Big Data and Smart (Equitable) Cities

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Abstract Elected officials and bureaucrats claim that Big Data is dramatically changing city hall by allowing more efficient and effective decision-making. This has sparked a rise in the number of "Offices of Innovation" that collect, manage, use and share Big Data, in major cities throughout the U.S. This paper seeks to answer two questions. First, is Big Data changing how decisions are made in city hall? Second, is Big Data being used to address social equity and how? This study examines Offices of Innovation that use Big Data in five major American cities: New York, Chicago, Boston, Philadelphia, and Louisville, focusing specifically on three dimensions of Big Data and social equity: data democratization, digital access and literacy, and promoting equitable outcomes. Furthermore, this study highlights innovative practices that address social problems in order to provide directions for future research and practice on the topic of Big Data and social equity.

Keywords Big Data • Smart cities • Equity • Local government

1 Introduction

Elected officials and bureaucrats claim that Big Data is dramatically changing city hall by allowing more efficient and effective decision-making. This has sparked a rise in the number of "Offices of Innovation" that collect, manage, use and share Big Data, in major cities throughout the United States. A watershed moment for Big Data and cities was President Obama's Open Government Initiative announced in January of 2009, which provided a Federal directive to establish deadlines for action on open data (Orzag 2009). Shortly thereafter, a number of local municipalities in the U.S. began making data more accessible, developed policies around open data, and made government services and civic engagement easier through the use of new technologies and Big Data.

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San Francisco launched the first open data portal for a U.S. city in 2009 and opened the first Mayor's Office of Civic Innovation in January 2012 (Appallicious 2014). As of July 2013, at least ten cities had Chief Innovation Officers, and a survey conducted in Spring 2013 found that "44 % of cities of populations of more than 300,000 and 10 % cities of populations between 50,000 and 100,000 had offices of innovation" (Burstein 2013). While San Francisco had the first office, Mayor Bloomberg's dedication to opening data in New York has been heralded by civic innovators as one of the driving forces behind the open data movement and the national trend towards greater civic entrepreneurship (Appallicious 2014).

Offices of Innovation have become popular because they offer the promise of using Big Data for predictive analytics, streamlining local government processes, and reducing costs. Yet, very little research has been conducted on what data is being harnessed, how it is organized and managed, who has access, and how its use affects residents. Even less attention has been paid to the relationship between Big Data and equity.

This paper seeks to answer two questions. First, is Big Data changing how decisions are made in city hall? Second, is Big Data being used to address social equity and how? This paper seeks to answer these questions by examining Offices of Innovation that use Big Data in five major American cities: New York, Chicago, Boston, Philadelphia, and Louisville. In particular, this study examines three dimensions of Big Data and social equity: data democratization, digital access and literacy, and promoting equitable outcomes. Furthermore, this study highlights innovative practices that address social problems in order to provide directions for future research and practice on the topic of Big Data and social equity.

2 Big Data, Governance, and Social Equity

Although the private sector has become highly sophisticated at culling Big Data to shape business practices and planning for some time now, the use of Big Data in the public sector is a relatively new phenomenon. Much of the academic literature to date on Big Data and cities has largely focused on the historical evolution of Big Data and smart cities (Batty 2012, 2013; Kitchin 2014; Batty et al. 2012; Chourabi et al. 2012), the potential impact that Big Data can have on the future of citizens' lives (Domingo et al. 2013; Batty 2013; Chen and Zhang 2014; Wigan and Clarke 2013; Hemerly 2013), and the challenges the public sector faces integrating Big Data into existing processes and strategies (Batty 2012; Joseph and Johnson 2013; Vilajosana et al. 2013; Almirall et al. 2014; Chen and Zhang 2014; Cumbley and Church 2013; Wigan and Clarke 2013; Kim et al. 2014; Hemerly 2013). However, less research has centered on the relationships between Big Data, local governance, and social equity.

Social equity in governance, is defined by the Standing Panel on Social Equity in Governance as "The fair, just and equitable management of all institutions serving the public directly or by contract; the fair, just and equitable distribution of public

services and implementation of public policy; and the commitment to promote fairness, justice, and equity in the formation of public policy" (National Academy of Public Administration, www.napawash.org). This definition of social equity focuses on the governance *process* and does not address equitable outcomes. For this study, we consider another dimension of social equity: public policies and government actions that promote greater equitable *outcomes* for the public. When social equity is tied to Big Data, a number of key themes emerge in the literature: digital access, digital literacy, and the use of Big Data to promote more equitable outcomes for the public. Thus, in our study, our definition of social equity considers both processes and outcomes.

2.1 Inequities in Access: The Digital Divide

As cities steadily transition towards a digital governance system, uneven access to digital technology across different groups, known as the "digital divide" may exacerbate social inequality (Light 2001; Gilbert et al. 2008). Existing research on digital access has focused on how and why certain demographic groups have historically been left out of the technological adoption process (Batty et al. 2012; Chourabi et al. 2012; Prieger and Hu 2008; Gilbert et al. 2008; Lee et al. 2015). Research indicates that the groups that have the least access to digital technology include: the poor, unemployed individuals, those with low levels of education, families without children, the elderly, non-whites (especially, Blacks and Hispanics), and those living in rural areas (DiMaggio et al. 2004; Azari and Pick 2005; Gilbert et al. 2008; Gilmour 2007; Hilbert 2011; LaRose et al. 2007; Lee et al. 2015; Prieger and Hu 2008; Prieger 2013; Velaga et al. 2012).

