Capability Challenges in Transforming Government through Open and Big Data: Tales of Two Cities

Completed Research Paper

Akemi Takeoka Chatfield
School of Computing and Information Technology
Faculty of Engineering and Information Sciences
University of Wollongong
Wollongong, NSW 2522, Australia
akemi@uow.edu.au

Christopher G. Reddick
Department of Public Administration
College of Public Policy
The University of Texas at San Antonio
501 W. Cesar E. Chavez Boulevard
San Antonio, Texas 78207-4415, USA
Chris.Reddick@utsa.edu

Wisam Haitham Abbood Al-Zubaidi
School of Computing and Information Technology
Faculty of Engineering and Information Sciences
University of Wollongong
Wollongong, NSW 2522, Australia
whaa807@uowmail.edu.au

Abstract

Hyper-connected and digitized governments are increasingly advancing a vision of data-driven government as producers and consumers of big data in the big data ecosystem. Despite the growing interests in the potential power of big data, we found paucity of empirical research on big data use in government. This paper explores organizational capability challenges in transforming government through big data use. Using systematic literature review approach we developed initial framework for examining impacts of socio-political, strategic change, analytical, and technical capability challenges in enhancing public policy and service through big data. We then applied the framework to conduct case study research on two large-size city governments' big data use. The findings indicate the framework's usefulness, shedding new insights into the unique government context. Consequently, the framework was revised by adding big data public policy, political leadership structure, and organizational culture to further explain impacts of organizational capability challenges in transforming government.

***Keywords*:** Big data, government, organizational capability challenges, framework, case study research

Introduction

The emergent phenomenon of the big data ecosystem as the next information frontier is still new. While the big data ecosystem's components may vary from government to government, we hold a view of big data as the innovative and transformative means which can be used for enhancing government transparency and accountability, innovation and productivity in public services, and active citizen engagement. Leading governments have been advancing a vision of data-driven government through digitization of government, data-driven policy agenda, and data-driven decisions. This may be a reflection of hyper-connected digital societies in which e-commerce firms and e-governments are fast becoming integral parts of the big data ecosystems as producers and consumers of big data.

In this paper we adopt a definition of big data as "things one can do at a large scale that cannot be done at a smaller one, to extract new insights or create new forms of value, in ways that change markets, organizations, the relationship between citizens and governments, and more" (Mayer-Schoenberger and Cukier, 2014, p. 6). Big data is characterized by so-called three Vs; volume, variety and velocity (Meta Group, 2001; McAfee and Brynjolfsson, 2012) and even by a fourth V; veracity (Goes, 2014). Volumes of internal and external data are characterized by the variety of unstructured data (e.g., click data, social media data, sensor data, and surveillance image data) that come from all information sources (Davenport, 2014). These volumes of data from the various information sources are generated at various velocities and veracities, making it difficult to access, process and extract insights using traditional IT tools, processing methods, and algorithms (Chen et al. 2014).

While the rise of big data has brought about new opportunities for discovering new insights and extracting hidden values, effective organization and management of such big data sets might present new capability challenges in transforming the government through insights and value extracted from the big data ecosystems that contain structured, semi-structured, and unstructured data streams. Because its ubiquitous and pervasive presence in business, government, and society, big data can affect our personal lives substantially and can cause a significant shift in the strategies and functions of government, business, and higher education organizations (Chen et al., 2012; Gabel and Tokarski, 2014). In consequence, governments announced major plans to accelerate big data research and applications (Chen et al., 2014). With the budget of more than $200 million, the Obama administration promoted stakeholders, including governments at all levels, non-profit organizations, and academic institutions, to participate in new projects that move big data from research knowledge to big data use and applications that can be implemented on the ground (Weiss and Zgorski, 2012). This new initiative stems from the extant open government and open data policies.

The US Federal Government was the first mover in articulating the open government policy's transparency, citizen participation, and collaboration outcomes through the US Open Government Directive of 2009 (US Executive Office, 2009). Open government reform practices have now spread to other developed and developing nations. Globally, as of 2015, Open Government Partnership (OGP), which was launched in 2011, has 65 nations which are committed to collaborate towards promoting open government policies among its member nations to realize the potential benefits of open data implementation (Open Government Partnership, 2015). In consequence, a number of large local governments in New York, Chicago, Los Angeles, and Houston, which all generate and capture big data, have implemented open data portals to share its big data with citizens and businesses.

Despite its newness, the big data ecosystem *as a new information frontier* has already drawn much attention from researchers in diverse disciplines. This has resulted in the fast growing literatures on big data, with a confusing array of different conceptions and definitions across many disciplines. This presents a pressing problem for developing a clear understanding of the new opportunities and emergent capability challenges in exploiting the big data ecosystems to transform the government, especially for public policy makers and public administrators responsible for big data investment and use. However, there has been a clear lack of prior empirical research on big data challenges. Moreover, case study research is clearly lacking. Specifically, case study research on capability challenges in harnessing the public-sector big data ecosystems is seriously lacking. Therefore, the overarching aim of this research

paper is to examine the organizational capability challenges in transforming the government through the use of open and big data by raising the following central research question:

> *What are socio-political, strategic change, analytical, and technical capability challenges in transforming the government through the use of open and big data?*

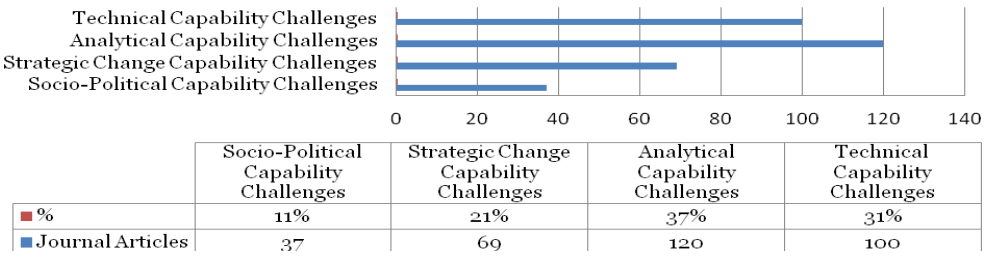
In order to answer this research question, we have developed a conceptual framework through the adoption of a Systematic Literature Review (SLR) approach (Webster and Watson, 2002). Given the paucity of case study research on big data use in government, we have used the conceptual framework to guide our case studies of open and big data use in two city governments in Houston and San Antonio in the state of Texas in the U.S. This paper aims to make contributions towards a better understanding of data-driven government as a new information frontier in this rapidly developing big data and analytics landscape.

