Much of this literature addresses the incentive structure facing politicians and civil servants. *The 2004 World Development Report: Making Services Work for the Poor* describes the long route of accountability where citizens as voters use voice to keep politicians accountable and a short route of accountability where citizens as monitors can hold frontline service providers accountable (The World Bank 2004).

In the long route to accountability, access to information is a critical prerequisite to active citizenship. In the seminal work on modernization theory, Lipset argues that education and access to information makes people more tolerant and helps them make more informed decisions (Lipset 1959). A more recent finding is that voting behavior is malleable, and so voters choose candidates who serve them more effectively provided they have the information that meaningfully identify performance levels (Banerjee et al. 2011). In the short route to accountability, citizens directly monitor the behavior of local providers (Björkman and Svensson 2010).

Not noted in this political economy work is the existence of a vast cognitive science and behavioral economics literature demonstrating that incentives are but one of several important factors considered when individuals make decisions. This literature articulates a framing problem: a wide variety of factors determine behavior, and therefore the underlying drivers of decision making are difficult to deduce (Gigerenzer, Todd, and the ABC Research Group 1999; Gilovich, Griffin, and Kahneman 2002). Some of the factors that researchers have added to the list of determinants include defaults, when the easier choice to make becomes more likely (Goldstein, Cialdini, and Griskevicius 2008; Thaler and Sunstein 2008); priming, when certain words or stimuli can affect behavior (Bargh, Chen, and Burrows 1996; Mandel and Johnson 2002); or confirmation bias, when individuals are more likely to favor information that confirms their prior beliefs (Bond et al. 2007).

It may be impossible to determine all of the inputs to individual decision making, however, physicists and social scientists are exploring the network science of how behavior spreads among individuals. A large part of this literature explores positional inequality; or how the relationship to the core of any network determines behavior. This work has shown, for example, that the risk of dying of a heart attack increases after shocks to an individual's social network, such as after the death of a spouse (Elwert and Christakis 2008). This network science literature also explores how ideas and information flows across the network itself (Christakis and Fowler 2009; Watts 2003). Economists have found that criminal behavior is contagious through social interactions, increasing the likelihood that more crimes will occur in particular neighborhood (Glaeser, Sacerdote, and Scheinkman 1996) and that charity spreads with the same characteristics; when people move from a less-generous to a more-generous neighborhood, their likelihood of giving increases (Carman 2003).

PERVASIVE AND MOBILE COMPUTING

Are high levels of quality in service delivery contagious in the same way as crime and charity? More broadly, what can a better understanding of network structure tell us about the decisions of individuals at the front lines of public service delivery. Recently, computer scientists, physicists, and social scientists have developed approaches to using network structure data to answer important social science questions (Lazer et al. 2009). The mobile phone has been called "perhaps the biggest source of data in the world" for these kinds of studies (Pentland 2011).

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An early attempt to use mobile phones to collect behavioral data was made in 2005, when researchers at the MIT Media Lab conducted experimental ethnographic research by tracking movements using cellphone tower location and tracking voice, text, and data usage among subjects. Building on this work, researchers in 2011 developed smartphone software to collect multidimensional datasets about the lives of individuals and social groups. They labeled this approach Social fMRI, drawing parallels to functional magnetic resonance imaging (fMRI), a leading tool in the medical world for measuring and studying the brain's response to stimuli. Like fMRI, Social fMRI seeks to sense the social world through the use of technology and test a number of interventions in the real world without disrupting the lives of participants.

The Friends and Family Study put Social fMRI to the test with a group of MIT graduate students mapping how networks affect patterns of decision-making and conducting experiments related to increasing frequency and levels of exercise (Aharony et al. 2011). This study collected a variety of measures of social networks (face-to-face, phone usage, and self-reported), sleep patterns (through alarm usage), patterns of physical activity, and movements around campus. Analyzing these data alongside background survey information, researchers found that individual preferences and changes in behavior were strongly influenced by those around them. For

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example, face-to-face interaction drives diffusion of mobile application more than perceived friendship ties, and behavior change (in this case level of exercise) can be influenced by social support systems. These behaviors are in line with the observable characteristics of the contagion hypothesis described earlier. Following the publication of the MIT Friends and Family Study, the research team launched Behavio, an open-source Android platform that offers a wide range of possibilities for researchers interested in understanding a wide range of behaviors.

TANZANIA'S COMMITMENT TO IMPROVING GOVERNANCE

Tanzania offers a unique opportunity to examine the applicability and utility of pervasive computing data in testing hypotheses about the link between networks and governance outcomes. Tanzania is an emerging leader in the field of open government, and its efforts to lead in this area have generated some of the first data that could be used to rigorously test this hypothesis.

The Tanzanian Minister of Justice and Constitutional Affairs, Mathias Chikawe, is a member of the Steering Committee, and Tanzania's central OGP commitments focus on improving core services such as water, education, and health. The Ministry of Health and Social Welfare (MoHSW), for example, has committed to building a grievance redressal mechanism that will publicly track the reporting and resolution of service delivery complaints (Government of Tanzania 2012). It has also committed to publicly tracking the availability of 15 essential medicines, which the government has mandated must be stocked in every clinic at all times.

Tanzania's approach suggests a causal logic similar to that outlined in the literature described above, wherein citizens with more access to information on the performance of clinics in their community will be likely to demand improved service delivery from politicians and frontline providers. At the same time, however, emerging evidence suggests that this causal logic may be either flawed or, at least, incomplete. One recent study in East Africa found that a program called Uwezo, which focused on empowering citizens through sharing information about local education performance, had no statistically significant effect on levels of active citizenship (Lieberman, Posner, and Tsai 2012).