There is a large and growing body of research on the digital divide that focuses largely on broadband adoption, Internet usage, and computer access. To address this divide, federal funding has been used to develop initiatives to provide better access to computing centers and expanding availability of Internet services (Bailey and Ngwenyama 2011; Revenaugh 2000). Furthermore, local governments have attempted to improve computer and Internet access for underserved population groups through partnerships with local schools and community centers and by improving local digital infrastructure in disconnected neighborhoods (Gilbert et al. 2008; Araque et al. 2013). Despite these efforts at eliminating the inequities in digital access, the digital divide still persists (Gilbert et al. 2008; Kvasny and Keil 2006; Correa 2010; Hargittai 2002; Looker and Thiessen 2003; DiMaggio et al. 2004; Light 2001).

2.2 Digital Literacy: The "Participatory Gap"

While scholars have paid attention to the digital divide in relation to digital access over the past 15 years, recent research has emphasized growing concerns over digital literacy—the skills, knowledge, or familiarity with digital technology (Gilbert et al. 2008; Gilmour 2007; Lee et al. 2015; Correa 2010; Hargittai 2002). This form of digital divide has been referred to as the "participatory gap" (Fuentes-Bautista 2013) and signifies that even if individuals have access to computers, smartphones, or the Internet, they may lack the skills, education, or familiarity to take advantage of the opportunities that information and communications technologies (ICTs) can provide (Warren 2007; Gilbert et al. 2008; Kvasny and Keil 2006; Looker and Thiessen 2003; DiMaggio et al. 2004; Light 2001). Differences in levels of accessibility and digital literacy are found to be correlated with typical patterns of social exclusion in society (Warren 2007; Lee et al. 2015; Mossberger et al. 2012; DiMaggio et al. 2004). In particular, socioeconomic status is considered the leading cause of the new digital literacy divide (Guillen and Suarez 2005).

As municipal governments become increasingly reliant on digital technology, the ability to navigate public agency websites, download and submit forms electronically, scan documents, and a host of other digital skills are increasingly becoming important. Digital illiteracy will undoubtedly limit the ability of individuals, organizations, and local businesses to access resources and opportunities. Community-based organizations, for example, often struggle with having low capacity to perform sophisticated studies or evaluations using Big Data and, therefore, do not have the ability to provide quantitative analyses that may be required to apply for and receive government or philanthropic funding. Thus, understanding the barriers to digital literacy and the characteristics of groups and organizations that are persistently illiterate will allow local governments to adopt policies and practices to address it.

2.3 Closing the Digital Divide: What Have We Learned?

The first generation of initiatives developed to address the digital divide proposed that by improving digital accessibility, this would benefit disadvantaged groups and reduce gaps in access and usage (Azari and Pick 2005). The idea behind these initiatives relied on the assumption that closing gaps in technological access would mitigate broader inequalities, including literacy. These initiatives also assumed that providing access to ICTs would improve disadvantaged groups' social statuses (e.g. income) (Light 2001). However, studies found confounding factors associated with digital inequality, including available equipment, autonomy in using ICTs, skills, support (e.g. technical assistance), and variations in purposes (e.g. using ICTS to obtain jobs vs. social networking) (DiMaggio et al. 2004). Increasing digital access does not adequately address these five issues and, therefore may be

ineffective at reducing the digital divide (Looker and Thiessen 2003). For example, Kvasny and Keil's (2006) study found that providing computers, Internet access, and basic computer training was helpful, but not sufficient at eliminating the digital divide for low-income families in high-poverty areas. This study pointed to the intersection between digital inequities and other social structural inequities, such as lack of access to high-quality schools, limited public investment, and pervasive poverty. Even when digital divide initiatives do help low-income Americans living in poor neighborhoods to gain digital literacy, these programs often do not mitigate inequities caused by disparities in transportation access or educational status (Light 2001; Tapia et al. 2011). Thus, the literature suggests that in order to be effective in closing the digital gap, digital programs and policies must also be coordinated with other social policies that address the root causes of the digital divide: poverty, poor education, economic residential segregation, and public and private sector disinvestment in poor neighborhoods.

Technological innovations have become an integral part of America's communication, information, and educational culture over the past decade. Access to information and computer technologies is increasingly considered a "necessity" to participate in many daily functions (Light 2001). As ICTs have become more integrated into daily life, populations that have historically not had access to or familiarity with how to use ICTs may become increasingly disadvantaged without improved access and literacy (Tapia et al. 2011). This may also exacerbate other forms of social, economic, and political marginalization for excluded groups (Gilbert et al. 2008; Lee et al. 2015). Furthermore, growing disparities between the digital "haves" and "have-nots" can have lasting negative social and economic consequences to neighborhoods and cities.

Recognizing how data is collected and who provides the data has important implications for democracy and the distribution of government resources. For example, crowdsourcing—a citizen engagement platform—will disproportionately benefit individuals and groups that provide data through mobile applications or web-based applications. Without an understanding of how to use ICTs, disadvantaged groups will not have their voices heard (Jenkins et al. 2009; Bailey and Ngwenyama 2011; Lee et al. 2015). However, being digitally illiterate may be of greater concern for more common procedures, such as job applications or qualifying for federal assistance programs. Today, even some minimum wage jobs require job applications to be filed online. Individuals without access to a computer or the Internet and/or individuals without any familiarity in completing paperwork or forms online may experience significant difficultly completing the application, which may further exacerbate existing economic inequities. Data and digital inequities, in terms of both access and literacy, compound issues that disadvantaged populations face. As a result, it is important to continually address inequity in digital access and literacy in order to prevent populations from becoming increasingly disenfranchised and for inequalities to be exacerbated as technological innovations continue to develop.