The structure of this paper is organized as follows: the next section describes our conceptual framework for capability challenges in transforming government through open and big data. In the third section, we present our key case study research findings from the two local governments. In the fourth section, we discuss the validity of the conceptual framework against the case data. The final section presents conclusions, including the research limitations, contributions, and future research directions for further empirical research.

Conceptual Framework for Big Data Capability Challenges

In order for us to develop the initial conceptual framework that would guide our case study research conducted in this research, we have adopted a SLR approach. Due to the fast growing big data literatures, we have limited our SLR to SCOPUS database, which includes Social Sciences and Humanities journal articles. Conference papers are excluded on the assumption that quality conference papers would make their way into journal publications. We have used the following generic query strategy: (Title OR Abstract) CONTAINS ("big data") AND (“challenge”) AND (Publication Year) = (all years - 2015) AND (Publication Type) = (Journal Article), where "big data" was our primary keyword and "challenge" as our secondary keyword. This search strategy has yielded a total of 326 peer-reviewed journal articles on big data that have explicitly addressed big data challenges. Of the 326 journal articles, we found a subset of 22 empirical studies, including 12 case study research papers. Of the 12 case studies, only two case studies (O’Leary, 2013; French, 2014) focused on the government organization.

Therefore, we have decided to draw on the 326 journal articles on big data challenges to identify four categories of organizational capability challenges that might hinder the government organization from exploiting open and big data to transform the government for enhanced public services and increased citizen engagement. These four categories are: *Socio-political capability challenges*, *Strategic change capability challenges*, *Analytical capability challenges*, and *Technical capability challenges*. Figure 1 shows the frequency distribution of the four categories of organizational capability challenges.



	Socio-Political Capability Challenges	Strategic Change Capability Challenges	Analytical Capability Challenges	Technical Capability Challenges
%	11%	21%	37%	31%
Journal Articles	37	69	120	100

Figure 1. Frequency Distribution of 4 Categories of Big Data Challenges

Figure 2 below shows our conceptual framework on organizational capability challenges in transforming the government through open and big data. As Figure 2 shows, we postulate that these organizational challenges will influence the level of organizational transformation that can be achieved through open and big data use, which in turn may influence the level of beneficial impact of big data on organizational performance such as public service improvement.

Figure 2. Conceptual Framework of Organizational Capability Challenges in Transforming Government through Big Data

Socio-Political Capability Challenges

The first category of big data challenges in our framework is socio-political in nature. If the government agency fails to address the socio-political nature of big data challenges adequately and in a timely manner, it would diminish government accountability and legitimacy, erode citizens' trust in government, discourage citizens' political engagement and positive evaluations of government performance. The sub-set of 37 (or 11.3%) journal articles largely identified privacy and security issues related to big data.

Privacy and security

Privacy and security are the most important challenges with big data, having *socio-political*, conceptual, technical, and legal significance. As our society continues to become more digital and more global, privacy and security issues change alongside these developments. It is crucial and challenging to understand how privacy and security issues are changing. For any organization working with big data, privacy and security issues are considered major and growing challenges, especially when combining multiple large data sets. For example, there is the risk of revealing an individual's social security number (Boyd and Crawford, 2012). Because of that, much remains to be done towards detecting and quantifying risks to privacy that may result from data sharing (Choudhury et al., 2014).

In the big data age, vast amounts of information are transmitted by new technologies. Since data volume is growing exponentially, it is vital to use efficient data transfer protocols to protect information from being compromised (Marx, 2013; Shen and Zhang, 2014). In any organization, operational analytics, reporting and certain information tasks are indeed commodities and can be outsourced, but outsourcing might increase the challenges around security and privacy issues (Bhimani and Willcocks, 2014). Therefore, it is essential to ensure the strong coherence between privacy guidelines and the related released data while working in big data domains in organizations (Bertot et al., 2014). Effective security protocols are a significant factor in minimizing privacy risks, but it is important to realize that privacy is an ongoing risk which is difficult to completely eliminate (Abbott 2013).

Strategic Change Capability Challenges

Big data is essentially a strategic change initiative in many government organizations as a response to changes in the external environment – economic, technological, political, and socio-cultural. Strategic change capability in the strategy process within an organization can have a profound effect on radically improving organizational performance (Mintzberg et al., 2003). In consequence, performance feedback and sense-making of important issues that affect strategic change directions are critically important. In the literature on strategic change, antecedents and consequences of strategic change and the role of strategic leadership on organizational performance have been extensively studied (Rajagopalan and Spreitzer, 1997). While organizational culture or climate may affect big data initiatives in the government organization, their impacts were not explicitly studied in the 326 journal articles reviewed in this paper. The sub-set of 69 (or 21.2%) journal articles largely identified evidence-driven decision-making, strategic change leadership, data strategy, data sharing, and data governance issues related to big data.

Evidence-driven decision-making

In any organization, decision-making is considered one of the vital challenges of working with big data. There is no value in big data unless it is analyzed to produce critical information which can be effectively used to make informed decisions. It is clear that poor data quality can impact the process of decision-making negatively, leading to unacceptable and untrustworthy inferences or conclusions (Hu, 2013; Groves et al., 2013). Because big data can be considered a trusted basis for decision-making in organizations, to achieve this trust, senior decision makers must embrace evidence-based decision-making (Schermann et al., 2014; McAfee and Brynjolfsson, 2012; White, 2012).

