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Data, Analytics and Community-Based Organizations: Transforming Data to Decisions for Community Development

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ABSTRACT

The past ten years have seen a revolution in two disciplines related to operations and strategy design. "Big Data" has transformed the theory and practice of producing and selling goods and services through methods associated with computer science and information technology. "Analytics" has popularized primarily quantitative models and methods by which organizations and systems can measure multiple aspects of performance. As these fields rely on information technology to collect, store, process and share data, we refer to the collection of knowledge and applications associated with Big Data and analytics as "data analytics and information technology." The impacts of data analytics and information technology (IT) are most visible in the actions of for-profit organizations and government. The not-for-profit sector has a more ambivalent relationship with Big Data, analytics and information technology. This is particularly true for mission-driven community-based organizations (CBOs) with limited budgets and small staffs. What role can the Big Data and analytics movements play for nonprofit organizations, especially community-based organizations, and the communities they serve? Will the benefits that accrue to nonprofits from substantial investment in data- and analytics-related technologies and processes justify their costs?

This paper reviews the current state of research and practice of data analytics and information technology with a focus on community-based organizations. I argue that there are a number of dimensions along which the needs of CBOs differ markedly from other organizations with respect to data and analytics.

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Through descriptions of technologies that support data analytics for nonprofit organizations, and frameworks for data-driven analysis, I develop principles to support theory development for CBO data analytics and IT, and perform field research to evaluate propositions related to capacity of CBOs to make productive use of data. Finally, I describe opportunities for specific research projects that that will serve as an opportunity for theory-building, data analysis and information technology solution design.

I. INTRODUCTION

Statistics and anecdotes about the changes that new data and information technologies have wrought throughout our society can seem commonplace nowadays, and the technologies themselves ubiquitous, yet it's worth reminding ourselves of the scale and scope of the information revolution: By 2015, there will be 8 zettabytes of data created by 3 billion internet users worldwide, enough data to fill the Library of Congress 1.8 million times over (Ammirati, 2011). According to Brynjolfsson, Hitt and Kim, heads of for-profit organizations are now using data analytics to make critical decisions, rather than going with their "gut"; American companies that used data-guided management processes improved outputs and productivity by 5 to 6% (2011, p. 5).

Data not only makes companies more productive, it helps them create new opportunities and find new markets. Thanks to the growth of mobile technologies and geographic information systems (GIS), data can be used to analyze customers' spatial patterns, which can help firms decide where to locate and which markets to exploit (Bollier, 2010, p. 16 - 17). The BBC's Channel 4 CEO David Abraham declared that "data is the new oil"; it not only a valuable commodity, but it also provides the energy which firms and organizations will need to run successfully (Mateos-Garcia, 2014).

The focus of this paper is on two movements related to data and information technologies – "Big Data" and "analytics" – and a specific sector within the U.S. economy that has been affected by these movements – community-based organizations (CBOs). "Big Data" has transformed the theory and practice of producing and selling goods and services through methods associated with computer science and information technology. "Analytics" has popularized models and methods by which organizations and systems can learn

more about data that may improve multiple measures of performance. Both of these fields rely on information technology to collect, store, process and share data. Thus, we refer to the constellation of knowledge and applications associated with Big Data and analytics as "data analytics and information technology".

The impacts of data analytics and IT are most visible in the actions of for-profit organizations as well as government. Companies such as Amazon, Google and Facebook have used data analytics and IT to predict customers' reactions to new services and to design products more responsive to customers' needs (VisualNews.com, 2013). Government uses data analytics and IT to implement and manage services such as health insurance through the Affordable Care Act, and also to analyze citizens' behaviors for national-security purposes. However, I will show that the not-for-profit sector, which provides essential services to diverse populations, has a more ambivalent relationship with data analytics and information technology. This is particularly true for smaller, mission-driven CBOs.

One example of this tension is a community-based organization in Boston (a key informant for a pilot study conducted for this paper, described below), which has expressed an awareness of sophisticated Web-based applications designed to provide relevant data for CBOs to develop new programs and services, but believes that these applications do not tell them anything that they do not already know. This is so even as they acknowledge a lack of capacity to take full advantage of Big Data and analytics applications. Another example of this tension is the controversy in the nonprofit community regarding reporting overhead ratios as an organizational performance measure. In this case, pressure to reduce overhead, including cost categories such as information technology, and a lack of willingness on the part of funders to support overhead-related expenses, results in perverse incentives to underfund, or misrepresent, overhead-related activities (Nonprofit Quarterly, 2013). One can conclude, then, that advocates for data analytics and IT for nonprofits need to demonstrate that effective data collection and analysis can add value, are cost-effective and worthy of external support.

Nonprofits, including community-based organizations, are faced with the imperative of documenting impacts of their work using data that may reside with stakeholders inside as well as outside the organization and developing a better understanding of the purposes for which data are collected and the uses to which it is put (Boland, 2012). This analysis requires a theory by which the data can be analyzed, may entail multiple

analysis efforts, and must account for policy context (Boland, 2013). As a first step to contributing to this theory, this paper will address the following research question: How can community-based organizations use data analytics and information technology to create information and make decisions that better fulfill their organizational missions? Specifically, we will answer the following questions: (1) How do CBOs access and use data for operations and strategy design? (2) What challenges do CBOs face in making best use of data and analytics? (3) How can data and analytics enable CBOs to identify and solve mission-aligned decision problems? Later in the paper we propose ways to learn about the relevance of these research questions to the larger nonprofit sector.

A. *The Nonprofit Sector and Community Based Organizations*

We distinguish between three broad categories of organizations in the American economy: for-profit organizations, non-profit organizations, and government organizations. For-profit organizations are designed to generate profit, i.e., to have revenues exceed costs; owners may distribute profits to themselves, to the firm, or to shareholders (Free Management Library, 2014). Non-profit organizations are organized for purposes other than generating profit and in which no income is distributed to their members, directors or officers. Nonprofits are organized under state law and may qualify for exemption from taxation and other legal privileges (Legal Information Institute, 2014). Government can be construed broadly as the process by which people are governed, i.e., governance, or by which state policy is enforced, by entities comprising legislators, administrators and arbitrators (Mirriam-Webster, 2015).

Within the nonprofit sector, we distinguish between those federally-registered organizations that receive tax exemptions under section 501(c) of the federal tax code and those that do not. Approximately 1.56 million of 2.3 million nonprofit organizations in the U.S. are registered with the Internal Revenue Service, contributing $804.9 billion to the U.S. economy in 2010, comprising 5.5% of the U.S. gross domestic product. Of these, about 980,000 nonprofits are 501(c)(3) public charities, and of these about 366,000 nonprofits who have $25,000 or more in revenues have filed forms with the IRS listing revenues and expenses (Blackwood, Roeger and Pettijohn, 2012, p. 4).

Non-profit organizational missions are also classified by the IRS according to organization type using a

system developed by the National Center for Charitable Statistics at the Urban Institute (2014). The Urban Institute has found that the nonprofit sector is diverse and growing, and that revenues are dominated by fees and services from private sources, and fees, services and grants from government. According to Blackwood, Roeger and Pettijohn (2012, p. 3 - 4), human services, such as food banks, homeless shelters, youth sports and family or legal services comprise 34% of all NPOs; similar statistics for other NPO categories include education, comprising mostly other education institutions such as booster clubs and PTAs, as well as higher education (18.2% of all NPOs); health, comprising hospitals and other primary care facilities, and other health care services (12.1% of all NPOs); public and social benefit, such as civil rights, advocacy and race/ethnicity affinity organizations (12.0% of all NPOs), and many other organization types.

Total revenue for all NPOs has increased by 81% between 2000 and 2010, from $837 billion to $1.5 trillion, while total assets have increased from $1.5 billion to $2.7 billion in the same period. Nearly three-quarters of NPO revenues are comprised of fees for goods and services from private sources (49.6%) and from government (23.9%), with another 8.3% resulting from government grants. The remainder of NPO revenues comes from private contributions (13.3%), and investment and other income (4.9%) (Blackwood, Roeger and Pettijohn, 2012, p. 3). Higher education and hospitals, which produce over 60% of all NPO revenues, account for less than 3% of all NPOs (Blackwood, Roeger and Pettijohn, 2012, p. 4). Private charitable donations to NPOs, estimated at $286.91 million in 2010, have declined in recent years due to the recession. Of these donations, foundation giving comprised $45.7 billion in 2010. Separately, the value of volunteer labor is estimated to be $296.2 billion (Blackwood, Roeger and Pettijohn, 2012, p. 4 - 6).

Within the NPO sector, we focus in this paper on those that are classified by The Boston Foundation as "grassroots" and "safety net" organizations; the former have budgets of $250,000 or less, while the latter have budgets between $250,000 and $50 million (2007, p. 8). Within Massachusetts, grassroots organizations, while comprising over 55% of all NPOs in 2003, account for less than 1% of revenues, spending and assets; safety net organizations, about 43% of all NPOs, account for about 27% of revenues and spending, and about 19% of assets (The Boston Foundation, 2007, p. 26). The Boston Foundation also classifies NPOs according to business model, distinguishing between "large institutions," which are asset-intensive and show economies of scale, typically health and education organizations; "service providers,"

which meet needs in housing, human services and health care on behalf of government; "support organizations," which provide fundraising and other services on behalf of NPOs; "membership organizations," such as advocacy groups, cultural organizations and associations, and "expressive voice organizations," such as small community and cultural groups (The Boston Foundation, 2007, p. 27).

Community-based organizations (CBOs) are defined by the National Community-Based Organization Network as "driven by community residents in all aspects"; they are characterized by predominately locally-defined needs and services and locally-based and -directed program design, implementation and evaluation (NCBON, 2011). Alternatively, "grassroots community-based organizations" are defined by size (10 or fewer employees and a budget of $500,000 or less, or four or fewer employees and a budget of $250,000 or less (National Crime Prevention Council, undated, p. 3)). Using these definitions, and the classifications of NPOs provided above, I propose for the purposes of this paper that CBOs are grassroots and safety net organizations with the following characteristics:

- relatively small budgets ($2 million or less);
- classified primarily as health and human service providers, community and economic development organizations, membership organizations and smaller education organizations;
- addressing the needs of low-income and underserved populations, whose constituents are often defined by explicit spatial boundaries or social groupings, and
- specializing in services that provide direct contact with constituents such as community development, human services and advocacy.

As we will show later in this paper, these organizations, being mission-driven, locally-focused and resource-constrained, have special needs with respect to data analytics and information technology.