3 Case Study Cities: Boston, Chicago, Louisville, New York and Boston

To better understand whether and how Big Data is changing decision-making in city hall and how it is used to address social inequity, we conduct interviews with key informants in five cities that have well-established Offices of Urban Innovation: Boston, Chicago, Louisville, New York and Philadelphia. For more information about each city's office of urban innovations, see Appendix. We used a snowball sampling design, which started with contacting the directors of each of the offices and receiving referrals from individuals we made contact with. We conducted a total of 19 semi-structured phone interviews with staff in the Offices of Innovations and key local stakeholders, such as users of Big Data disseminated by local governments, developers of new mobile applications that collect data, and staff of non-profits. These interviews lasted between 30 min and 1 h and were transcribed. We supplemented our interviews with reports, newspaper articles, and scholarly publications that provided information about the five offices of innovations' mission, goals, organizational and institutional structure, operational priorities, portfolio of programs, and key initiatives.

Offices of Innovation are typically responsible for information technology activities, such as providing Wi-Fi and broadband infrastructure, developing information technology policies, strategies, and benchmarks, and providing access to open data and mapping data through online portals. However, each of these offices have unique initiatives that have garnered nationwide attention.

4 Is Big Data Changing City Hall?

4.1 Big Data and Government Decision-Making

One of the primary way in which Big Data is changing City Halls nationwide is by increasing the number of data sources (e.g. administrative, mobile application data, social media) available to develop data analytics and predictive processes to inform decision-making. These types of systems are being developed to save money, allowing municipal governments to stretch budgets, improve efficiency, and develop new methods of communication and networking internally in order to be more innovative in delivering public services. Two of our case study cities offer insights into how Big Data is used to inform local government decision-making: New York and Chicago. New York has been approaching Big Data from a problem solving approach, whereas Chicago is working to infuse data analytics into their existing governmental structure in a comprehensive way.

4.1.1 Big Data and Predictive Processes: New York and Chicago

New York City's Mayor's Office of Data Analytics (MODA) has been widely recognized for using predictive analytics in government decision-making over the past several years. Since 2012, New York City has approached predictive analytics as a way to "evolve government" to improve the efficient allocation of resources and develop a better response to the real-time needs of citizens (Howard 2011). The City's repository for administrative data is called DataBridge and was designed to perform cross-agency data analysis utilizing data from 45 city agencies simultaneously. According to Nicholas O'Brien, the Acting Chief Analytics Officer of New York, the main challenge the office has had to overcome has been working with Big Data from "45 mayoral agencies spread out in a distributed system. . .[this has been a challenging and arduous process because] each city department has a different anthology for how they characterize the data, so it's important to understand the overlaps and the exceptions" (Personal Communication, February 24, 2014). Thus, matching the data across administrative units and ensuring the quality of the data is extremely important as the decisions made through the predictive analytics process are only as valid and reliable as the data utilized to predict the outcomes.

Some of MODA's most lauded successes include: "(1) a five-fold return on the time that building inspectors spend on looking for illegal apartments, (2) an increase in the rate of detection for dangerous buildings prone to fire-related issues, (3) more than a doubling of the hit rate for discovering stores selling bootlegged cigarettes, and (4) a five-fold increase in the detection of business licenses being flipped" (Howard 2012). MODA's quantifiable successes using predictive analytics has inspired other cities nationwide to create these types of processes to improve their own internal productivity and decision-making. Although the benefits have been well documented, there is no account of how much it costs to collect, manage, and analyze the data. Therefore, this does not allow for a critical examination of whether Big Data predictive analytics is a more cost-effective problem solving tool than other methods.

In January 2014, Chicago received a $1 million grant from Bloomberg Philanthropies to create the first open-source, predictive analytics platform, called Smart Data (Ash Center Mayors Challenge Research Team 2014). Chicago collects seven million rows of data each day that is automatically populated and gathered in varying formats, through separate systems. The SmartData platform will be able to analyze millions of lines of data in real time to improve Chicago's predictive processes and according to Brenna Berman, will "develop a new method of data-driven decision making that can change how cities across the country operate" (Ash Center Mayors Challenge Research Team 2014).

The SmartData platform will have the power to transform predictive analytics for cities nationwide through its open-source technology. If successful, the development of this replicable model for predictive processes can potentially change decision-making processes for every municipal government nationwide that utilizes

this software. The platform designed to be user-friendly and understandable to government employees with varying levels of data familiarity. Brenna Berman states, "…we need to find a way to make analytics become available to the non-data engineer" (Shueh 2014a, b). While Chicago has a team of data engineers, most cities do not have access to those resources and city staffers must make decisions without extensive experience in ICTs or data analytics. In addition, the use of predictive analytics may assist with preventing problems rather than responding to problems, which is how most cities operate. Brett Goldstein, former Chief Data Officer of Chicago, explains that predictive analytics is "having governments think about, 'How do we prevent rather than react?'…Part of my role now is to say, 'How can we use those techniques to do government better and do it smarter?'" (Rich 2012).

4.1.2 Using Big Data for Predictive Policing

One area of predictive analytics adopted by cities is predictive policing, which employs data analytics to assist police in making decisions that can prevent crimes, such as homicides, burglaries, and vehicle thefts (Novotny 2013). Predictive policing systems use software that builds models similar to private sector models of forecasting consumer behavior. Municipal police agencies use this technology to predict and prevent crime. The concept behind predictive policing is that situational awareness can be improved to create strategies that improve public safety and utilize police resources more efficiently and effectively (Hollywood et al. 2012). Employing limited resources more effectively and working proactively can help police departments anticipate human behavior and identify and develop strategies to prevent criminal activity. However, in order for predictive policing to be successful, rigorous evaluations must be conducted to determine if reductions in crime are directly due to predictive policing (Hollywood et al. 2012).

Two of our case study cities, Philadelphia and Boston, have already seen some quantifiable successes utilizing predictive policing. Philadelphia has been training police officers as data scientists in a "smart policing" program since April 2012. Officers completed a 2-week crime science program focused on utilizing technology to map crimes, understanding predictive software, and generating digital surveys to collect information from residents, which is a form of data crowdsourcing (Reyes 2014). This program changes traditional police protocol because police officers, rather than external consultants, are directly trained in these technologies and build upon their skills and knowledge as a result of the program. Violent and property crimes decreased by 5.8 % and residential burglaries decreased by 39 % in one district between 2012 and 2013. Philadelphia's Deputy Commissioner, Nola Joyce, believes that the reductions in crime are due to the smart policing program and as a result of developing this program, the police department is moving from "counting and reporting crime" to "understanding" crime (Reyes 2014).