In addition, decision-making can be a critical challenge if large amounts of data are not effectively processed through efficient analysis and effective implementation (Zhang, 2013). In any organization, in order to make optimal decisions, it is essential for the board or decision-makers to comprehensively understand big data-related technology. Lack of focus or discussion by the board or decision-makers would negatively impact on decisions around technology and raise further challenges (Stewart and Valentine, 2013; Chang et al., 2014). Furthermore, neglecting the data-driven decision-making approach may create difficulties in accumulation of successful experience with corporate data usage, regardless of the sources (internal or external) (Kwon et al., 2014; Hu, 2013).

Strategic change leadership

Leadership is one of the core components in any effective organization's strategy. In the big data era, more or better data does not guarantee success for big data initiatives. Therefore, for any organization to achieve a higher level of performance through big data, leadership teams must establish clear goals through a new data-driven, analytical organizational culture or climate for decision-making (Chiang et al., 2012; McAfee and Brynjolfsson, 2012). The main challenge and hurdle that leadership teams face is how to change the way their organization makes decisions (Chiang et al., 2012; Fawcett and Waller, 2014). Most often, the senior executives have the challenging responsibility of determining how to create the core competencies and to improve analytical insights that will enable them to become big data and analytics leaders within their organization. This will require them to encourage sharing knowledge and insight with the IT professionals in their organizations (Katal et al., 2013).

Data strategy

In the big data world, planning for a significant and efficient data strategy is challenging, because the main focus is being at the top of the trend rather than investing in new technology (Gleditsch et al., 2014). A growing number of organizations have already started to formulate their big data strategy and to build their capabilities (Fattah, 2014). Stewart and Valentine (2013) stated that the boards of organizations who do not clearly understand their organization's strategic orientation to information use, and which also do not have the necessary balance of strategy-matching board competencies, most often face amplified risk, including reputational, compliance and competitive risks. The lack of data strategy in any organization will definitely affect the outcomes of that organization in negative ways. It is because the lack of strategic cohesion will make it difficult for any organization to overcome this challenge. Therefore, any

organizational system working with big data must recommend a variety of strategies for knowledge construction and modeling complexity in order to support sustainability (Godfrey et al., 2014).

Data sharing

Data sharing among organizations can provide useful insight for any ecosystem in the big data era. However, sharing of data cannot be easily achieved among many collaborative organizations, because it is associated with the transfer of large, unstructured data sets (Marx, 2013). In sharing large volumes of data sets, such as social media data sets, there are ethical and privacy implications around what these data sets contain, including the posts and associated metadata of thousands or millions of users. This presents a barrier to an open sharing of data sets, causing difficulties in the sharing process (Bruns, 2013; Choudhury et al., 2014). In some organizations, the most challenging issue is how to protect the privacy and how to transfer information securely. An example is US health care organizations' health record systems and the issue of privacy (Khansa et al. 2012). Finally, the technical hurdles which may emerge through the process of data transfer can contribute to the data sharing challenge.

Data governance

Data governance means an effective and efficient mechanism to manage data within an organization through the alignment of the objectives of multiple functions (Tallon et al., 2013). Tallon et al. (2014) stated that data governance decisions are directly affected by the strategy of having data protection regulations. The main critical challenge in data governance is to determine the gap between the current level of confidence in data and the necessary level of confidence for specific big data use cases. A data governance model should be comprehensive, which means taking into consideration the following issues: privacy, data reuse, data accuracy, archiving and preservation, and development of data standards. While taking into consideration all these issues enables the organizations to achieve the high level of performance which they are seeking, it is a serious challenge for any organization to overcome the barriers to implement data governance (Bertot et al., 2014).

Analytical Capability Challenges

As our definition of big data (Mayer-Schoenberger and Cukier, 2014) adopted in this paper clearly indicates, effective use of big data applications is expected to produce new predictive, explanatory, exploratory and visualizing analytics capability gains in the increasingly complex decision-making process (Goes 2014). The sub-set of 120 (or 36.8%) journal articles largely identified knowledge, skills, cost, and data scientist issues related to big data.

Knowledge

Gaps in knowledge can be considered one of the essential challenges in dealing with big data. Knowledge helps organizations to understand the scenario of how big data works and how to address opportunities while working with this massive data. Schroeck et al. (2012) argue that individuals and working groups in organizations should undertake learning and training to achieve this knowledge to meet this challenge. So far, the potential for big data has not yet been fully understood and embraced by the business executives.

Working with big data needs the codification of workers' knowledge; that is, turning highly skilled experts into exchangeable applicants of well-documented modules of knowledge. Therefore, there is great need for a more efficient strategic approach regarding decisions concerning knowledge in organizations with different conditions where knowledge management takes place (Holtgrewe, 2014; Rothberg and Erickson, 2013). There are many hurdles to overcome when transferring active knowledge between human and technical systems. To overcome this challenge, strong links between these two aspects are needed via in-depth collaboration and knowledge transfer (Shen and Varvel, 2013).

Skills

One of the most prominent challenges for big data is the skills shortage in this domain, especially with the major and rapid development of analytic and reporting tools designed for working with big data (McAfee and Brynjolfsson, 2012). In consequence, many organizations do not possess efficient and adequate

analytic skill sets, with the high demand for attracting new partners and new employees with diverse new skill sets. Moreover, these skill sets should not be restricted to solving only one specific problem. Therefore, there is indeed a need to develop these skills in individuals through comprehensive training programs hosted by organizations that produce skilled employees (Katal et al., 2013; Hu et al., 2013).