B. *Research and Practice Motivation for Non-Profit Organizations*

Distinctions between nonprofit organizations and for-profit organizations and government go well beyond distinctions of profit orientation and political and social representation; they address as well the nature of planning for day-to-day tasks of goods production and service delivery ("operations") and longer-term goal-setting and organization design ("strategy"), as well as the nature and goals of resource acquisition

and accountability for funds acquired and expended. As these two dimensions of organization characteristics are salient to data analytics and information technology adoption and usage, we address each in turn.

The first part of this research and practice motivation for CBO data analytics and IT is associated with defining the range of tasks associated with nonprofit planning and operations broadly according to the nature of the organization, as well as specifying methods used to analyze the organization's performance of these tasks. Three streams of research related to planning and operations are: economic development, community development, and humanitarian logistics.

Economic development is defined as a process to improve the economic well-being of an area, encompassing programs to achieve macro-economic goals related to growth and employment, investments to provide services and build infrastructure, and programs to improve the quality of life for businesses (International Economic Development Council, undated). Within the context of organizations that follow the Main Street model of local economic development, Seidman has summarized a number of best practices associated with successful initiatives that center around collaborations, targeted physical improvements and improved business financial planning and operations, among others (2004, p. 3). Many activities related to economic development require extensive data regarding business and community characteristics, as well as the need to communicate these characteristics so as to provide businesses with the information they need to locate and grow within communities, and provide goods and services needed by local residents in a profitable and sustainable manner.

Community development can comprise the collection of services, interventions and initiatives that improve the lives of residents in a community. This can be achieved through "place-based" initiatives, i.e., improvements to the physical environment, such as housing, schools, parks and other amenities that are fixed in space, as well as "people-based" initiatives, i.e., services that increase the capacity of individuals to provide for their own and their family's economic, social and housing needs, no matter where they may live, work or play (Belsky and Fauth, 2012, p. 75). Erickson, Galloway and Cytron argue that the extensive needs associated with community development require a new organization – a "quarterback" – that can coordinate many local initiatives across sectors, manage data to identify the most appropriate strategies that balance investments in human and physical capital, and secure appropriate funding (2012, p. 382). The quarterback's

work will be greatly assisted by access to timely, comprehensive and easily- communicated data to build support for a range of initiatives.

Humanitarian logistics is a field of study rooted in operations research and management science that addresses analytic models to help organizations anticipate and respond to sudden-onset or slow-onset disasters, both natural and man-made, as well as long-term human and physical development, often within a developing country context (Çelik et al., 2012, p. 2). As many stakeholders in disaster and development planning are NPOs, and the phenomena defined above are localized and disproportionately affect disadvantaged populations, humanitarian logistics is an appropriate lens through which to view data analytics and information technology for community-based organizations.

We move now from a view of application areas for which CBO data analytics and information technology are salient to a discussion of two specific domains within which solutions useful to community-based practitioners might be crafted. The first is called "nonprofit operations management" (nonprofit OM), a term defined by Privett to encompass the problems of *supply* (fundraising, income- earning), *production* (achieving defined objectives, centralization and collaboration and means by which goods and services are made) and *consumer behavior* (consumer-side competition, and performance measurement and evaluation) (2011, p. 68-69). Berenguer and Shen emphasize the role that analytic decision models play in nonprofit OM, as well as the data needed to solve them and information technologies needed to implement solutions derived from them (2014, p. 2). Another perspective on decision models and information technologies for CBOs is provided by "community-based operations research" (CBOR). Johnson defines CBOR as a collection of models, methods and processes that is designed to provide insight to complex planning and operations problems of a local character, where community participation in problem formulation, problem solving and solution implementation is central (2012, p. 4 - 5). CBOR implies a focus on participatory action research methods and community informatics. We will have more to say about these methods later in the paper.

The second part of the research and practice motivation for CBO data analytics and information technology are application areas, of which we focus on funding, accountability and advocacy. "Funding" refers to the range of methods by which NPOs and CBOs generate revenue. Methods may include private

donations, foundation grants, government contracts, and volunteer labor, as well as revenue from social enterprises (Blackwood, Roeger and Pettijohn, 2012, p. 3). "Accountability" can be understood as a social process through which nonprofits attempt to demonstrate value and effectiveness, and stakeholders (funders, government, regulators and clients) attempt to assess nonprofits. Accountability is measured in three ways. *Performance management* is the set of processes by which organizations collect and assess measures of effectiveness, efficiency, workload and productivity (MacIndoe and Barman, 2012, p. 717). *Outcomes measurement* is the collection and assessment of metrics representing desirable results or qualities of organization services (Morley, Vinson and Hatry, 2001, p. 5). *Program evaluation* is a long-term investigation of the impact of a program on clients as well as the role an organization plays in directing the program (Barman and MacIndoe, 2012, p. 77). Assessing the quality and impact of programs and services provided are activities for which data and technology resources are important, though there is not much empirical literature on how nonprofits collect or use data to demonstrate their effectiveness (Stoecker, 2007, p. 98). "Advocacy", the third primary application area for CBO data analytics and IT, encompasses efforts such as community organizing, publicizing efforts to make changes in public policy, and lobbying to increase awareness of services, increase funding levels and propose favorable changes to rules defining permissible program activities (MacIndoe and Whalen, 2013, p. 120). Data analytics and information technology are increasingly important to NPOs to build the strongest case for their products and services and to engage diverse audiences to build support for desired changes in funding or laws and guidelines (McNutt, 2006, p. 93).

C. *Paper Findings*

Through reviews of the literature, examination of actual applications and field data derived from NPO key informant interviews, observations of training sessions for software intended for NPOs and a focus group of NPO employees, we identify a number of findings that together form a response to our motivating research question, "How can community-based organizations create information and make decisions to better fulfill their missions?" First, we find that CBOs understand data analytics and information technology in ways that may differ from other NPOs. Second, data analytics and information technology may generate distinctive benefits for CBOs. Third, there is a substantial gap between available resources and actual usage of data

analytics and IT applications by CBOs. Fourth, alternative research designs for data analytics and IT can yield different types of findings for CBOs. Fifth, our preliminary field analysis yields promising support for propositions related to CBO efficacy in data analytics and IT. Finally, there appear to be substantial opportunities for a research agenda reflecting the distinctive nature of CBO mission and resources.

D. *Paper Structure*

The remainder of this paper is divided into seven sections. In section II, we discuss the unique characteristics of CBOs with respect to data analytics and information technology. In section III, we learn of specific ways that CBOs may use data analytics and information technology in daily practice. Section IV explores alternative research frameworks by which we may learn more of the nature and level of engagement of CBOs with data analytics and information technology. Section V contains propositions regarding CBO use of data analytics and information technology, and support for these propositions drawn from field data collection. Section VI uses the results from the previous section to derive principles for research and practice in CBO data analytics and information technology, which may serve as the basis for a testable theory. Section VII proposes a research agenda in CBO data analytics and information technology. Section VIII concludes.

II. BIG DATA, ANALYTICS AND CBOS

A. *Perspective on Big Data*

The term "Big Data" has its roots in the computer industry, which refers to data sets that are so large that they require the use of supercomputers (Manovich, 2011, p. 460). Manovich notes that the size of these datasets varies depending on the capacity level of the organizations; thus Big Data could refer to datasets whose size varies over multiple orders of magnitude. With the exponential growth of information technology, it is expected that the data capacity of computers and servers will increase over time. A more appropriate view of Big Data comes from Schroeder et al., who define Big Data as *data unprecedented in its scale and scope in relation to a given phenomenon* (2013, p. 3).

The value of Big Data lies not only in the size of datasets maintained by an organization, or its ability to store data, but rather an organization's capacity to connect multiple datasets and multiple users, impose

structure on these data using innovative technologies, and extract information to meet an organization's goals and develop new products (Boyd & Crawford, 2011, pg. 2; McKinsey Global Institute, 2011, p. 5 - 6; Davenport and Dyché, 2013, p. 2). It is this ability to collect data and discover correlations that prompted Chris Anderson, the Editor-in-Chief of *Wired* Magazine, to claim in 2008 that Big Data has made the scientific method "obsolete" and that algorithms will allow users to identify associations and causal relationships (Anderson, 2008, as quoted in Bollier, 2010, p. 4). Anderson's claims stem from the perception that data are endogenous to the system under consideration and the belief that the application of quantitative analytical methods provides objective validity. Thus, argues Anderson, there is little use for social science-based theories or models of human behavior.

An alternative view of Big Data is that it is not in fact self-explanatory. Every discipline and disciplinary intuition has its own norms and standards for the imagination of data (Gitelman, 2011, p. 7), and each organization has its own philosophy, which employs a distinct methodology and subjective means of "cleaning" data (Bollier, 2010, p. 8). This alternative view is particularly salient to community-based organizations. The data needed by CBOs are often complex and incomplete, meaning that no matter how well a dataset is organized and how extensive the organization's capacity to analyze it, nonprofits are unlikely to find a solution to the problems that define their mission through an algorithm. It will take a human, preferably one with a social science background, to interpret the numbers within the context of the organization, its mission, and the community the nonprofit serves (Boyd and Crawford, 2011, p. 4).

As an example, Bishop (2010) analyzed the use of geographic information systems among nonprofits in Columbia, Missouri. One non-profit executive interviewed expressed his frustration with data on child abuse and neglect from the Missouri Department of Social Services. The executive found the data provided by the Department of Social Services to be very limiting, while the data his organization derived from their crisis hotlines better captured measures of child abuse and neglect, because they use a broader definition (p. 11, 14).

If data available to NPOs and CBOs are decentralized, incomplete and subject to multiple contextual interpretations, then better-quality data, analyzed more effectively, may yield two primary benefits to nonprofits that are less important to for-profit organizations. First, the data will help these organizations to better execute

their mission, their capabilities, and the communities they serve in order to help them tell the world their story (Taylor, 2014). Second, the data will provide a means to create meaningful dialogue, consensus building and community empowerment among multiple stakeholders (Ferreira, 1998). This could also result in increased support from various stakeholders.

B. *Nonprofits' Data Analytics Needs and Challenges*

The literature on Big Data is oriented towards application in the private sector, under the assumption that firms can attain capital from investors for data upgrades (Hackler and Saxton, 2007, p. 22). Many nonprofit organizations, however, face a variety of limitations to increasing their data analysis capabilities. Unlike venture capitalists, private and public funders are reluctant to help organizations improve their technological infrastructure (Al-Kodmany, 2012, p. 279). Though perhaps sympathetic towards the idea of improving IT infrastructure, many funders are not well-trained in data analytics and lack sufficient understanding of the data that nonprofits use for grant applications or program evaluation (Stoecker, 2007, p. 17 - 18).