Boston has established the Problem Properties Task Force, an interdepartmental effort to identify properties with persistent criminal activity and/or blight that have caused problems (Boston's Mayoral Transition: The Problem Properties Task Force 2013). Developed to improve the allocation of the city's limited resources, the Task Force convenes executive staff members from more than 12 departments and uses a data-driven, predictive analytics system that combines data from multiple city agencies. This program has resulted in reductions in property assessment times from days or weeks to seconds (Boston's Mayoral Transition: The Problem Properties Task Force 2013). The Problem Properties Task Force is notable because it is an example of multiple sources of city administrative data (Big Data) grounded in local knowledge from executive departmental staff to conduct predictive analytics and inform decision-making.

Critics of predictive policing raise concerns that the data used to prevent crime, such as race, ethnicity, or neighborhood could result in profiling. However, supporters of predictive policing argue that only data on past crimes, not criminals' characteristics, are used in the data analysis. These controversies raise questions about ethical and legal concerns over using Big Data for predictive analytics.

4.1.3 Balancing Predictive Analytics with Contextual Realities

While Big Data and predictive analytics offers the potential for greater efficiency and cost-savings, it can also do harm. Users of Big Data should be careful to ensure the accuracy and completeness of the data used in predictive models. There is also the potential for human error or misinterpretation of the results, thus it is important to cross check the findings from predictive models with individuals in the field—including staff who work within communities or the public at large. While efficiency is important, accuracy and transparency is equally important when using Big Data for predictive modeling or forecasting.

5 Big Data and Social Equity

Our case studies revealed that Big Data and new technologies have tackled tame problems (Rittel and Webber 1973), such as infrastructure improvements, how to allocate staff time, and making city hall run more efficiently and proactively, rather than focusing on the more intractable problems of inequality, poverty and social equity. Based on our research, we find that there are three ways that cities are addressing social equity with Big Data: democratizing data, improving digital access and literacy, and promoting equitable outcomes using Big Data. We discuss each of these topics in turn below.

5.1 Data Democratization

Data democratization is centered upon the idea of increasing access to typically inaccessible or unpublished data for widespread analysis and consumption. There are many legislative forms in which data democratization can be encouraged or required by municipal governments. According to the Sunlight Foundation, of the 32 cities with open data policies in place by April 2014, two are administrative memos, ten are executive orders, and 20 are "codified in legislation." Codified in legislation is the "strongest" policy form, because "it preserves consistent criteria and implementation steps for opening government data beyond the current administration" (Williams 2014). When open data laws become incorporated into legislation, consistency, enforcement, and management standards become part of the city's legislation and are more difficult to overturn or alter under changing leadership. Regardless of the type of policy passed, each city's relationship with open data is dependent on the municipal government's structure and support for transparency, as well as the city's existing mechanisms and capacity for data tracking and management.

5.1.1 Open Data in New York City

Enacted in March 2012, New York City's landmark Open Data law—Local Law 11—was the first of its kind at the local U.S. municipal level (NYC DoITT 2012). The result of Local Law 11 was that New York City established a plan with yearly milestones to release all of the city's data from city agencies by 2018. When finished, it will become the first U.S. local municipality with a complete comprehensive public agency dataset inventory (Williams, "NYC's Plan to Release All-ish of their data," 2013a). According to Gale Brewer, Manhattan Borough President, New York City's open data law was more significant and transformative than the federal directive because it demonstrated how this type of work could be implemented at the local level (Goodyear 2013).

The Mayor's Office of Data Analytics (MODA) operates New York City's open data portal and works closely with NYC DoITT to populate the data portal and pursue other projects relating to data innovation and analytics (Feuer 2013). MODA has been successful at procuring 1,500 datasets from the city's public agencies thus far. Yet, there remains many challenges to completing this task, including the cost, organizational capacity, data management skills, and ongoing maintenance and upkeep of the data. What is also not clear is who uses the data and for what purpose, which raises questions about data formatting and requisite skills and education of users. Nicholas O'Brien, Acting Director of MODA explains,

> We're also really starting to understand our audience. The customers of our open data portal are primarily non-profits, who we considered mid-tier data users that have some digital and data expertise but aren't necessarily writing code or programming. We also know for our tech-savvy users, we have to direct them to our developer portal for more robust resources,

> and we have a third level of users that have very limited skills with data analysis. Understanding what each of these audiences want and need is an ongoing process for us. (Personal Communication, February 24, 2014).

5.1.2 Open Data in Boston, Chicago, Louisville, and Philadelphia

Since 2012, Boston, Chicago, Louisville, and Philadelphia have established open data executive orders. These cities have largely developed open data portals and created new executive positions to manage data initiatives. Philadelphia is the only municipal government in the country that does not "unilaterally control" the city's open data portal (Wink, "What Happens to OpenDataPhilly Now?," 2013). Instead, Philadelphia's portal is managed by a non-profit and contains both municipal and non-municipal data (that users can submit directly).

In December 2012, Mayor Emanuel in Chicago established an open data executive order and created a position for a Chief Data Officer (CDO) to speed up the development of an open data portal. In order to improve transparency and build working relationships between departments with regard to Big Data, the executive order required that an Open Data Advisory Group, which includes representatives from each agency, to convene in order to discuss the portal's ongoing development (Thornton, "How open data is transforming Chicago", 2013a). According to Brenna Berman, Commissioner and Chief Information Officer, "meeting participants prioritize what datasets should be developed and identifies cross agency collaborations for data analytics" (Personal Communication, March 21, 2014). To support Chicago's open data portal, the city established an accompanying data dictionary for information about all data being published (Thornton, "How Chicago's Data Dictionary is Enhancing Open Government", 2013b). The Data Dictionary takes transparency to another level and enhances the open data experience beyond what the other major American cities are doing.