The skills of its employees are an important asset for any organization with a growing interest in big data and big data analytics tools. By 2018, however, the United States alone could face a shortage of 140,000 to 190,000 people with deep analytical skills, as well as 1.5 million managers and analysts with the know-how to use the analysis of big data to make effective decisions (Manyika et al., 2011). Although the lack of technical skills (such as knowledge of programming languages and tools, servers, networks, and cloud technologies and structures) in any organization represents a major technical challenge, the lack of nontechnical skills such as English, project management, organizational skills, and communication skills also can add more hurdles and challenges in these organizations (Holtgrewe, 2014). Adequate communication skills are essential to support organization-wide data-sharing culture. That is, the analyst must have the ability to clearly explain the findings in simple terms that people can understand, especially business people (Royster, 2013; Chiang et al., 2012).

Cost

Cost is one of the daunting issues faced by organizations dealing with big data. In order to improve analytical ability through big data, governments need to absorb these extra costs. Since the key point of adopting and using big data is to minimize costs, such as in hardware and processing, it is difficult for organizations to validate the value of big data, which has high processing costs, before committing significant organization resources (Chiang et al., 2012; Chen et al., 2014; Chen and Zhang, 2014). The organizational challenge of high costs can negatively affect productivity (Tallon et al., 2014; Abbott, 2013). For example, in the US the intelligent cloud-based electronic health record (ICEHR) system reduced costs and increased the productivity of health care organizations (Khansa et al., 2012). However, in the big data era the computational cost remains high (Qu et al., 2013). Storing huge amounts of data is costly. Also, the prolonged storage processes of such data can add higher costs for organizations working in the big data era (Groves et al., 2013).

Data scientist

Davenport and Patil (2012, p. 70) claim data scientists as a profession as "the sexiest job of the 21st century". Data scientists dealing with big data must have distinguished analytic capabilities. They know how to use large collections of unstructured data to extract insights and discover answers to an organization's key questions. Data scientists speak the language of business and can help leadership teams reformulate organizational challenges around tackling big data (McAfee and Brynjolfsson, 2012). A crucial point for any organization is to locate data scientists close to the products and services inside the organization, reducing the gap between decision makers and data scientists. Organizations working with big data are struggling to close this gap by building their own platforms, because acquiring in-depth knowledge from data scientists in the domain of big data typically takes years (Marx, 2013).

Data scientists are in demand, rare, and expensive (Fattah, 2014). Business leaders argue that they need them, although they are not sure about the nature and outcome of the data scientists' work. Often organizations wait a long time to find and recruit data scientists with high-level analytical capabilities, which might cause unnecessary delays in starting the big data analytics initiatives, negatively affecting organizational performance and competitiveness. Finally, an inability to share information between data scientists and other skilled workers within and across any organization represents a significant bottleneck to sharing different data set formats (Sukumar and Ferrell, 2013).

Technical Capability Challenges

As government organizations increasingly use big data which is characterized by 3V's and also by external data, such as click data, sensor data, and citizens-generated unstructured social media text data (e.g., tweets and Facebook page contents), leveraging these diverse sources of big data presents technical

capability challenges. The sub-set of 100 (or 30.7%) journal articles largely identified data quality, data extraction, reliability, and data scalability issues related to big data.

Data quality

Big data users must have some focus on data quality, which means not utilizing all the data available but choosing very large quantities of high-quality data. This is the main strategy in organizations using big data in order to achieve high-value solutions (Gleditsch et al., 2014). Dealing with huge amounts of data creates many difficulties: which data to dismiss, how to select the most appropriate data, and eventually how to evaluate the value of the data. Big data quality is a crucial point in detecting the quality of the insights extracted from that data (Chen et al., 2014). In some organizations, the source of data being used is external, which is outside the control of the organization. Therefore, the quality of the data may be unknown and the supply uncertain, such as massive data for commercial use (Jetzek et al., 2014; French, 2014). Companies with low data quality face sets of barriers regarding technical issues, leading to low levels of performance and productivity (Arora and Predmore, 2013). Data of poor quality can lead to inaccurate insights or interpretations that will consequently affect decision-making processes (Bertot et al. 2014).

Data extraction

Data extraction is an important step in order to gain information from the transformed data, and then demonstrate the information in a form that is appropriate for analysis and be able to help with the company's decision-making (Jetzek et al., 2014; Lee and Chien, 2013). Data extraction is considered to be a challenge which is posed by fast-growing amounts of data, especially in dealing with big data such as health care records, in which there are difficulties around extracting information and knowledge from data (Demirkan and Delen, 2013).

To extract value from large volumes of data, technology plays a significant role for automatic extraction of information without using a human coder, such as in the automatic (algorithmic) extraction of "meaning" through inclusion of "context" into computational linguistic models of analysis. This means that comprehensive and sustainable insight about advanced technologies is required to know how to correctly extract the suitable and valuable information from data in time (Qu et al., 2013; Tufekci, 2014; Wiedemann, 2013). The process of data extraction itself is time consuming, and when organizations deal with big data, this process becomes more complex and, consequently, even more time consuming. Therefore, organizations need to be aligned with technology developments and implement a comprehensive strategy to overcome this challenge (Lomotey and Deters, 2014). Ultimately, understanding text and extracting knowledge from it remains an ongoing challenge for many organizations when using big data (Lim et al., 2013).

Reliability

When large volumes of data sets are needed to be stored, such as in the big data domain, it is essential that these data sets are effective and highly dependable, and that they have been excluded from the redundant data in order to achieve reliability and avoid wasting storage (Chen and Chen, 2013). Achieving reliability will critically help employees to use the stored data without any supervision, because all these data are identifiable, consistent and dependable. It is imperative to assess the reliability of the data being captured at the early stages of a project, because this will influence the future and ongoing outcomes and performance (Procter et al., 2013; O'Leary, 2013).