What can social network data tell us about the quality of essential medicine provision in Tanzania? The remainder of this article explores how pervasive computing can help identify network data for individuals involved in the essential medicine supply chain in Tanzania, and how these data could provide a new way to experimentally test the role of these claims.

Positional Inequality

In network science, positional inequality is the notion that "some are better off in terms of where they are located in the network" (Christakis and Fowler 2011). Positional inequality builds on research that shows that individuals with many strong ties and a small number of weak ties in a network will be best positioned for the diffusion of influence, information, and opportunities (Granovetter 1973). The implication of positional inequality is that individuals who are prominently placed within networks of essential medicine suppliers are more likely to be effective as measured by SDI. If this hypothesis is true, the centrality of an individual (or group of individuals, such as a clinic staff) within a social network will correlate with their effectiveness in service delivery. An important assumption behind this hypothesis is that social norms in the service provider network reward high, rather than low, performance. Under this assumption individuals who perform poorly are more likely to shirk communication rather than display it prominently.

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Distributing mobile phones loaded with pervasive computing software such as Behavio could help researchers answer this question. Behavio could measure several different networks—including physical co-location networks (how often an individual comes face-to-face with others in the experiment), networks of phone calls and texts, and Facebook networks—to help identify links between network ties and performance. Further, Behavio could track physical movements to identify if there is a link between the patterns of individual visits to clinics and the quality of service delivered in a particular clinic or system of clinics. Finally, data generated using pervasive computing techniques could be combined with more traditional surveys about background, years of experience, and other demographic information to better understand characteristics of individuals in the service provision value chain.

Contagion

Are high levels of performance among essential medicine providers in Tanzania contagious? In other words, are levels of SDI likely to improve when information about individual performance spreads throughout the network? Pervasive computing can help social scientists test a range of incentive schemes to find out which ones are the most effective at improving the quality of service delivery.

Following the precedent of the Friends and Family Study, researchers could create a game pairing individuals who want

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to achieve a common goal with individuals seeking these goals alone, and see which situation leads to increased performance. Pairing members of the supply chain using Behavio would allow researchers to test the effectiveness of social support from someone inside that individual's friend network to the effectiveness of support from outside the friend network. Researchers could also test the causal effect of social as compared to material incentives—for example, by using "mobile money" to distribute cash rewards. To test the impact of material rewards, the amount of award money would be varied across individuals. Conditioning the rewards on personal performance as compared to the performance of team members would allow researchers to explore potential interaction effects between social and material incentives.

Research ethics require that scholars carefully think about the potential for these technologies to become surveillance tools, and the political and ethical risks associated with distribution of a technology they may no longer be able to control.

RISKS AND LIMITATIONS

The preceding sections have demonstrated the promise of data generated by pervasive computing for social science research—particularly their utility for generating a wealth of detailed, empirical data on the incentives and behavior of civil servants. As a result, this approach presents new opportunities to explore the micro-foundations of public service delivery and bureaucratic performance at an unprecedented level of rigor and detail.

There are, however, important limitations and risks to this approach, both technical and social. These limits and risks vary across economic and political contexts. On the technical side, programs like Behavio operate on smartphones running the Android mobile platform. This makes the software easily accessible and customizable, but also requires, in many developing country settings, that researchers distribute phones to the target population. This requires a larger research budget, careful thinking about how research subjects are selected, and careful consideration of whether the introduction of phones themselves might introduce changes in network shape and behavior and therefore exert an independent causal effect. Other logistical issues in developing countries involve ensuring that subjects have the ability to charge phones—particularly important given that Behavio and other data usage functions quickly draw down the batteries of smartphones—and a nuanced understanding of the connectivity available in a particular research setting, since data collection from smartphones requires at least a semiregular Internet connection to transfer data remotely.

The use of pervasive computing technology also raises important concerns about privacy. In the realm of global policy, pervasive computing has led to an extensive conversation about who owns the massive amounts of information that these technologies consistently generate (Pentland 2011). In the United States, the Data Bill of Rights has taken important steps to break these data out of their silos and make sure the citizens who generates them has as much control as possible (The White House 2012). This could be a challenge in countries without the full protection of civil liberties. Research ethics require that scholars carefully think about the potential for these technologies to become surveillance tools, and the political and ethical risks associated with distribution of a technology they may no longer be able to control. Best practice in the field is to remove all human readable text from the information collected, such as phone numbers, text messages, and other unique identifiers, but this does not guarantee that personal data cannot be reconstituted. As these technologies become more extensive and are used in new ways, scholars and institutional ethical review boards will have to consider carefully the ethical issues involved.

CONCLUSION

This article has outlined the ways in which pervasive computing can be used to explain and further explore the causes of variation in health governance and the delivery of public health services in Tanzania. The technology offers new advantages to researchers by introducing the ability to test hypotheses in real life settings. This approach not only allows the generation of more data than is normally available to social scientists, but has the potential to generate it in a less-intrusive way, and in more useful and flexible formats. At the same time, however, the use of this technology presents several technical limitations and raises ethical questions about privacy and surveillance that researchers will need to consider carefully. It is likely that these questions will only be resolved by testing these new tools in field settings in some of the ways outlined by this article. ■

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