In October 2013, Louisville announced an executive order for creating an open data plan. At that time, Louisville's open data policy was the first U.S. municipal policy that stated open data will be the "default mode" for how government electronic information will be formatted, stored, and made available to the public (Williams, "New Louisville's Open Data Policy Insists Open by Default is the Future", 2013b). The implications are that data that is legally accessible will be proactively disclosed online through the city's open data portal. Since January 2014, Louisville's open data portal has been in development and operated by a small team working within the Louisville Metro Technology Services department (Personal Communication, February 25, 2014).

Among our case study cities, Louisville has the lowest population with almost 600,000 residents and the smallest city government. Currently, the city has a "homegrown portal" that the city staff developed. The current process for this homegrown portal requires a data specialist to determine (with a small team) which datasets should be prioritized based on volume of requests and ease of "cleaning" the data. Louisville hopes to eventually publish between 500 and 1000

datasets in the portal (Personal Communication, February 25, 2014). Unlike New York City's law that mandates that all city agencies make their data accessible, Louisville relies on one staff member to collect, store, and manage the data, thereby making their call for open data to be the "default mode," very challenging.

5.2 Data Democratization and Equity

Developing and maintaining an open data portal is a significant investment in terms of infrastructure and finances. However, to democratize data, open data portals are only the first step. The next step is for open data to be user-friendly to a larger range of the population and to have broad impact. According to Justin Holmes, the Interim Chief Information Officer in Boston,

> We have to figure out how we take that data and make it more relevant. We know that Excel spreadsheets are not relevant to your grandmother. City departments need to be activists and understand why and how data can be impactful and then create a user-friendly platform (March 19, 2014).

While the open data movement has generated excitement and support from municipal governments, civic hackers, and tech-savvy citizens, these innovative applications typically provide benefits or services to those who also already utilize data and technology in their everyday lives. For citizens that have access to and understand these systems, they are able to receive benefits in terms of cost, efficiency, and decision-making.

Despite the publicity surrounding open data, providing data does not mean that every citizen will directly receive or experience a benefit or improve their quality of life. Truly innovative municipal governments should aim to provide widespread access and understanding of data and technologies to their citizenry (McAuley et al. 2011). The following analogy between libraries and open data portals is instructive for how data portals should be conceived: "we didn't build libraries for an already literate citizenry. We built libraries to help citizens become literate. Today we build open data portals not because we have a data or public policy literate citizenry, we build them so citizens may become literate in data, visualization, and public policy" (Eaves 2010). Nigel Jacob of Boston's MONUM echoes these sentiments by saying "open data is a passive role for the government. . .fine for software development, but it does not actively engaged with citizens." Thus, in order for cities to develop a democratic data system, they need to make the data usable and provide supplementary resources and training to ensure widespread use and impact.

5.3 The New Digital Divide: Digital Literacy

In the last few decades, local governments have been engaged in activities to reduce the digital divide by increasing access to broadband, Wi-Fi, ICTs, and computer centers. Coupled with these programs and the increasing affordability of acquiring technology, digital access is becoming less of a problem.

However, a new digital divide is emerging between individuals who can effectively access and use digital resources and data to improve their well-being and those who can not. For example, being unable to download, fill out, and submit a job application on-line will severely limit their job opportunities. If digital literacy is low among groups that are traditionally disadvantaged, this may exacerbate social inequality.

5.3.1 Chicago and New York: Digital Access and Literacy Initiatives

In 2009, every city in our study, except Louisville received funding from the Broadband Technologies Opportunities Program (BTOP), a federal program designed to expand access to broadband services nationwide. New York City received $42 million from BTOP and developed the NYC Connected Communities program, which focused on broadband adoption and improving access to computer centers in low-income and limited-English neighborhoods throughout five boroughs (Personal Communication, March 10, 2014). Through this program, 100 computing centers were opened at local public libraries, public housing developments, community centers and senior centers. The majority of these centers have remained open as more funding was acquired in 2013 when the BTOP funding expired. NYC Connected Communities included computer training and digital literacy programs designed to meet community needs (Personal Communication, March 10, 2014). Since 2010, the NYC Connected Communities program has hosted more than three million user sessions citywide, approximately 100,000 residents have participated in training classes, and over 4.7 million residents have attended open lab sessions (NYC DoITT, "Technology & Public Service Innovation: Broadband Access" n.d.; City of New York Public Computing Centers 2014).

In Chicago, the Smart Communities program received $7 million of federal funding in 2010 to develop training and outreach initiatives centralized in five low-income communities in Chicago (Tolbert et al. 2012). The Smart Communities program created a master plan that included considerable input from community members to determine program priorities to address challenges specific to their community (Deronne and Walek 2010). Thus, in Chicago, the design of the programs was developed through a "bottom up" participatory process that resulted in unique programmatic components that focused on the idea that the "community knows best." (Personal Communication, February 25, 2014).

Through early 2013, the Smart Communities program has trained approximately 20,000 people in computer and digital literacy skills (City of Chicago Public

Computing Centers 2014). One of the Smart Communities program's most applauded successes is a statistically significant 15 % point increase in Internet usage in Smart Communities neighborhoods compared to other neighborhoods in the city between 2008 and 2011 (Tolbert et al. 2012).