One of the important implemented processes to ensure data reliability is the comprehensive database screening process, in which the present data is compared with pre-existing database information, aiming to increase the individual reliability in this database (Hu, 2013). Shen and Zhang (2014) state that while achieving reliability is a complex procedure, it is important to be aware of how to be flexible in control of this reliability. The reliability of big data is the key issue for government research, scientific, and private sectors (Bertot et al., 2014).

Data scalability

Data scalability refers to handling huge volumes of data, most of it unstructured, with rapid arrival from the real world (Miller, 2013). It refers to the capability of storage to handle continuously growing amounts of data in an efficient manner. Furthermore, scalability is a necessary technique in order to meet expanding computational requirements, such as scalable infrastructure, what is called "elastic scalability", which allows users to retain full control of their data (Procter et al., 2013). To process the entire volume of data, it is essential to have efficient, distributed, and scalable storage. But in many projects new data is obtained continuously and arrives quickly. Consequently, there will be explosions and bottlenecks in the data volume, which will lead to difficulty in the process of data scalability. This is very important in real-time decision-making processes. Managers should have insight into, and scientific knowledge about, the types of devices which are available and specify for the scalability their supporting infrastructure, in order to use the proper device for this process. That will help managers meet business requirements for their companies through obtaining the sufficient quality of data that they are seeking, to improve their competencies and, consequently, their performance and productivity (O'Leary, 2013).

Application of the Framework to Case Study Research

In this section of the paper, we will apply our conceptual framework shown in Figure 2 to two case studies on government big data challenges at the local level. We have conducted our own case studies to more fully address the overarching research question: *What are socio-political, strategic change, analytical, and technical capability challenges in transforming the government through the use of open and big data?* This question requires a deep theoretical understanding of antecedent conditions necessary to realize the potential power of big data in effecting organizational transformation and impacts through effective use of big data. In order to address this question, the study has adopted case study research for theory development (Eisenhardt, 1989) and is grounded in a real-life community setting. The case study research strategy is suitable to answer our research question, since it enables researchers to capture the dynamic interactions (Eisenhardt, 1989) to focus on emerging and complex big data ecosystem phenomena, and to induce theories (Benbasat et al., 1987).

We have selected two city governments in Houston and San Antonio, Texas, U.S. for our case study sites. The State of Texas is one of the nine States in the U.S. that have established open data policies either through executive order or legislation (Center for Data Innovation, 2014). Both City of Houston and City of San Antonio are two of the ten largest cities by population in the U.S. (wikipeadia, 2015). In both cities, we have surveyed and analyzed the city government's e-government website information content and open data portal as well as government documents including annual reports, fiscal budget reports, and information technology strategic plans. In the case of the City of Houston we conducted interviews (approximately 90 minutes each) with the city's Chief Operating Officer and Chief Information Officer. In the case of the City of San Antonio we also conducted an interview (over 1.5 hours) with the city's Chief Information Officer and Chief Technology Officer (the previously two separate roles merged into one after the restructure) as well as the public lecture on the city operations by the city manager (over 1.5 hours).

Description of the Two City Governments

Despite the State of Texas's early implementation of open data policies vis-a-vis other states, the two city governments differ in the maturity level of exploiting open and big data for internal operations and sharing big data openly with the public through the creation of a dedicated open data portal. Table 1 shows some of the descriptions of the two city governments.

Table 1. Comparing characteristics of the City of Houston with the City of San Antonio

	City of Houston	City of San Antonio
City size (by population, 2013)	2,195,914 – fourth largest city in the U.S.	1,409,019 – seventh largest city in the U.S.
City adopted budget (2013)	US $4.9 billion	US$2.5 billion

Government structure	Mayor-Council	Council-Manager
Mayor's vision	"Data-driven government" and "collaborative government" – Mayor Annise Parker (2014)	"Smart and fiscally responsible city government" – Mayor Ivy Taylor (March 3, 2015)
Open data portal	MyCity.houstontx.gov	Open government website but no dedicated open data portal
Open data portal managed by:	Department of Planning and Development	Open government website managed by Department of Communications and Public Affairs
CIO reporting to:	Chief Executive Officer	Chief Financial Officer
IT organization leadership	1 CIO, 1 CTO, 4 Deputy CIOs/Deputy Directors & Chief Information Security Officer	1 CIO/CTO
Enterprise resource planning systems and BI tools	Yes	Yes
Project Management Office for IT projects	Yes	No
# email end users IT Services supports:	17,000 + 7,000 federated users	11,000

Transformational Vision of Information Technology Services

In alignment with the City of Houston Mayor's vision of "a data-driven government", the city government's IT Strategic Plan FY2014-2016 (City of Houston, 2013) clearly documents "a vision for transforming the deployment, implementation, and adoption of technology into the lives of our employees, communities, and citizens (Houston Information Technology Services, 2015, p. 1)." The city government's CIO further states: "Our focus in Houston Information Technology Services (HITS) will be on service delivery, IT Governance, the building of customer service centric relationships/partnerships and operational efficiency … all with a sense of urgency." Through this transformational vision of HITS, the IT organization's ultimate goal is to build a collaborative IT organization that would enable its employees, partners, and citizens to realize "the utmost value from our technology investments now and in the future".

Similarly, the City of San Antonio's more dated IT Strategic Plan FY10-FY13 (p. 6 of 26) (City of San Antonio, 2013) states that one of the goals of the Department of IT Services is to "enabling a data-driven government". However, the previous CIO of the City of San Antonio pointedly states: "Historically, much of the City's IT infrastructure was built in department-specific silos. This fragmented structure resulted in costly duplication, unnecessary complexity, an inability to share and collaborate, and an increased vulnerability to security threats. Many of these silo systems have become or are rapidly becoming antiquated legacy systems that are expensive and difficult to maintain." Our interview with the current CIO/CTO confirmed his predecessor's astute observation of the departmental silos which are still in operation. The current CIO/CTO with private-industry senior IT leadership experience remarked that unlike most of the firms operating in competitive markets, government operates in the monopoly market. In this monopoly market situation, the city's departments such as fire, police, and health operate independently, without much interdependence in functions and hence lacking real needs for inter-departmental data sharing.