Another perspective on Big Data is related to its cost and availability. The growth of Big Data comes from the fact it is a large and lucrative market, expected to be valued at $16.9 billion by 2015 (Lohr, 2012). This means there is a potential for a digital divide between organizations, where larger well-funded organizations will have the means to access and use Big Data effectively, while smaller organizations will struggle to survive (Boyd & Crawford, 2011, p. 8 – 10, 12). This digital divide may lead to the creation a three-tier class system among non-profit organizations and professionals: 1) those that create the data, 2) those that are able to collect data, and 3) those that are able to analyze it (Manovich, 2011, p. 471). The third group is both the smallest and the most skilled, which means that organizations that can employ the services of this group will be the ones that are best positioned to succeed (Boyd & Crawford, 2011, p. 13).

Nonprofits face internal constraints to making the best use of hardware, software and professional expertise for data analytics and information technology. For-profit organizations tend to place greatest emphasis on software tools such as Hadoop and R for large tabular datasets and ArcGIS for spatial datasets that require extensive training and maintenance (Revolution Analytics, 2014). However, over half of

nonprofits surveyed by Hackler and Saxton (2007) spend less than 2% of their budget on IT infrastructure, i.e., hardware, software, and maintenance, and only 36% of organizations budget for IT training at all (p. 12). NPOs thus face the challenge of choosing data analytics technologies that are appropriate to their extensive needs and limited resources.

Beyond the choice of appropriate data analytics technologies, nonprofits have limited resources to attract and train professionals to deploy qualitative and quantitative skills to tell a nuanced story about organization needs and missions (Boyd and Crawford, 2011, p. 12). While 84% of nonprofits surveyed had a full-time staff person to provide tech support, over a quarter of them were volunteers, friends, or interns. This human resource shortage is bifurcated by organization size: among organizations with a budget of less than $1 million, 86% had to rely exclusively on volunteers, and only organizations with budgets of over $5 million had a full time IT support staff (Hackler and Saxton, 2007, p. 13).

Since the average nonprofit organization has five paid staff members and four volunteers (Stoecker, 2007, p. 108), it is difficult for NPOs to attract and retain data analysts with the qualitative and quantitative skills needed to tell nuanced stories about nonprofit missions. Such individuals, once trained, become attractive to other, often for-profit organizations. According to one nonprofit vice president: "It's been my experience that as soon as we trained someone in the GIS and they became fairly good at it, that person would offered a salary three times higher by someone in the private sector" (Specht, 1996, quoted in Al-Kodmany, 2012, p. 294). Such instability in the ranks of data analysts makes it difficult for knowledge to be diffused through the organization (Sieber, 2000, p. 26). These findings are summarized in Figure 1, below.

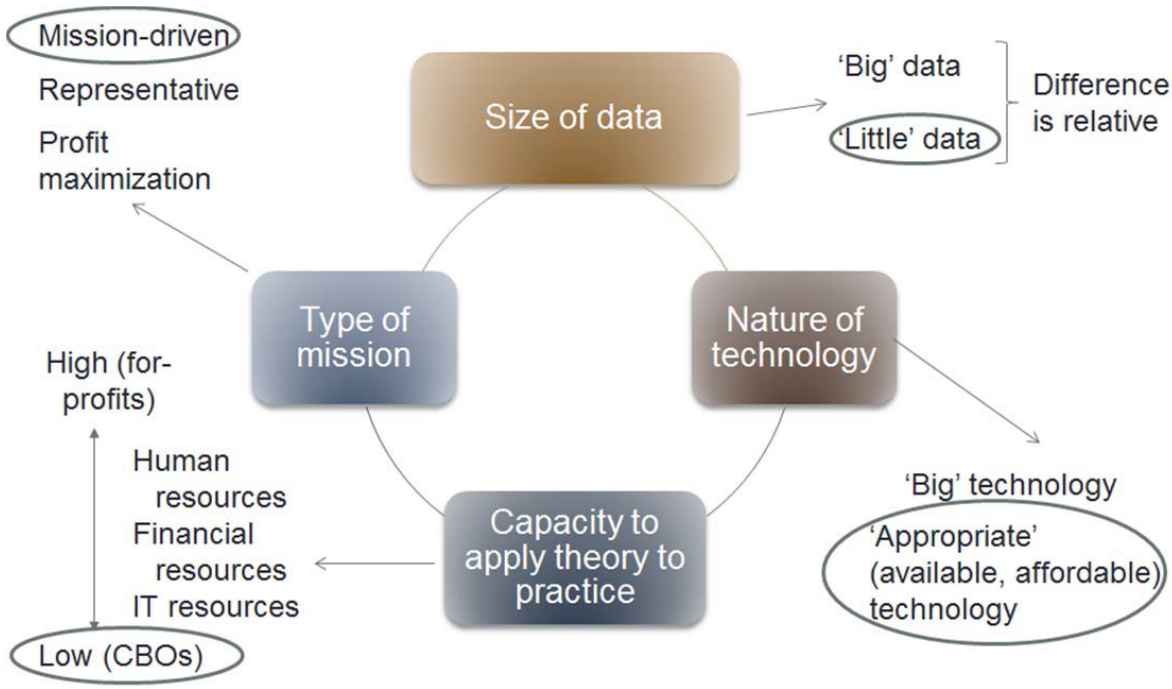


Figure 1: Organization Characteristics Associated with Big Data and Analytics

This figure shows that NPOs, and especially mission-driven CBOs, are designed to meet social needs of communities that may not be addressed by representative government or profit-maximizing firms. While the precise nature of "Big Data" is context-dependent, NPOs tend not to have the need for truly large datasets or expensive and sophisticated technology as compared to those used by government or for-profit organizations. Finally, personnel, finance and technological limitations restrict an NPO's ability to apply theory to practice. In the following section, we review a number of currently available data analytics technologies that show promise for NPOs to fulfill their social missions.

III. How CBOs Can Use Data Analytics and Information Technology in Practice

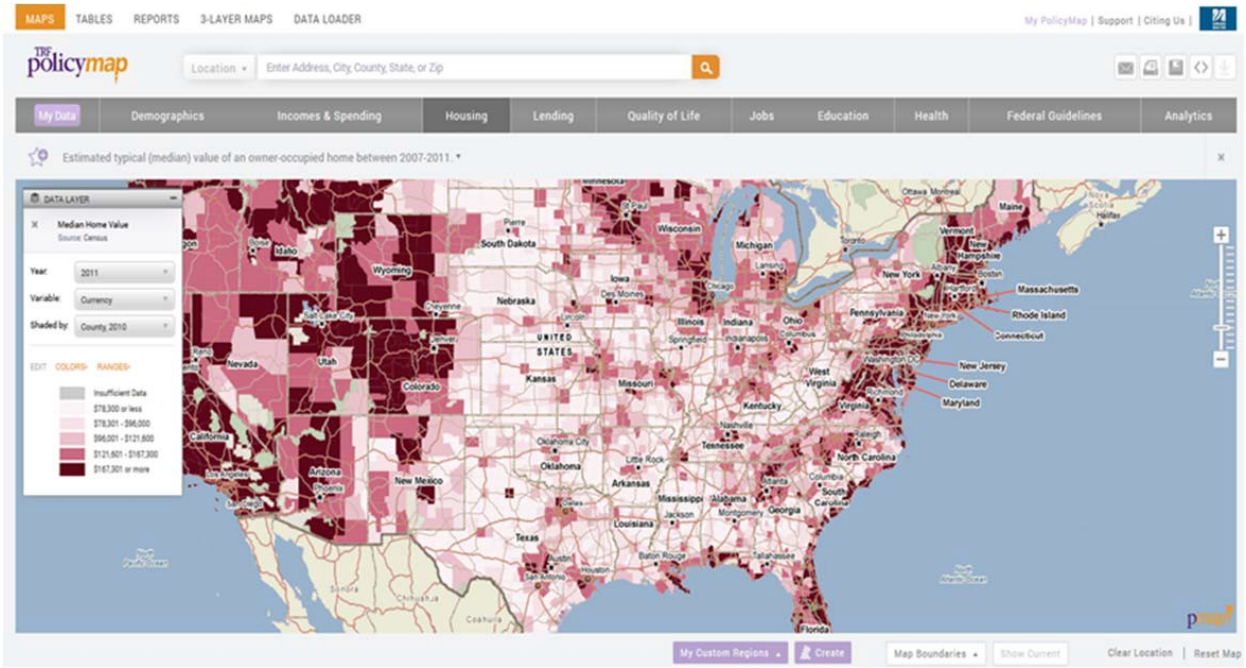
This paper is an effort to assess the state of art and practice regarding the use of mission-relevant data analytics and information technologies by community-based organizations and, in so doing, to make a contribution towards theory in this area. By "mission-relevant," we refer to software technologies whose use is designed to help CBOs generate insights and evaluate alternative courses of action related to operations and

strategy planning in order to help them fulfill their missions. We exclude from consideration, then, "generalist" software such as office productivity applications and well-known analytic methods such as logic maps or program evaluation that are not closely associated with data analytics and IT specifically.

This initial and incomplete survey of data analytic methods and software described in this section is divided into three parts. The first describes software whose innovation resides largely in novel ways to explore spatial data that are particularly salient to CBO practices and missions. The second category consists of applications that generate visualizations of data that are not primarily spatial in nature. The last category describes data-driven analytic methods by which spatial and non-spatial data alike may be used to generate insights and prescriptions for action, both short-term and long-term—methods that are especially relevant to CBO practices and capabilities.