5.3.2 Small-Scale Approaches to Digital Access and Literacy

The programs mentioned above are supported by large sums of federal funds. But, these funds are not available to the vast majority of cities throughout the country. Thus, we offer examples of smaller scale initiatives to improve digital access and literacy found in our case study cities. In Chicago, LISC, a non-profit community-based organization, has built upon the Smart Communities program and developed community-focused initiatives that provide training for residents from a diversity of demographic backgrounds and offers an online presence for low-income neighborhoods. Boston and New York have installed computers in vans to serve as mobile city halls that bring public staff into the field to offer services and to provide access to technology to residents of concentrated poor and minority neighborhoods. Boston operates "Tech Goes Home" (TGH), an initiative that provides digital literacy courses, subsidized computer software, and broadband access to school-age children and their families. Louisville's focus on digital literacy comes from a workforce development perspective. The city has made investments in developing high-level data analysis skills in residents that can improve employment opportunities while simultaneously making the city more attractive to businesses.

The one issue with these smaller-scale approaches is that it is difficult to develop an initiative or program that tackles both digital access and digital literacy on a smaller scale and budget. The initiatives in Chicago have managed to continue this dual emphasis through LISC's partnership with their other organizations. Boston's Tech Goes Home program has managed to expand since its development in 2000 and has evolved into one of the more sustainable models of digital literacy by providing a computer and low-cost access to broadband to those who complete their program.

5.3.3 Digital Access and Literacy Recommendations

All the cities in this study have worked to close the digital divide in terms of access and literacy. However, the innovativeness and diversity of Boston and Chicago's programs demonstrate the significant investment and local resources required, both financially and in terms of the coordination between local stakeholders. Justin Holmes at Boston's Office of Innovation & Technology's describes the complexity of approaching issues of data access and literacy in diverse communities:

> "Our engagement approach is multichannel. . .we need to be mobile, move beyond call centers and traditional centers, and use social media as a 'value add' to reach people. We're

working to meet people where they are comfortable" (Personal Communication, March 19, 2014).

The main commonality between most cities was the development of public computing centers to improve access. Dan O'Neil, Executive Director of the Smart Chicago Collaborative, believes that "public computing centers are the most essential building block in providing access to technology" (Personal Communication, March 6, 2014). However, the programs with the potential for long-lasting impacts appear to be those with a concentrated effort on providing extensive on-site training through a site-specific curriculum tailored to the wants and needs of the community. Andrew Buss, the Director of Innovation Management in the Philadelphia Office of Innovation & Technology, identified that the key to Philadelphia's KEYSPOT computing center initiative was having an instructor on site:

"You can't just have a room with a bunch of technology. . .you need to have a person onsite at each location for assistance on how to use the equipment and to solve minor tech issues [which creates] a guided experience" (Personal Communication, February 28, 2014).

The availability and expertise of on-site instructors was also seen in each of the mobile van initiatives and has proven to be crucial for digital literacy programs. Furthermore, it seems that establishing a high level of trust between the program providers, teachers, and participants is integral to the program's success and to see positive outcomes gained for students.

Improving data literacy is important for a diversity of users, not only user groups that do not have access to new technologies. Brenna Berman, the Chief Information Officer at Chicago's Department of Innovation & Technology, spoke about the importance of non-profits accessing and utilizing data:

"We've been creating a partnership between commercial organizations and the philanthropic community to make sure non-profits are benefiting from Big Data and using some indirect organizations that have been addressing the gap. . .we know non-profits were not embracing Big Data and weren't using data to inform decisions. They needed representatives from communities to teach them how to do this, so we've run education workshops to collaborate and educate. . .like that saying, a rising tide raises all ships" (Personal Communication, March 21, 2014).

Therefore, closing the digital divide gap may not be simply a matter of providing access and training to individuals, but also to low capacity organizations.

5.4 Promoting Equitable Outcomes with Big Data

The third dimension of social equity relates to the promotion of equitable outcomes using Big Data. This could be conceived in two ways. First, directing Big Data analysis to reduce disparities across various social dimensions (i.e. income, race, ethnicity, and gender) for different groups. Second, targeting disadvantaged or underserved groups by using Big Data to improve their quality of life. The city of

Louisville offers some innovative ways to address equitable outcomes using Big Data.

5.4.1 Sensor Technology in Louisville

Among government agencies, public health agencies have been leading the way in using Big Data to reduce health disparities. New technologies offer innovative ways to assist low-income individuals to manage their healthcare and improve their health. In 2010, the city of Louisville created an inhaler sensor called Asthmapolis, which also comes with a supplementary mobile application that allows asthma patients and their doctors to understand asthma's triggers and provides an effective way to control asthma, while simultaneously generating data for public health researchers (Propeller 2013). More than 500 sensors have been deployed to low-income residents suffering with asthma in Louisville. While the program is still in the early stages, the benefits for residents have been notable. Interviews with program participants highlight their increased confidence in their disease management due to the "smart inhalers." Furthermore, participants are happy to be part of the program because the inhaler sensor is provided free of charge through funding from philanthropic grants (Runyon 2013).

This program in Louisville is believed to be truly transformative in "breaking down data silos in the public sector. . .[and] is a model project for how the public sector and communities should start working with informatics" (RWJF Public Health Blog 2012). Utilizing this technology provides a benefit to the user, as their disease management improves. It is also useful to doctors and public health officials because the individual-level data, geo-tagged by location, generated can be utilized to inform future public health decisions. The City of Louisville has pushed to incorporate innovations that improve public health because of the belief that having a healthy population contributes to regional and economic competitiveness, which encourages businesses to locate in the city (RWJF Public Health Blog 2012). This mindset is consistent with Louisville's strategy to improve data literacy as a workforce development tool to increase the city's economic competitiveness. Thus, for smaller cities such as Louisville, innovations in technology and Big Data that promotes the image and reputation of the city as cutting edge and with a good quality of life can improve economic competitiveness.