Big Data Use and Impact in the Two City Governments

The Houston city government provides its employees, businesses, and citizens with a dedicated open data portal, MyCity.houstontx.gov, which openly shares government-owned data. The open data portal is managed and operated not by the Department of Information Technology Services but rather by the Department of Planning and Development which also owns and operates the city government's geographic information systems (GIS). The city government policy mandates that data and big data each department collects or generates will be shared with the Department of Planning and Development. The Department monitors the usage trend of these open data to understand and stimulate the external demand for big data in the communities.

The internal demand for big data by the various departments has been on the rise largely in response to the public's demand for government services. During our interview with the Chief Operating Officer, he illustrated this increasing use of big data in the City of Houston through some of the prime examples, including more effective use of 311 system (the city's non-emergency calls) for more rapid and efficient repair of potholes on the city's roads and more efficient operations of the city's solid waste collection services.

The city government's IT organization supports a wide area network that connects over 450 sites across the city, including Police, Fire, Public Works Departments such as Solid Waste and Road Infrastructure, and Library. It also supports several physical and virtual servers across the city's several data centers. Importantly, the IT organization also supports 152 call centers which include 911, 311, and other emergency services. The city's 911 Computer-Aided Dispatch (CAD) system dispatched approximately 1.7 million Police and Fire events in Fiscal Year 2013. With the dynamically growing energy and health industries, the City of Houston population and road traffic have also been rapidly growing. The problem of potholes has become an urgent agenda of the Mayor's Office. Citizens can register a complaint or a repair request through multiple communication channels: 311 call centers, 311 online, the city government's social media channels, among others. Previously, the city government responded to the citizens' pothole complaints and repaired the ones reported without much planning. However, through the use of big data, GIS, and operation research tools, the city government has a new capability to map the potholes' locations and to optimize the repair vehicles' best routes for dispatch in the most efficient way. These new insights gained through the use of big data for short-run repair have given the city government a long-run, clearer view for better planning for road infrastructure. The city government also analyzes big data generated by GPS on the city's solid waste trucks for the citywide garbage collection to optimize the service routes. This use of big data resulted in over 60% cost reduction in the public services.

The City of San Antonio used to have two separate positions of Chief Information Officer and Chief Technology Officer similar to the city government of Houston. However, as part of the city government restructuring, these positions were combined into the current CIO position. As the Mayor's vision of "smart and fiscally responsible city government" may indicate, the current CIO reports to the Chief Financial Officer. During our interview with the CIO, he underscores that all new IT initiatives need to go through very rigorous reviews by various committees for clear evidence of positive return on investments. While the city government uses big data, it does not have a dedicated open data portal to share data with its employees, businesses, and citizens, unlike the city government of Houston. The absence of a dedicated open data portal may be the long established organizational culture of operating departments in silos and not sharing the department-owned data and big data. According to the CIO, 35 Departments are not dependent on each other in public service delivery, although the Police and the Fire share the same CAD system but use their record management systems differently.

The City of San Antonio CIO gave us a prime example of big data use by the city's Police for better public safety decision-making. In San Antonio, in-car videos generate 2 GB data per vehicle a day for the fleet of 650 Police vehicles. The city's CAD system currently responds to approximately 1,000 unique Police incidents a day. The city plans to adopt the police body cameras which will further generate image data in volumes. These volumes of image data need meta-data logic and index for storing, referencing and retrieving for data mining. The city has gained new insights through big data analysis and can anticipate crimes in certain communities and certain streets. In the case of the police use of big data, it serves dual purposes: (1) to mitigate the risk of potential lawsuits against the city and (2) to enable the police to be preventive and proactive by monitoring the crime big data and better managing police incidents.

Similar to the big data use by Houston, the City of San Antonio also uses big data for better response to citizens' calls to the city's 311 system and 311 online. The city's Customer Relationship Management (CRM) system initially manages their information or service requests on potholes' repair, animal shelters, and solid waste services. The city's GIS portal then shares information on the service locations and the status of the requested services. The CIO views the use of big data as an enabler of better customer management and an optimization tool in public service delivery. Furthermore, the City of San Antonio uses big data from its traffic lights' sensor cameras to better synchronize the city's traffic lights and traffic flows. This use has dual benefits: (1) fuel and time savings for citizens and (2) more efficient centralized traffic management systems for the city government. The city government also uses big data generated by temperature-based sensors for early flood warnings. Big data analysis enables the city to shut down some roads for better disaster risk management. Finally, the CIO observed that "value of big data is more beneficial in volumes".

Organizational Capability Challenges

Table 2 shows our analysis results of the four types of organizational capability challenges in transforming government through the use of open and big data.

Table 2. Summary of Organizational Capability Challenges of Houston and San Antonio

	Houston	San Antonio
Socio-political capability challenges	*With the increased use of GIS, cloud computing, and mobile services the protection of personal privacy presents a key socio-political capability challenge, even when data privacy and security is well guarded technically. *The city government now provides a sophisticated and dedicated open data portal. A key socio-political capability challenges for the city government would be to encourage citizens to develop innovative applications using these open and big data for enhanced public services.	*As the previous CIO pointedly stated, the city government's fragmented IT infrastructure created an inability to share and collaborate, with the resultant increased vulnerability to security threats. The increased vulnerability to security threats would be further increase with the variety of unstructured data as the city government increases the use of sensors and surveillance videos in the streets, on police vehicles, and even the near future use of surveillance cameras on the body of police officers.
Strategic change capability challenges	*Big data use by the departments for better *decision-making* and more efficient public service delivery has been on the rise. *The CIO reports to the Mayor's Office. The Mayor's vision of a data-driven government and a collaborative government seem to reinforce authentic *leadership* down the line. For example, the COO has built an organizational climate where employees are made to feel safe to experiment in new ways of doing things and an error is accepted unless repeated errors of the same kind. *According to the city's COO, once	*Big data use by the city's police has resulted in a better understanding of the communities with higher crimes. However, largely due to the existing department silos, *data sharing* remains a key strategic capability challenge.