A. *Visualization Based Technologies*

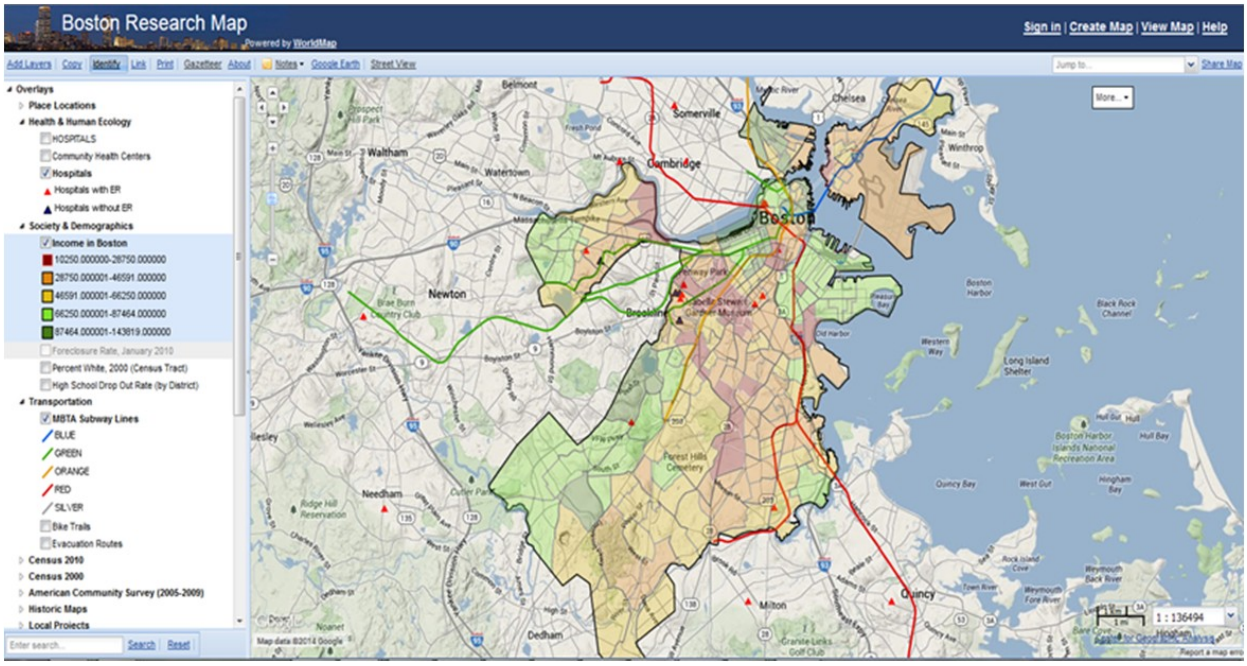
The Reinvestment Fund's PolicyMap (http://www.policymap.com/) is a Web-based mapping application that can enable practitioners and researchers at all skill levels to create maps at a variety of levels, from neighborhoods to the entire U.S., using over 15,000 datasets in demographics, housing, lending, consumer spending, education and many other categories. An example of PolicyMap is shown in Figure 2, below.



Source: http://www.policymap.com

Figure 2: Visualization-Based Technologies: PolicyMap

By allowing the user to overlay up to three distinct datasets and to perform many common mapping functions, PolicyMap allows resource-constrained CBOs to avoid the cost of expensive geographic information systems software and training. PolicyMap, for all of its advantages in providing a wide range of spatial data in an easily-understood Web browser interface, is suboptimal in two ways: its code is proprietary, and it is PolicyMap's managers who decide which datasets to share with their users. A recent initiative of Harvard University's Center for Geographic Analysis, called WorldMap, addresses these concerns through an open-source mapping application that is based on user-developed spatial data content that can be modified in various ways to create professional-quality maps. Moreover, WorldMap allows maps to be shared with specific groups of users and data to be exported. One instance of WorldMap, designed to meet the needs of users in the Boston metropolitan area, is called Boston Research Map (http://worldmap.harvard.edu/boston), and is shown below in Figure 3.

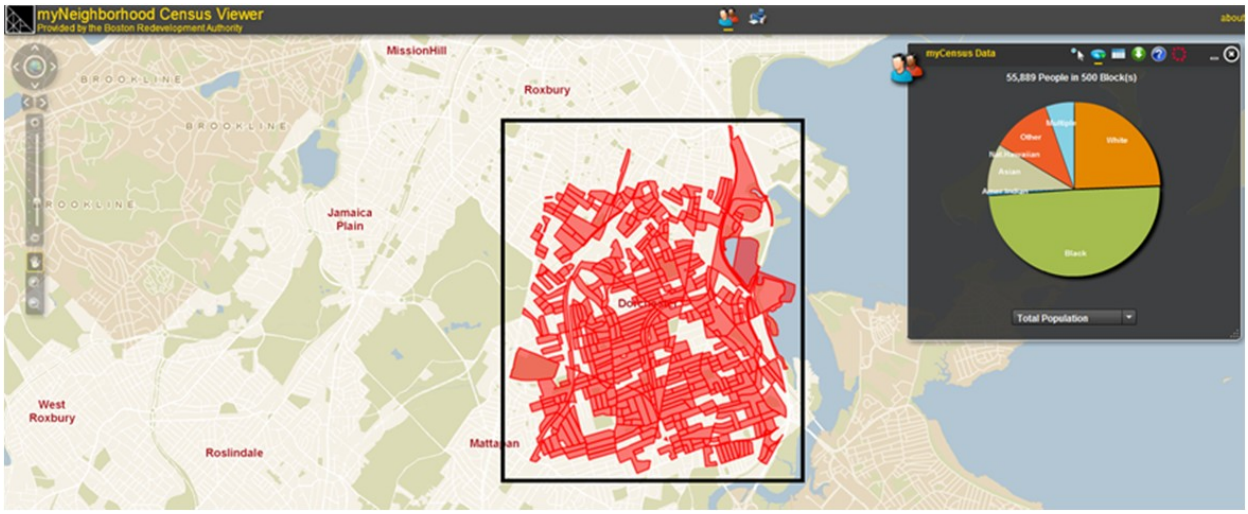


Source: http://worldmap.harvard.edu/boston/

Figure 3: Visualization-Based Technologies: Boston Research Map

Boston Research Map relies on the deep knowledge of local researchers and practitioners to enable users to explore neighborhoods in the Boston region via many different historical and contemporary spatial datasets.

Applications such as PolicyMap and Boston Research Map rely on the display of extensive datasets using commonly understood geographic units such as Census tracts and municipality boundaries. In many community applications, however, local residents may not feel their neighborhoods correspond to administratively defined boundaries. This real-life example of "mental mapping" (Mantaay and Ziegler, 2006, p. 58 - 60) may make it difficult for CBOs to perform customized analyses in ways that their constituents see as relevant to them. In response, the Boston Redevelopment Authority has developed a web-based application called MyNeighborhood Census Viewer (http://hubmaps.cityofboston.gov/myneighborhood/) that allows users to draw boundaries that define communities that reflect their own interests, and to assemble demographic characteristics of these new communities using 2010 Census data at the block level. A screen capture of this application is shown in Figure 4, below.

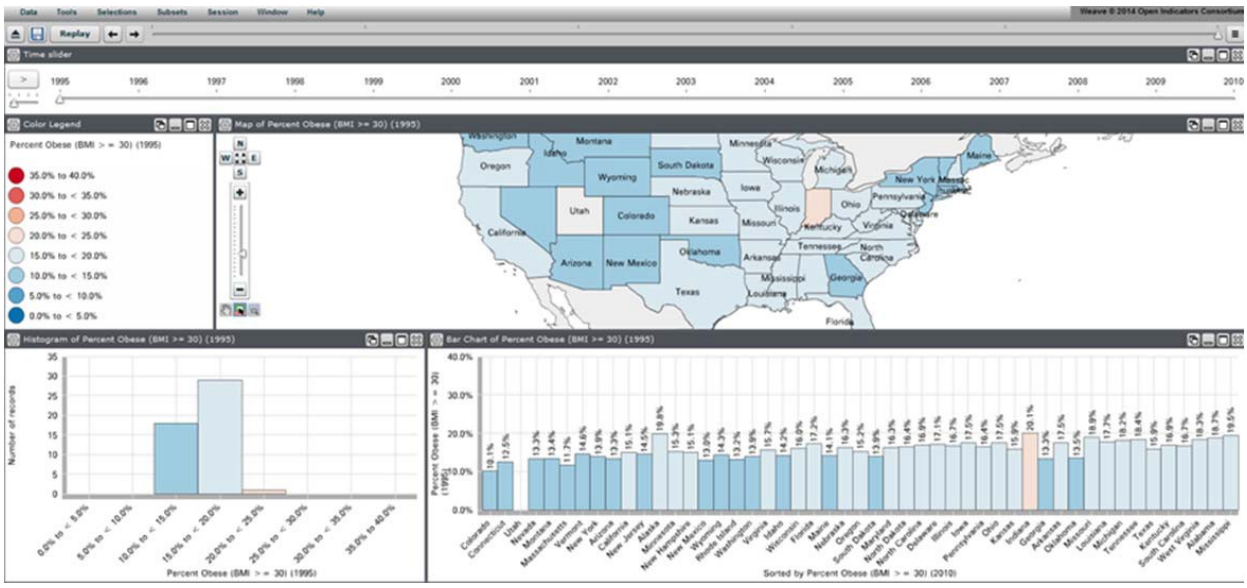


Source: http://hubmaps.cityofboston.gov/myneighborhood

Figure 4: Visualization-Based Technologies: MyNeighborhood Census Viewer

This application enables non-specialist community members as well as CBOs to better research and advocate on behalf of residents. However, this application is, to date, available for the city of Boston, only, and is limited to variables that the Census collects for the decennial Census (Boston Redevelopment Authority, 2014), which is more limited than those available for the American Community Survey, which is performed more frequently (NCSU Libraries, 2014).

Another extension of the spatial display philosophy of WorldMap/Boston Research Map is the notion that spatial analytic tools associated with workstation-based applications such as ArcGIS should be available to users and developers as a basis for customized applications. The Weave initiative of University of Massachusetts Lowell (University of Massachusetts Lowell, 2014; http://oicweave.org/) is an application development platform that allows the integration and visualization of spatial data at multiple, "nested" levels of geographies, and for these data to be displayed in map and chart form. Figure 5, below, is an example of Weave that has been specifically designed to show trends in population obesity across U.S. states over time.



Source: http://oicweave.org/

Figure 5: Visualization-Based Technologies: Weave

In this example, trends over time in obesity are made visible when the user drags a time slider at the top of the figure from left to right. Standard pan and zoom features of the map are available in the middle of the map. Nearly all features of interest for the map, including map and chart colors and breakpoints, are under the control of the user.