5.4.2 New York City: Improving Social Service Delivery

In 2009, HHS-Connect was developed in New York to collect all data relating to social services in one digital repository in order to streamline the intake process for clients visiting different social service agencies. HHS Connect has transformed service delivery for social services into a client-centric model. The increased coordination between city agencies has improved case management processes and provided clients with one access point to self-screen for over 30 benefit programs.

These types of internal innovations can make the experience easier for clients while helping overburdened agencies detect fraud, improve service delivery, and reduce costs (Goldsmith 2014).

These programs emphasize the need to develop partnerships between social service providers to allow data sharing between agencies and streamline intake services. This creates organizational efficiencies and also makes receiving services for socially vulnerable populations easier and more efficient, thus saving individuals time and money. However, there are a variety of issues that limit the power of Big Data. On the federal level, statutes vary about what health records, educational transcripts, and data related to homelessness, child welfare, drug abuse and mental health can be collected, published, or shared (Goldsmith and Kingsley 2013). On the state and local level, many laws were written prior to the digital age and can create conflict and confusion, thereby slowing down the adoption of innovations in these fields.

6 Lessons Learned About Big Data, Governance, and Social Equity

This case study of five U.S. cities with Offices of Innovation sought to answer two primary research questions. First, is Big Data changing decision-making in city hall? Second, is Big Data being used to address social equity and how? To varying degrees, Big Data in all of our case study cities is altering the way in which decisions are made in local government by supplying more data sources, integrating cross agency data, and to use predictive rather than reactive analytics to make decisions. This has the potential to improve administrative efficiency and reduce man hours spent on tasks, thereby saving time, energy, and money. While this may be true, cities often do not calculate the costs associated with collecting, cleaning, managing, and updating Big Data. No study to date has examined the cost-effectiveness of these programs to determine the return on investment. Furthermore, local government's focus on tame problems using a rational framework that promotes efficiency in government systems, raises long-standing concerns about "problem definition" within government (Rittel and Webber 1973; Dery 1984; Baumgartner and Jones 1993; Rochefort and Cobb 1994). In particular, top down models of decision-making that use technologies accessible by groups that are already advantaged may exacerbate social inequalities and inhibit democratic processes.

While major cities, such as New York, have high capacity public agencies that can populate the data required in a centralized repository, smaller cities may not. Louisville's open data portal, for example, relies on one staff member populating the data using a data portal that was developed in-house. What happens if this staff member leaves his post? New York City's MODA provides the needed expertise and capacity to assist public agencies and departments to conduct predictive

analytics. Their model of support is dependent on a separate government entity staffed with ICT experts dedicated solely to supporting other agencies. Other models of predictive analytics can be found in training agency staff members. Training police officers in predicting policing analytics is an example of Big Data analytics altering the operations within a single public agency.

While there is great promise that predictive analytics will become widely accessible and affordable (e.g. Chicago's Smart Data platform), caution should be taken to ensure that there are checks and balances when using Big Data. Big Data analytics are only useful if the data is accurate and if the analysis of the data is context relevant. Therefore, Big Data analytics alone should not be used to make decisions, but rather, Big Data coupled with public engagement and experiential knowledge should make predictive analytics and decision-making more effective.

The second question is how Big Data is being used to address issues related to social equity? We examine three primary ways that Big Data relates to social equity. First, making data available and accessible can promote more social equity and open data portals are the primary way cities are doing so. But open data portals alone do not lead to equitable outcomes. While open data portals provide data to the general public, having data available does not ensure that every resident within a city is able to access, analyze, or use it for their benefit. Truly innovative municipal governments should aim to promote widespread access and understanding of data and technologies among a broad cross-section of the population, especially groups that are traditionally disadvantaged and digitally disconnected. Boston's MONUM, for example, does not operate Boston's open data portal and instead focuses their resources on utilizing new technologies to improve citizen engagement experiences, education learning tools, and streetscapes.

None of the Offices of Innovation studied have programs that directly engage or teach the public how to maximize the potential of open data portals. The one organization that is attempting to teach disadvantaged populations about the benefits of open data is LISC Chicago, a non-profit community-based organization. Expanding these types of sessions through partnerships established between Offices of Innovation and local community groups would be one way of making the open data movement have greater impact and reach.

The second dimension of equity, digital access and literacy, has been an area of concern for four of the five cities in our study. Using federal funding aimed at digital access and literacy programs, each city has struggled, to varying degrees, to continue these efforts after the funding expired. Chicago's efforts at bridging the digital gap has continued due to the efforts of non-profits, such as LISC Chicago and local public investment. Chicago's work highlights the importance of federal funding, local planning, and effective collaborations with non-government organizations. The city of Boston also has innovative programs, such as Tech Goes Home, that addresses digital access and literacy. Furthermore, bringing city services to neighborhoods through City Hall to Go is reframing the relationship between Boston's City Hall and the public by providing direct access to municipal staff and services on the van. Residents are able to interact directly with decision-

makers, and benefit from spending less time and effort to receive municipal services when the van arrives in their neighborhood.

Understanding how Big Data can be used to address issues of equity is complex, due to the various dimensions of equity that can be considered. Each of the cities studied have been focusing on some issues of equity, but none have taken a comprehensive, multi-faceted approach to social equity. Big Data and new technologies have the potential to address thornier wicked issues if different policy questions and priorities were raised and if there is political support for it. Our study suggests that cities using Big Data have opted to more frequently tackle questions focused on system optimization rather than on targeting social inequality.