	government is digitized and the central mechanism for open data has been established, *data sharing* has not been a problem.	
Analytical capability challenges	*The city government has been using business intelligence (BI) tools for data mining. According to the COO, the city's increased use of sensors for flood monitoring and police vehicle surveillance cameras generate big data. Processing these new sources of data seems to take a longer time and presents analytical capability challenges.	*The city government has been using SAP for HR, procurement, finances, and scheduling, as well as business intelligence (BI) tools for data mining. According to the CIO/CTO, the city government of San Antonio has access to a very large pool of educated labor force, without a significant knowledge or skills shortage.
Technical capability challenges	*Data quality is governed and controlled by IT Governance Board and Project Management Office with the underlying PMI principles. Overall, the Houston IT organization seems to cope flexibly with the increasing data volumes.	*While the city government's digital infrastructure is sufficiently advanced, data quality and data extract present technical capability challenges due to the department silos, the resultant lack of data format standardization, and the lack of a more mature level of IT governance observed in the city of Houston. *The government reports often need to access legacy systems written in COBOL, which makes extracting data difficult.

Discussion

In this paper, we developed an initial conceptual framework for examining impacts of organizational capability challenges on transforming government through big data use (Figure 2). The framework has four categories of big data capability challenges, which were identified through a systematic literature review of 326 journal articles on big data challenges. While they include a large portion of conceptual papers, a very small portion consists of simulation, experiments, survey research, and case study research. Of the 12 case studies published on big data challenges, only two cases focused on government use of big data. As shown in Figure 1, the four categories of big data capability challenges showed differential frequency distribution. The highest frequency distribution of analytical capability challenges (37%) was followed by technical (31%), strategic change (21%) and socio-political capability challenges (11%).

In the next phase of our research we applied our conceptual framework in Figure 2 to conduct case study research on two large-size city governments in the State of Texas: the City of San Antonio and the City of Houston (Table 1). When we compared and contrasted the four categories of organizational capability challenges facing these two city governments, the relative severity of the four categories of organizational capability challenges varied between them (Table 2). In the City of San Antonio which has long experienced the departmental silos in functions, operation, and data ownership, the technical capability challenges such as data quality, reliability, data extraction, and data scalability were more dominantly mentioned during the case interviews. It may be that the departments that operate in silos would most likely resist not only the enterprise-wide standardization in data quality assurance and data formatting but also the enterprise-wide data sharing for better insights into the common public policy and service issues the city government as a whole faces. In fact, after a fairly long public speech, the city manager was

asked by an audience: "What is the most frustrating thing you have been experiencing as the city manager?" Without hesitation, she answered: "Resistance to change!"

In contrast, during our interview with the City of Houston COO, he listed "employees who embrace change – those who experiment new ways of doing things" as one of the critical success factors in transforming public services through big data use. He explicated that as the fourth largest city government, government leadership, including himself, encourages experimentation and accepts errors committed by the city employees as long as the same errors are not repeated. The City of Houston's innovative organizational culture is radically different from the City of San Antonio's culture of departmental silos and cost control performance. Our case study analysis findings suggest that while big data may offer innovative means for achieving the elusive goals of transforming government, the government's leadership team needs to take the strategic capability challenges rather seriously to create what Roy refers to as "transformative collaboration" (Roy, 2007, p. 58) that would diminish the power of the existing departmental silos and bureaucratic resistance to radical change. Our case study analysis findings are consistent with the insights of McAfee and Brynjolfsson (2012, p. 68) on big data as the management revolution: "The evidence is clear: Data-driven decisions tend to be better decisions." While they hold that big data can radically improve organizational performance, they pointedly argue: "But first, you'll have to change your decision making culture (p. 61)."

Finally, as the CIO/CTO for the City of San Antonio remarked on greater benefits from greater volumes of data, Accenture (2014, p. 2) reports one of its survey findings as "Bigger companies are getting more from big data". Similarly, earlier adoption of innovations such as e-government and intranet was associated with larger-size city governments (Moon, 2002). These consistent findings may highlight lesser impacts of analytical capability challenges in larger-size city governments with greater financial and human resources, such as the City of Houston, as measured by the budget, the size of the IT organization, and the more mature IT governance in practice. Furthermore, they may also highlight lesser impacts of technical capability challenges in those governments.

Based on the new insights gained from the two case studies we conducted in this research and post hoc review of the literatures and expert comments, we revised the initial framework by adding three new constructs: *big data public policy*, *political leadership structure*, and *organizational culture*. Our revised conceptual framework we propose in this research paper is shown in Figure 3 below. Here we explain only these new constructs that are added to our initial framework shown in Figure 2.