B. *Database Oriented Technologies*

Another category of data analytic technologies of particular use to community-based organizations are those that are specially designed to present data in the form of tables and charts, thus removing from consideration the need for users to be comfortable with spatial data analysis. One example of such an application is the Boston Indicators Project, an initiative of The Boston Foundation (The Boston Foundation, 2012; http://www.bostonindicators.org/). This website represents a decade's worth of efforts to document the state of the Boston metropolitan area through goals, indicators and measures that highlight conditions and trends by geography (neighborhoods, municipalities and regions) and specific population groups within the Boston area. Categories of indicators displayed by the Boston Indicators Project include: Civic Vitality, Cultural Life and the Arts, Education, Health, Housing and Public Safety. The Weave technology (see above)

is used to display these indicators in tabular as well as in map form. An example of indicator visualization is shown in Figure 6, below.

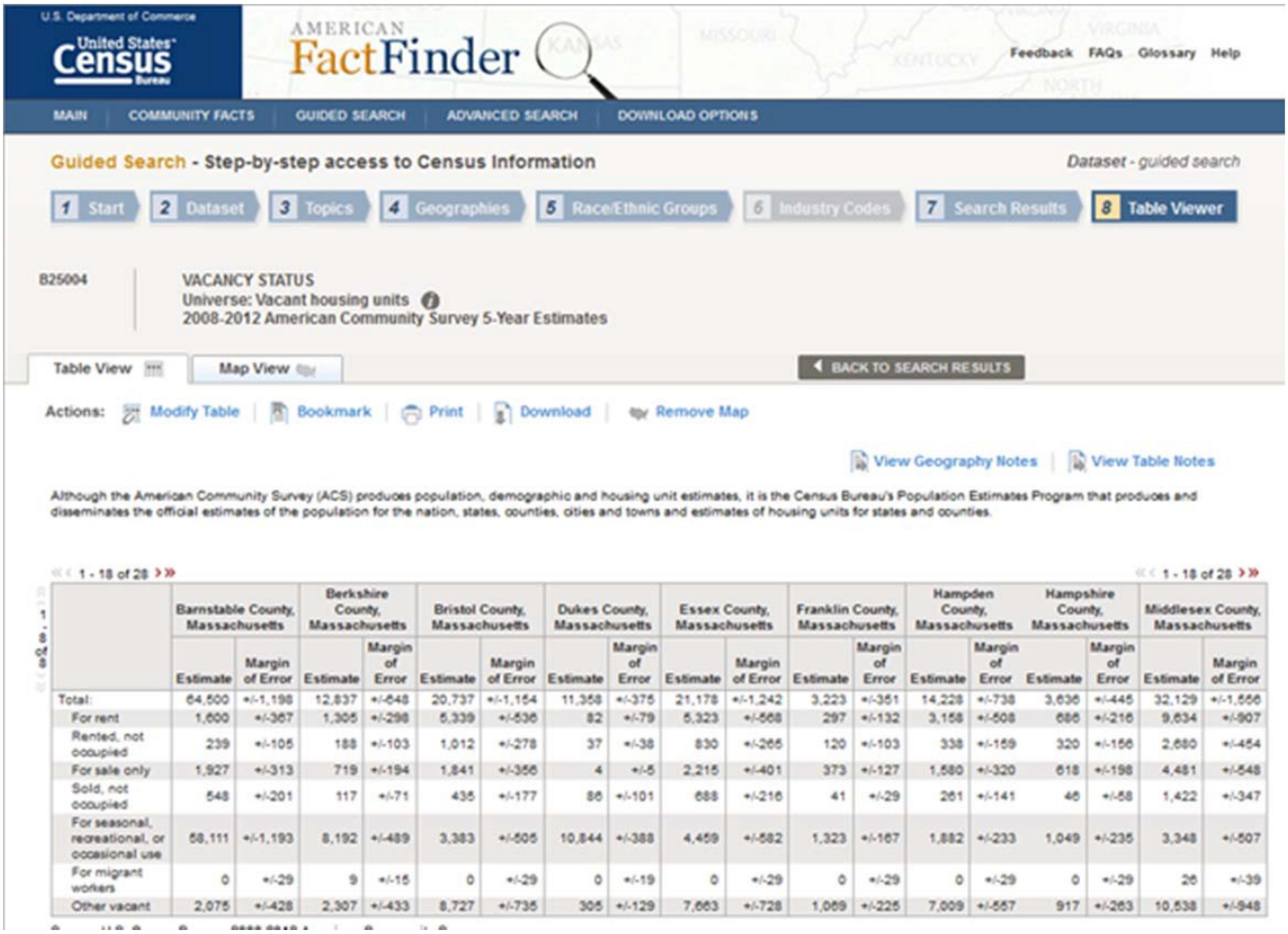
Source: http://www.bostonindicators.org/

Figure 6: Database-Driven Technologies: Boston Indicators Project

While the format of the displays (variables, colors, cut-points) is pre-defined, these displays are specially designed to be accessible to practitioners at a variety of skill levels. In addition, the data used to power these displays can be shared and downloaded, and the maps can be embedded in other documents. The Boston Indicators Project supports user-generated civic data visualizations through an initiative of the Metropolitan Area Planning Council's MetroBoston DataCommon data portal (http://metrobostondatacommon.org/); this portal, in turn, is developed using the Weave technology.

An authoritative source of neighborhood and population group data is the U.S. Census Bureau. In recent years, the Census has gone to considerable lengths to integrate multiple data sources into a more user-

friendly Web application to generate customized reports. This application, American FactFinder (http://factfinder2.census.gov), provides access to data on the U.S., Puerto Rico and island areas at multiple geographical levels (tracts, municipalities, counties, states); these data come from a multitude of sources, including the American Community Survey, the Decennial Census, American Housing Survey and the Economic Census. American FactFinder's web site allows users to create customized reports, selecting from an extensive set of variables, time frames and geographies, while obscuring from the user the details of specific datasets. An illustrative report on housing at the county level in Massachusetts is shown in Figure 7, below. These reports can be downloaded in multiple formats for analysis in other analysis packages. American FactFinder also allows users to search for and display data on maps (see the tab "Map View" in Figure 7).



	Barnstable County, Massachusetts		Berkshire County, Massachusetts		Bristol County, Massachusetts		Dukes County, Massachusetts		Essex County, Massachusetts		Franklin County, Massachusetts		Hampden County, Massachusetts		Hampshire County, Massachusetts		Middlesex County, Massachusetts	
	Estimate	Margin of Error	Estimate	Margin of Error	Estimate	Margin of Error	Estimate	Margin of Error	Estimate	Margin of Error	Estimate	Margin of Error	Estimate	Margin of Error	Estimate	Margin of Error	Estimate	Margin of Error
Total:	64,500	+/-1,198	12,837	+/-648	20,737	+/-1,154	11,358	+/-375	21,178	+/-1,242	3,223	+/-351	14,228	+/-738	3,636	+/-445	32,129	+/-1,556
For rent	1,600	+/-367	1,305	+/-298	5,339	+/-536	82	+/-79	5,323	+/-568	297	+/-132	3,158	+/-508	686	+/-216	9,634	+/-907
Rented, not occupied	239	+/-105	188	+/-103	1,012	+/-278	37	+/-38	830	+/-265	120	+/-103	338	+/-159	320	+/-156	2,680	+/-454
For sale only	1,927	+/-313	719	+/-194	1,841	+/-356	4	+/-5	2,215	+/-401	373	+/-127	1,580	+/-320	618	+/-198	4,481	+/-548
Sold, not occupied	548	+/-201	117	+/-71	435	+/-177	86	+/-101	688	+/-216	41	+/-29	261	+/-141	46	+/-58	1,422	+/-347
For seasonal, recreational, or occasional use	58,111	+/-1,193	8,192	+/-489	3,383	+/-505	10,844	+/-388	4,459	+/-582	1,323	+/-167	1,882	+/-233	1,049	+/-235	3,348	+/-507
For migrant workers	0	+/-29	9	+/-15	0	+/-29	0	+/-19	0	+/-29	0	+/-29	0	+/-29	0	+/-29	26	+/-39
Other vacant	2,075	+/-428	2,307	+/-433	8,727	+/-735	305	+/-129	7,663	+/-728	1,069	+/-225	7,009	+/-557	917	+/-263	10,538	+/-948

Source: http://factfinder2.census.gov/

Figure 7: Database-Driven Technologies: American FactFinder

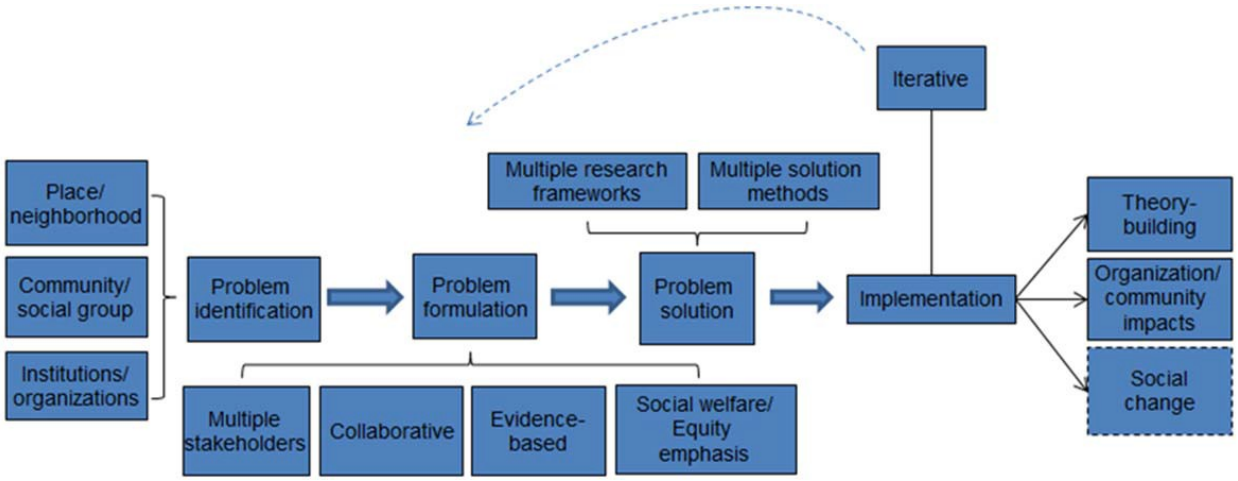
There are many other Web-based resources for community-level data. One of these is the National Neighborhood Indicators Partnership (http://www.neighborhoodindicators.org/), which reports data provided by 28 community partners across the U.S.