Appendix: Case Study Cities

Boston Department of Innovation and Technology (DoIT)

The city of Boston has a unique structure for their office of innovation. Their office is called the Boston Department of Innovation and Technology or DoIT and is housed in Boston's City Hall. Their primary role is to collect, manage, and organize Big Data. DoIt is also the city's internal social media team and operates a coordinated, data-driven, strategy across all social media platforms, such as Facebook and Twitter, with the goal of curating daily engagement to help improve residents' quality of life ("Boston's Mayoral Transition", NextBoston). The city has a social media policy and an organizational strategy to support this work with a social media liaison positioned in each of the city's departments. Due to these efforts, Boston's social media strategy has received national recognition and has seen exponential growth in terms of engagement with the public. For example, in 2013, the City of Boston's Facebook page followers grew by 200 % and the page's reach grew 400 % between 2012 and 2013 ("Boston's Mayoral Transition", NextBoston).

DoIt collaborates very closely with the Mayor's Office for New Urban Mechanics or MONUM. According to the Co-Founder of MONUM, the department, "serves as a complementary force for city departments to innovate city services and we're there to support them. . .[and unlike DoIt], MONUM has a great deal of independence and the ability to be innovative while not being encumbered by maintaining and supporting the innovation" (personal communication, March 19, 2014). Because MONUM is not managing the Big Data, the department focuses on piloting innovative, and sometimes risky programs that if successful, will be scaled up within a city department or city-wide. Thus, they are provided the freedom and flexibility to be creative and innovative. In 2013, Boston was named the #1 Digital City in America by the Center for Digital Government's annual Digital Cities Survey. Between the efforts of DoIt and MONUM, and their social media strategy, the city of Boston is widely regarded as one of the leading Big Data innovators in municipal government.

Chicago Department of Innovation and Technology (DoIT)

In Chicago, the office of innovation is also known as the Department of Innovation and Technology (DoIT). This department takes a "comprehensive approach to data and analytics" and focuses their efforts on several key programs, including Chicago's Digital Excellence Initiative, the Smart Communities program, and implementing Chicago's Technology Plan, a comprehensive plan of five strategies and 28 initiatives to improve Chicago's efforts in innovation and technology (Personal Communication, March 21, 2014). Since Brenna Berman was promoted to Chief Information Officer in late 2013, the department's efforts have emphasized Ms. Berman's personal vision of "resident-centered technology and innovation," as well as internal innovations that foster data-driven decision making, such as predictive analytics programs, internal dashboards, and modernizing existing systems into user-friendly applications (Thorton, "Chicago Welcomes New CIO Brenna Berman").

Louisville Department of Economic Growth and Innovation

In early 2012, Louisville's Economic Development Department was restructured to become the Department of Economic Growth and Innovation. Ted Smith, previously the Director of Innovation, was appointed the Director of this new department. Louisville's Department of Economic Growth and Innovation is a separate but coordinated department of the Louisville Metro Government, a regional government entity. According to Smith, the Department has three primary goals: (1) civic innovation, such as new approaches to community engagement, (2) government innovation, particularly innovating existing government processes, and (3) service of performance improvement, including creating internal dashboards, establishing cultural methodologies, and improving outcomes from a "bottom-up" perspective (Personal communication, February 27, 2014). Louisville's Department takes a very unique approach to innovation, fusing economic growth and development principles and innovation. Much of the Department's efforts are focused on making the city more attractive to private businesses as well as developing digital platforms and infrastructure that can benefit both the city's residents and the private sector.

New York Mayor's Office of Data Analytics (MODA)

New York City's innovation office is known as the Mayor's Office of Data Analytics (MODA). MODA works in coordination with New York City's Department of Information Technology & Communications (DoITT). NYC DoITT is

primarily responsible for managing and improving the city government's IT infrastructure and telecommunication services to enhance service delivery for New York's residents and businesses. MODA was officially established by an executive order from Mayor Bloomberg in April 2013, but the agency had been working informally within New York City government for several years previously under the name "Financial Crime Task Force" (Personal Communication, February 24, 2014). MODA manages the city's Open Data portal and works extensively on data management and analytics using their internally developed data platform, known as DataBridge. In order to establish DataBridge, MODA collaborated with DoITT to consolidate references for each building address in the city throughout all of the city's agencies into one database, so that when one searches by address, all of the information from every department is accessible in one place (Nicholas O'Brien, personal communication, February 24, 2014). MODA operates specific projects to improve processes or gather more information about the city's operations. MODA's projects typically fall into one of these four categories: (1) aiding disaster response and recovery through improved information, (2) assisting NYC agencies with data analysis and delivery of their services, (3) using analytics to deliver insights for economic development, and (4) encouraging transparency of data between the city's agencies, as well as to the general public.

Philadelphia Office of Innovation and Technology (OIT)

Previously known as the Division of Technology, Philadelphia's Office of Innovation and Technology (OIT) was established in 2011 (Wink, "Office of Innovation and Technology to replace Division of Technology at City of Philadelphia", 2013). Prior to reinventing and restructuring the office to include innovation, the Division was responsible for the city's day-to-day technological operations. Philadelphia OIT was created as the city began changing its culture and projects that were more innovative externally, as well as internally within the infrastructure of municipal government. While Philadelphia OIT is responsible for all major technology initiatives in the city, the department is broken into 11 units, one of which is Innovation Management. The Innovation Management unit's responsibilities fall under three internal categories: (1) open data, (2) civic technology, including mobile applications, and (3) innovation (Personal communication, February 28, 2014). The innovation category was established as the Philly KEYSPOT initiative was launched, a federally funded public-private partnership that established approximately 80 public computing centers in communities and provides residents with Internet access and training.

As mentioned earlier, the city of Boston's Mayor's Office of New Urban Mechanics has a satellite office in Philadelphia with the same name. According to Almirall et al. (2014), Philadelphia's MONUM is referred to as a civic accelerator, which is an organization that "match(es) cities with start-ups, private firms, and non-profit organizations interested in partnering with government to provide better

services, bring modern technology to cities, or change the way citizens interact with city hall" (p. 4). MONUM's Philadelphia office is also located in city hall and its mission to transform city services and engage citizens and institutions throughout the city to participate in addressing the needs of city residents.

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