C. *Analytic Methodologies*

A third category of data analytics and information technology of potential use to community-based organizations is that of methodologies that enable researchers and practitioners to use data from diverse sources to make specific operations and strategic planning decisions. Here, the focus is not on retrospective analysis, such as program evaluation or performance management, which help managers and policy makers

use data to better understand the efficiency and effectiveness of particular programs, but prospective analysis, which can help managers allocate resources or design new initiatives intended to optimize multiple social objectives. As described in the Introduction, the fields of humanitarian logistics, nonprofit operations management and community-based operations research, all instances of the broader field of analytics, are well-studied domains representing prospective or forward-looking analysis. In particular, as they focus on generating policies and recommendations intended to provide specific guidance to decision-makers, they represent *prescriptive* analytic approaches, as distinct from methods to forecast uncertain conditions and outcomes referred to as *predictive analytics* (Bertolucci, 2013).

In this paper, we focus on a particular prescriptive analytic framework, called community-based operations research (CBOR; Johnson, 2012, p. 4 - 5) that is intended specifically for the needs of mission-driven, resource-constrained, locally-focused nonprofit organizations. As Figure 8 shows, this framework allows considerable flexibility in problem identification, formulation, solution and implementation.



Adapted from Johnson (2010)

Figure 8: Model-Driven Technologies: Community-Based Operations Research

CBOR's insight is that for some organizations, in some problem contexts, gaining understanding about a problem—a subjective and iterative procedure dependent on input from a variety of stakeholders—may be as important as applying traditional data analytic and decision science-based methods to derive specific solutions to a certain problem formulation. The latter approach to solutions, though perhaps

"optimal" for a stylized representation of the actual problem (and organization), may in fact capture only part of the challenges an organization may face (Johnson, 2010, p. 14). CBOR allows organizations to use qualitative as well as quantitative data, to incorporate issues of multiple stakeholders and social justice into the solution process, and to connect problem-solving to organization and community change.

Another perspective on accumulating data for decision-making, not associated with a particular technology, is community-based knowledge transfer and exchange. This process can assist in translating research into action through supporting a culture of valuing research evidence, producing evidence of value to the target audience, engaging activities to link evidence to action, and formally evaluating such efforts (Wilson et al., 2010, p. 4).

In Section V, we discuss findings from field research that include observations on practitioner trainings for software, including American FactFinder and the MetroBoston DataCommon. Such observations are useful to understand the potential for actual benefit of these technologies to users without specialized training or experience in data analytics and information technology.

IV. Research Approaches for CBO-Focused Data Analytics and Information Technology

In contrast to the application- and methods-focused view of Big Data and analytics discussed in the previous section, that is particularly useful to practitioners, we turn our attention to the many ways that researchers can learn about community-based organizations in ways that are relevant to data analytics and information technology. We do this by exploring the nature of the organizations that conduct this research, the nature of the inquiry that researchers may conduct, and the nature of data that support this inquiry.

A. *Alternative Approaches to CBO Knowledge Building*

There appear to be two primary approaches to learning about community-based organizations and the services they provide: a centralized approach, in which an individual or organization defines the problem of interest, contacts the CBO to collect the data, and shares research results with the CBO; and a decentralized approach, which involves a more collaborative relationship with a CBO. The former approach represents a

standard perspective in externally-driven applied research (Hedrick, Bickman and Rog, 1993, p. 1). The latter approach represents critical, equitable, inclusive and user-driven approaches typical of participatory action research (McIntyre, 2008, p. 1) and community-based participatory research (Wilson et al., 2010, p. 3).

An example of a more centralized approach to public-sector data-gathering and research is that of the Boston Area Research Initiative (BARI; http://www.bostonarearesearchinitiative.net/). BARI is an inter-university research partnership supported by the Radcliffe Institute for Advanced Study, the Rappaport Institute for Greater Boston, and the City of Boston. BARI has developed relationships with the City of Boston to collect and analyze large volumes of data on 311 calls (address-based citizen requests for city services), to develop novel reporting tools by which citizens can track neighborhood quality and make requests for city services, and to collect and analyze data on crashes involving bicyclists to better understand factors associated with these crashes. BARI has also sponsored an initiative called "Data Swap" in which researchers and students developed novel ways to analyze large, complex databases containing information in the public interest.

Every research initiative that involves collection of primary data that resides, partially or fully, within the control of nonprofit organizations must involve a non-trivial level of organizational collaboration in order to be successful. Thus, BARI's innovative and successful research projects have involved some measure of collaboration. However, this work appears best-suited for large, well-funded organizations such as governments and education and medical nonprofits, whose staff are relatively well-trained in data analytics, or who can engage productively with researchers who specialize in analytic methods, that can make large data stores available quickly, and for whom questions of mission are quite settled. As described in Section II above, these are not characteristics that would typically describe most nonprofit organizations, especially community-based organizations.

A more decentralized approach to research on CBOs is represented by the Urban Research-Based Action Network (URBAN, http://urbanresearchnetwork.org/). URBAN's origin is in the Collaborative Innovations Laboratory of Massachusetts Institute of Technology and has grown to multiple "nodes" in cities such as Boston, Los Angeles and New York, and within professional disciplines such as sociology and education. URBAN's goal is to create a community of scholars and community-based practitioners who

focus on developing long-term partnerships across institutions, academic disciplines and geographies, and to gain legitimacy for applied research that is explicitly focused on community capacity-building, community change and social justice. URBAN's focus, therefore, is less on building and testing theory about public services and social processes than on building relationships with community partners from which research initiatives that benefit the local organizations as well as the researchers, may emerge.

Examples of URBAN's work include youth engagement for community improvement in Florida (Alfonso et al., 2008), discussion of the rhetoric and politics of "crisis" in the context of drastically reduced support for public education in Philadelphia (Conner and Rosen, 2013), and development of guiding principles for collaborative research, in partnership with a community-based organization in Boston (Garlick, 2014).

Another example of a decentralized approach to CBO learning is Code for America (CFA; http://codeforamerica.org/). CFA is a nonprofit organization that engages in collaborative information technology application design with individuals, nonprofit organizations and governments. Supported by the Omidyar Network, Google and the Knight Foundation, CFA sponsors a fellowship program in which developers, designers and researchers work in local governments to build innovative IT solution approaches and hands-on applications for immediate use in the field. CFA's Civic Startups program supports entrepreneurs to grow IT-focused businesses in the public interest. Its Peer Network enables public servants to share civic technology resources, best practices and open data policies via trainings, events and discussions. The Brigade Network is a locally driven collection of volunteers and government employees who convene regular "hack nights" to share knowledge and develop applications. CFA's highest-profile public activity is its yearly Code Across America series of events in multiple cities in which participants from diverse backgrounds share knowledge and develop applications in real-time.

B. *Alternative Views of Inquiry*

We may also view data analytics and IT research and application design for CBOs according to the nature of inquiry. A model-based approach is rooted in traditional statistics, information systems, social sciences and analytics. Here, a stylized representation of organizations, services, processes and communities

allows researchers to identify relationships between human, financial and IT resources and designated outputs and outcomes. This representation also allows information systems researchers and practitioners to view information systems design as the central activity of information systems, and the production of an application as the central goal of this activity (Stillman and Linger, 2009, p. 258). This deductive approach enables the development of descriptive and exploratory statistics and decision models whose validity and significance rely heavily on the nature of assumptions made about the human, service and information systems being modeled. The Boston Indicators Project, many aspects of the Boston Area Research Initiative, and nonprofit operations management applications would be examples of this approach. This deductive approach is most closely associated with a post-positivist worldview and is commonly practiced using theories and methods associated with quantitative research (Creswell, 2014, p. 7)

A non-model-based approach reflects an exploratory, theory- and model-generating view of systems analysis and application development. Here, relatively few assumptions are made about the structure of the organizations or services of interest; the goal is to use the data as inputs to methods such as machine learning or participatory action research to identify relationships and visualizations that generate value for organizations. The results of this approach are heavily dependent on the nature of the organizations and processes being studied; there is little presumption that the solutions generated can or should be generalizable across sectors or industries. An example of this approach is community informatics, described by Kling, et al. (2003) as a socio-technical network that includes "people (including organizations), equipment, data, diverse resources (money, skill, status), documents and messages, legal arrangements and enforcement mechanisms, and resource flows" (p. 48). In different ways, the Weave technology, BARI's Data Swap initiative, URBAN and Code for America are examples of this approach. This inductive approach is most closely associated with constructivist and transformative worldviews and can be implemented using both quantitative and qualitative research methods (Creswell, 2014, p. 8 – 10).

A hybrid approach combines deductive and inductive approaches to data analytics and information technology application development. Geographic information systems, for example, allows users to construct visualizations of social phenomena at various geographic extents and areal units, levels of data aggregation, using a range of data sources and data classification methods, for the purpose of subjective and intuitive data

exploration as well as more objective analytic methods rooted in spatial science (see e.g. Mantaay and Ziegler, 2006). PolicyMap, WorldMap/Boston Research Map, MyNeighborhood Census Viewer, Weave, URBAN and community-based operations research are examples of applications, methodologies and initiatives which support this approach. Knowledge-based transfer and exchange, defined above, can also be adapted for community-based efforts in strategy design, services delivery and decision-making (Wilson et al., 2010, p. 11). Hybrid approaches such as these, which we believe reflect a pragmatic worldview (as defined by Creswell, 2010, p. 4), are examples of mixed-methods research.

C. *Alternative Data Sources*

Data are clearly essential for successful data analytics and IT applications. However, the sources of these data, and the costs in time, money and expertise necessary to acquire and use these data have different implications for community-based organizations as compared to other nonprofits and government.

There are many sources of publicly-available data that CBOs can use to meet their analysis needs. Some, mostly primary sources, are available through the Federal government, such as the Economic Census (http://www.census.gov/econ/census/), the Population Census (http://factfinder2.census.gov/faces/nav/jsf/pages/index.xhtml) and Employment Statistics (http://www/bls.gov/ces). Other sources of publicly-available data consist of aggregations of primary data. These are available through nonprofit organizations, such as the National Neighborhood Indicators Partnership.

Other sources of data are proprietary. Access to them may require only an inquiry to researchers that have developed them or, in some cases, formal contracts with organizations that manage the datasets. Examples of proprietary but low-cost datasets include the Boston Area Nonprofit Survey (MacIndoe and Barman, 2012) and the collection of 311 calls in the city of Boston compiled by the Boston Area Research Initiative. Access to certain other datasets of interest to CBOs is fee-based. Examples of these resources include The Reinvestment Fund's Market Value Analysis (http://www.trfund.com/policy/public-policy/market-value-analysis/) and The Warren Group's foreclosure database

(http://www.warrengroupforeclosures.com/fcsub/signin.asp).

It seems clear at this point that research and practice on issues and policies of special importance to community-based organizations can be performed by entities of differing organizational designs, based on multiple models of inquiry, and using freely available as well as proprietary datasets. The decision on how to design a collaborative, community-engaged initiative reflecting best research and practice knowledge in data analytics and information technology is thus a difficult one. An approach that many NPOs and CBOs have found useful for designing diverse initiatives and programs, not limited to data analytics and information technology, is the *collaborative action* methodology of Strauss and Layton (2002). Collaborative Action is a problem-solving process that incorporates consulting and facilitating, training, and technology-supported problem solving to help organizations to become "architects of their own futures" (Strauss and Layton, 2002, p. 14). This is done through principles that support interactive, introspective and exploratory learning in real time that are based on cooperation and a fidelity to process rather than content (Strauss and Layton, 2002, p. 5 – 6).

V. A Pilot Study on CBO Understanding of Data Analytics and Information Technology

We have presented a variety of research and practice perspectives on the unique characteristics of community-based organizations with respect to data analytics and information technology, a variety of analytic software and modeling technologies that can support the work of CBOs, and complementary approaches to research on data analytics and IT for CBOs. How well are actual CBOs positioned to take advantage of these data sources and technologies? To answer this question, we conducted a pilot study of community-based organizations in the Boston metropolitan area to learn how they make use of data analytics and information technology, to observe the ways in which their practices might reflect the research insights from previous sections of this paper, and to contribute to an emerging theory regarding CBO use of data analytics and IT. From the author's previous experience with CBOs and from the research literature, we present three theoretical propositions for which observed empirical support will help achieve these goals. First, *CBOs can effectively articulate their information needs*. Second, *CBOs lack knowledge of and access to*

expertise and technology to create appropriate information. Third, *CBOs lack capacity to identify and solve mission-aligned decision problems*. There are no studies known to this author that have attempted to engage propositions such as these.

We gathered field data to evaluate these propositions in three ways. First, we conducted interviews with 10 key informants representing five community-based organizations, a Federal government agency, a local university, and three regional nonprofits. Second, we observed training sessions in data analytics software in which CBO employees were the primary participants. Last, we conducted a focus group with a local CBO to probe more deeply that organization's perspectives on data analytics and data-driven decision-making. (A detailed list of anonymized field study participants is contained in the Appendix.)

A. *Key Informant Interviews*

Informant interview participants were identified through 'snowball' sampling and the author's community organization networks. Interviews followed standardized prompts (available from the author) and lasted about an hour apiece. The author, with a research assistant, took notes during interviews. Findings were identified and analyzed by hand, using informal coding and sorting methods inspired by Weiss (1994).

Results from our key informant interviews appeared to reflect three perspectives: the effects of practice context on data analytics and IT, the level of personal and organizational knowledge of data analytics and IT, and the organizational resources available to make productive use of data analytics and IT.

1. *Practice*

CBO respondent EB identified five uses of data relevant to practice: advocacy, operations, performance management and outcomes measurement, funding and community engagement.

Regional nonprofit respondent LB believes that community-oriented academics can support the data analytics and IT missions of local nonprofits by providing data on an on-demand basis, and by teaching practitioners how to make best use of the data available to them.

CBO respondent URBAN uses multiple proprietary software packages as well as freeware such as American FactFinder to support their housing and economic development activities, but makes little use of spatial data resources intended for CBO use such as MetroBoston DataCommon or PolicyMap. Regional

nonprofit respondent HLW also uses multiple proprietary software packages, but has trouble integrating the separate applications, sometimes resorting to entering data by hand that exists on one application into another. HLW also finds that important information about their clients is not captured in any of their software packages. HLW believes that "Big Data" is not salient to its work, and feels that the large datasets that are accessible to them are not well-suited to their needs, or are obsolete. Respondent EB reported using data provided by the Boston Indicators Project, but identified specialized needs for data that exceed what is available through standard sources. AWH observed that multiple datasets are not easily integrated and do not contain variables of interest at the level of communities or neighborhoods.

Federal employee AB observes that nonprofit data needs are driven by external factors, such as proposal writing for funding, and internal factors, such as strategy planning. In particular, AB observes that nonprofits and especially community-focused organizations often scramble to acquire data required for proposals. Funders frequently request program outcome measures rather than process-oriented outputs, and nonprofits have difficulties identifying required figures. CBO respondent AWH believes that efforts by it and other CBOs to do a better job collecting data will yield two desirable outcomes. First, funders will better understand their goals and resources; second, CBOs will be able to better advocate on behalf of their communities.

DEF, a nonprofit technical support organization, believes that for many NPOs, goals and mission are mismatched or not well-articulated, and there is limited understanding of a "theory of change" that would help identify project benchmarks and quantify them using appropriate data. As a result, NPOs face uncertainty regarding what data are really necessary to further their mission.

2. *Knowledge*

Respondent DEF observes that decision modeling based on appropriate data might help NPOs make better decisions that often currently rely on "feel-good" anecdotes; this view was confirmed by respondent EB. Federal employee AB believes that the IT applications and analytic skills essential for organizations to meet their data analytics needs are spreadsheets, geographic information systems, and a basic knowledge descriptive statistics. However, AB observes that nonprofit organizations with whom she works typically do

not have the time to understand the data that are available to them. Respondent AWH knows that technologies such as Weave are available, but believes it to be difficult to learn and to adapt for the organization's specific needs.

Respondent URBAN mentioned that mapping is important to their work, but that freeware such as Google Maps are insufficient to their needs, and that they knew of no accessible, easy-to-use mapping products. One URBAN interviewee asserted that employees are largely "computer literate" and quoted a staffer's belief that "if you can work a phone, you can work a database." However, the interviewee acknowledged at another point in the interview that some employees refuse to use office productivity software such as Microsoft Excel.

3. *Resources*

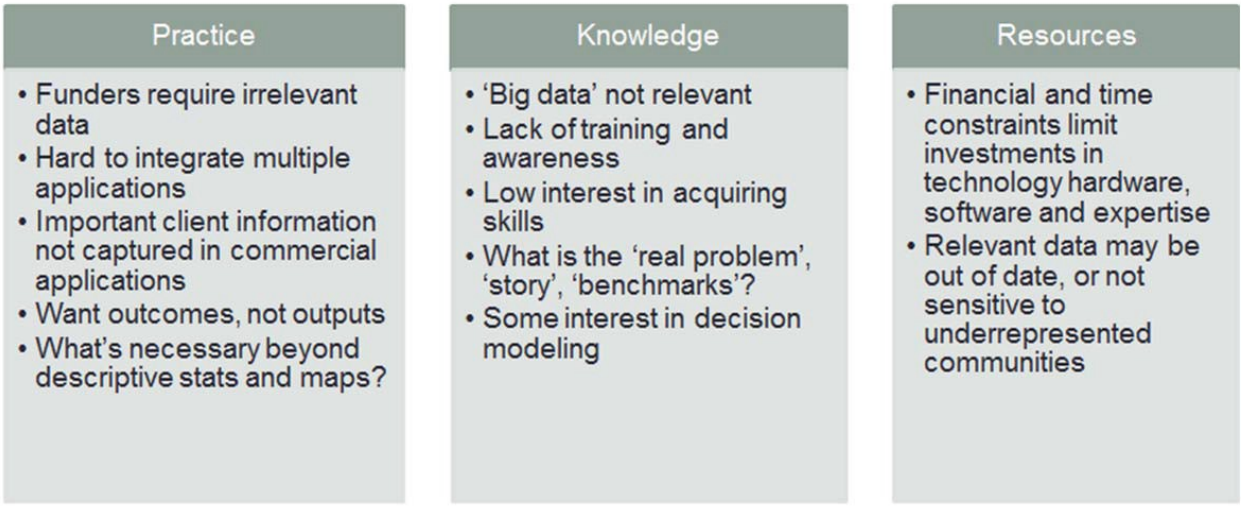
Respondent HLW mentioned that limited IT resources mean that staff must perform multiple tasks related to data acquisition and analysis. They would like to see increased standardization of data and improved data integration and reporting. CBO respondent EB noted the need for specialized expertise at the level master's degree training in planning and related fields to acquire, analyze and publicize mission-relevant data.

Respondent URBAN proposed that external grants should include funds for IT-related overhead expenses. They feel themselves to be at a beginning stage with respect to investments in technology hardware, software and expertise. AB observed that organizations usually don't have the capacity or staff to use the data that's provided to them. She observed that the U.S. Census Bureau has a large volume of geographic data that are easily accessible to non-profit organizations, but the organizations with which AB works usually do not have the capacity or personnel to access or manage such data.

Respondent DEF confirms that funders often do not provide support for data acquisition and analytics, and believes that data solutions for NPOs should consist of education, funding and appropriate systems infrastructure. Nonprofit technical support organization respondent HSC observes that NPOs are dissatisfied with standardized data reports from software applications and prefer customized cross-tabulations.

However, these organizations realize that they lack sufficient funds to pay for these specialized reports. CBO respondent AWH mentioned that data they may be interested in that are provided by researchers with whom they collaborate are out of date when these papers appear in print, and that data available to them directly from provider organizations may be inaccurate or imprecise, may not capture measures that are important to them, or may be inaccessible to or reflect the needs of language minorities. For example, some data sources may combine distinct but related racial and ethnic subgroups into one, or not report results in a way that reflects socially relevant geographic boundaries, or use data that, while collected using a variety of non-English languages, has not used those languages that are actually spoken by the organization's clients.

A summary of these key informant findings is contained in Figure 9, below.



Source: Author's tabulations

Figure 9: Summary of Key Informant Interview Results

These findings indicate substantial gaps between needs for data and analytics knowledge and the resources available to NPOs and especially CBOs to acquire, analyze and deploy such knowledge in practice. In particular, a lack of standardized measures for needed data, and training to collect such data are significant barriers to CBO engagement with data and analytics.

B. *Software Training Observations*

The next step in our field research was to attend trainings on software packages that were designed especially for nonprofit organizations. One training session, on American FactFinder (http://factfinder2.census.gov), revealed that while NPO employees articulated specific data needs, they had very little previous knowledge of widely available Census datasets, and little understanding of how to relate their specific data needs to the data structures available in standard datasets. Though organization participants were enthusiastic about the training, at the end of the session there appeared to be only modest increases in technical capabilities. Another training session, for the MetroBoston DataCommon data portal (http://metrobostondatacommon.org/), revealed that this dataset, though extensive, flexible, and reflective of nonprofit data needs for program descriptions and evaluations, appeared to be quite difficult to use, even for people with specialized data analytics experience.

C. *CBO Focus Group*

Finally, we conducted a focus group with employees of a city-wide nonprofit organization BMS that is comprised of many small neighborhood offices. The goal of this focus group was to learn about the data necessary to perform daily tasks, their analytic needs in transforming data into information to support decisions, and gaps they perceive in access to data and analysis of data. BMS employees expressed a desire to collect data that will allow them to evaluate the effectiveness of their organization's programs, to display these data on easily-understood "dashboards" and to make decisions regarding most- appropriate community activities. While able to articulate the type of information they need, BMS employees asserted difficulty in identifying specific data elements that might be inputs to analysis to generate such information, as well as identifying ways to measure, collect and analyze these data elements. Such difficulties appear to arise from a lack of organization information technology expertise and appropriate software, and the fact that different offices of this nonprofit, serving neighborhoods that differ across many dimensions, have distinct and specialized data needs. The solutions that BMS' employees seek are predominately low-tech and relatively inexpensive, though they may require specialized training. Developing these solutions may require collaboration and learning with community stakeholders consistent with principles of community-based

participatory research.

D. *Field Study Conclusions*

Our field research allowed validated two key assumptions underlying this research paper and the specific engagement with nonprofit organizations, namely, that there appears to be a mismatch between CBO needs and perceived resource availability, and CBOs perceive missed opportunities to provide better services due to a lack of information technology expertise. We conclude that the first proposition we have stated, that CBOs can articulate their information needs, is *supported*. In addition, the proposition that CBOs lack knowledge of and access to expertise and technology to create information is *supported* as well. However, our assumption that CBOs lack the capacity to identify mission-aligned decision problems is *not supported,* while it appears that the assumption that they lack the capacity to formulate and solve such problems is *supported*. Support for this last assumption is consistent with the notion that many CBOs use data in a reactive versus a proactive manner.

VI. Principles for Research on CBO Use of Data Analytics and Information Technologies

Our field data collection on CBO use of data analytics and information technology, described in the previous section, may provide the building blocks for a theory that could yield a variety of testable hypotheses and support the development of datasets and applications designed to respond to the needs, resources and challenges of community-based organizations. As a prelude to a statement of principles that might provide the basis for such a theory, we describe the experience of a network of community-based organizations whose practices seem consistent with the ideals of effective CBO use of data analytics and information technology.

The Data Center in Milwaukee, Wisconsin, founded by the Nonprofit Center of Milwaukee (NPCM), one of the largest associations of non-profit organizations in the Milwaukee metropolitan area, is an example of the impact of open source data and collaboration (Lin and Ghose, 2008, p. 37). The Data Center's primary goal is to support collaborations between community groups, local government and the private sector. Its

primary objectives are to be a data clearinghouse for community organizations, to provide data-related services, such as data analysis and GIS, to community organizations, and to increase the data-analytic capacity of local community organizations (Lin and Ghose, 2008, p. 37). The CBOs that use the services of the Data Center not only have limited budgets, but they serve some of the poorest neighborhoods in the Milwaukee region. In exchange for the use of the Data Center, these organizations provide the Data Center data and information on the communities they serve. Inspired by the example of the Data Center, the field research described in the previous section and the special attributes of community-based operations research (Johnson, 2012), we provide a set of principles that may inform applied research and research-informed practice in community-focused data analytics and information technology.

1.*Values-driven*: Data analytics and information technology for CBOs must reflect the mission of the organization, as well as specific organizational objective, measurable performance metrics and a well-articulated set of changes CBO activities in data analytics and information technology.

2. *Collaborative*: CBO data analytics practices must incorporate sharing ideas, models and methods among similarly-situated CBOs.

3. *Inductive and Iterative*: Knowledge associated with data analytics and IT initiatives must reflect learning in the field that is based on an accretion of knowledge that may not have a clearly articulated end goal. This learning should be rooted in a theory that contextualizes knowledge derived from the field.

4. *Mixed Methods*: Data analytics and IT research and applications development should incorporate qualitative and quantitative data and analytic methods that use computer-assisted as well as manual data collection and analysis.

5. *Appropriate Use of Resources and Capacity*: Recognizing the limited financial, technical and human resources of CBOs, data analytics and IT research and applications should generate solutions that do not

require extensive software development, expensive hardware or training.

VII. Research Agenda and Next Steps

With the principles formulated above, one may develop a research agenda to support rigorous analysis and generate valuable policy and operations guidance to CBOs. Scholarly research regarding the diffusion, influence, adoption and use of data analytics and information systems by nonprofit organizations, especially community-based nonprofits, is focused on two tracks: geographic information systems, and information systems generally. Brown and Kyttä (2014) survey the literature on public participation geographic information systems for land use planning and management in order to develop research priorities on public participation rates, data quality and PPGIS effectiveness. Sieber (2000) presents case studies of GIS adoption and usage in nonprofit conservation organizations in California. Merkel et al. (2007) discuss multiple methods to support organizational adoption of IT in nonprofit organizations through three case studies. Groundwork Group (2010) studied nonprofits in Ohio to describe the state of impacts of IT upon multiple dimensions of operations and strategy.

Berlinger and Te'eni (1999) surveyed churches in a Midwestern American city to learn about the dynamics of IT adoption and usage. Stoecker (2007) surveyed 80 nonprofit organizations in the Toledo metropolitan area to learn more about current practices in nonprofit research, particularly the data and infrastructure issues associated with conducting good-quality research at the local level.

We believe that there is an opportunity to enlarge the scholarly literature in this area through two approaches: a large-scale survey of nonprofits, including community-based organizations, and a case study of a nonprofit organization that has developed a data analytics initiative. We describe each of these research opportunities in turn.

There appear to be few examples of studies that use large-sample surveys to explore the attitudes of nonprofit professionals regarding data analytics and IT adoption and usage and the relationship of data analytics and IT to organizational characteristics that are similar in scope, grounding in theory and methodological rigor to the Boston-area nonprofit organization survey developed by MacIndoe and Barman

(2012). We believe that such a survey could provide valuable information regarding data, IT and analytic needs, resources and capabilities that our pilot study described in Section V has only hinted at. By asking a range of questions regarding organization characteristics related to size, service type, intensity and scope, and use of monitoring methods such as performance measurement, it may be possible to develop theory that explains the circumstances under which nonprofits, especially CBOs, may choose to make and sustain investments in data analytics and information technology infrastructure, and the benefits and costs of doing so.

Our pilot study in Section V, particularly the focus group results, has also provided evidence that CBOs are willing to engage in applied research to develop new data analytics and IT capabilities through discussion of values, attributes and alternatives associated with current and future practice. We have also found evidence to support the design of new applications and services for management and communication of data and maintenance of data infrastructure, as well as decision modeling. Such a project, based on community-based participatory research principles, could expand our understanding of the potential for data analytics and IT to improve outcomes for smaller, resource- constrained and mission-driven urban nonprofits. The collaboration between workforce development nonprofit CareerEdge and analytics consulting firm Capital Analytics to measure the impact of a job training program (Pease and Beresford, 2013), may be a model for this sort of study. It uses methods associated with Big Data analytics and community-based participatory research to measure qualitative and quantitative program impacts. However, the proposed study described above, with its focus on information systems design to support localized decision making, is also motivated directly by a contemporary view of community informatics (Stillman and Linger, 2009, p. 261) and community-based operations research. Finally, there is an opportunity to pursue this research agenda with an explicitly comparative focus across the not-for-profit sector, addressing government and nonprofit organizations as well as civic-sector organizations and informal organizations[2].

VIII. CONCLUSION

[2] These are nonprofit organizations not recognized under the Federal tax code that may have an explicit organization, membership and meeting space (civic associations), or may be informal in all respects.

This paper is an initial effort to survey the research and practice landscape on knowledge and use of data analytics and information technology, inspired by current trends in "Big Data" and "analytics." We have argued that community-based organizations, in particular, have specialized needs for data analytics and IT, across multiple dimensions of organizational characteristics, which are not well addressed by applications designed for government, large or regional nonprofits, or for-profit organizations. We have surveyed a range of existing technologies, rooted in data as well as decision science, which offer the potential for CBOs to apply data analytics and IT cheaply and effectively in practice. We have discussed a variety of research approaches to data analytics and IT for community-based organizations and shown that there are many ways for CBOs to engage productively with academics and to use existing datasets to add value to their operations and strategy. We have presented results from a pilot field study of community-based organizations in the Boston area that provide preliminary support for multiple propositions related to CBOs and data acquisition and uses. Based on these findings, we have proposed a set of principles for CBO data analytics, reflecting best practices and research knowledge in domains such as community-based operations research, nonprofit information technology and community-based participatory research, that offer CBOs a foundation for adapting, developing and deploying applications in data analytics and IT that can help them better fulfill their missions. Finally, we have proposed a research agenda, comprised of large-sample surveys and field studies of data analytics design, development and implementation that could enable community-based organizations to better meet the needs of their constituents. We hope that these research findings may enable students, researchers and practitioners to collaborate with community-based organizations to provide services, advocacy and knowledge rooted in data, analytics and information technology that can help their communities become desirable and sustainable places to live, work and visit.

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APPENDIX

Field Study Participants (anonymized)

"AB" – A U.S. Census employee tasked with data training for nonprofits throughout New England

"AWH" – An advocacy organization for health issues affecting women across multiple Asian-American communities in metropolitan Boston

"BMS" – A neighborhood-level nonprofit devoted to local economic development

"DEF" – A senior technical advisor and strategist at an information technology technical assistance, IT tech support and advocacy organization in Boston

"EB" – Director of community building and environment at a Boston community development corporation focused on housing development, environmental advocacy and community economic development

"HLW" – A Boston-based human services nonprofit providing child welfare and community based and congregate care services

"HSC" – Director of data services at a nonprofit regional planning organization

"LB" – Senior program manager, nonprofit corporation to promote economic development through direct funding and technical assistance

"NEL" – Faculty member in a law and policy doctoral program and researcher in public health, environmental, and climate-change adaptation policy at a Boston-area university

"URBAN" – A community development corporation in the Roxbury neighborhood of Boston