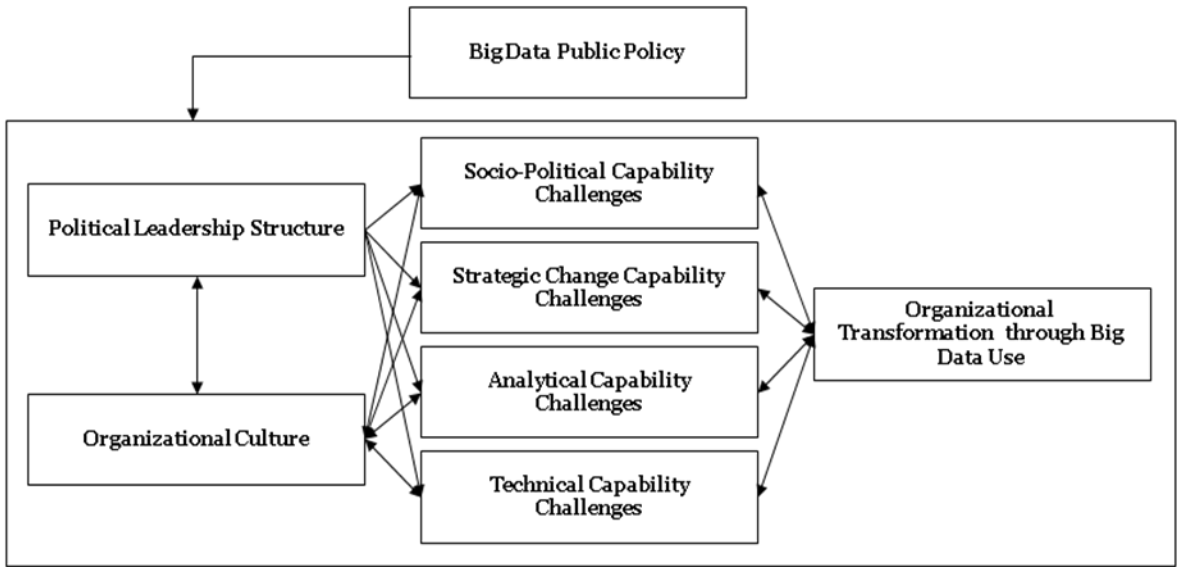


Figure 3. Revised Conceptual Framework for Organizational Capability Challenges in Transforming Government through Big Data

Big Data Public Policy

As Figure 3 shows, we postulate that efficacy (or the lack thereof) of big data public policy, which is exogenous to the government organization, may also exert some direct or indirect influence on the overall government organization's big data capability challenges. While big data public policy as a challenge has not been explicitly mentioned in the academic literatures, big data public policy framework debates are just emerging in the leading big data nations. In 2013, both the UK and Australia released a big data strategy on seizing the big data opportunity and building national big data capability (UK HM Government, 2013) and on identifying opportunities and challenges for Australian government agencies (Australian Government Department of Finance and Deregulation, 2013). Similarly, the US and Canada, independently, completed studies on private-sector and public-sector management of big data to make recommendations towards developing a public policy framework to address big data use impacts on the citizen and the consumer as well as discrimination and privacy issues from big data (US Executive Office of the President, 2014) and to advance national big data capability (Government of Canada, 2013). While it is too early to examine efficacy (or the lack thereof) of big data public policy frameworks and big data strategies being developed in these nations, we hold that efficacy (or the lack thereof) of big data public policy implementation would likely exert either direct or indirect effects on the government agency in enabling (or inhibiting) their capacity to respond to any of the four categories of big data challenges we have earlier discussed in this paper. For instance, from our case study analysis we noticed the importance placed on big data policy in Houston, with the agenda of the Mayor specifically stating that the city will have data driven government.

Political Leadership Structure

Political leadership structure for policy decision-making governance can exert differential impact on organizational capability challenges in transforming government through open and big data innovations. Research on e-government shows the importance of political leadership structure as a way of institutionalizing the adoption of new innovations (Moon, 2002; Moon and Norris, 2005). As we discussed earlier, the City of Houston is a mayor-council form of government, with a strong mayor acting as chief executive in setting the policy agenda of "data driven government" for the city. In contrast, the City of San Antonio is a council-manager form of government where the mayoral power of an elected mayor is relatively weak in comparison to the executive power of the city manager as a permanent professional administrator who has a larger policy governance role in setting and executing the city's agenda. The City of San Antonio focuses more on cost control, administrative efficiency, and return on investment from IT and business initiatives that will enhance its bond rating. These case study findings are consistent with a longitudinal public administration research which found that the council-manager form of government adoption and abandonment in the U.S. has been strongly influenced by economic conditions (Choi et al., 2013). More important, the council-manager form of government tends to demonstrate the dominant characteristic of administrative efficiency, whereas strong mayoral powers in the mayor-council form of government can push and diffuse innovations across the government organization (Frederickson et al., 2004). Since big data is a strategic change initiative with some economic, political and social risks, efficacy of (or lack thereof) political leadership structure seems to play an important role in mitigating (or sustaining or even accentuating) the four categories of capability challenges.

Organizational Culture

Organizational culture can be broadly construed to include virtually everything in the organization (Iivari and Huisman, 2007). Therefore, organizational culture can encompass different underlying dimensions or elements. For example, Schein (1996) argues that the misalignment of the three sub-organizational cultures, namely executives, engineers, and operators that is detrimental to organizational learning and hinders organizational diffusion of an innovative practice. In general, however, organizational culture can be defined "as a pattern of shared basic assumptions that was learned by a group as it solved its problems of external adaptation and internal integration, that has worked well enough to be considered valid and, therefore, to be taught to new members as the correct way to perceive, think, and feel in relation to those problems." (Schein, 2004, p. 17) When the organization experiences adaptive difficulties, as its external environment changes to the point where some of its assumptions are no longer valid, leadership is now

required to step outside the organizational culture and to initiate transformational change processes that are more adaptive. Schein further argues that this leadership capability to perceive the limitations of one's own organizational culture and to transform it adaptively is the essence and ultimate challenge of strategic change leadership.

However, Roy (2007, p. 44) in assessing Canada's e-government argues: "A key question is whether or not a new government is prepared to embrace holistic redesign of political institutions predicated on information openness and public engagement." It is largely because Roy (2007, p. 58) observes a resilient culture of government bureaucracy: "it is government more than elsewhere that has continued to rely on the foundational pillars of Weberian bureaucracy that include hierarchy, clarity, and specialized (or stove pipe) organization. In this largely vertical world, the interface between formal structures and informal culture creates a reflective preference for top-down management and process control."

In our revised framework in Figure 3, therefore, we propose a more narrowly focused dimension of the broader construct of organizational culture; namely innovative organizational culture. In contrast to a culture of government bureaucracy, which has been viewed as a key barrier to technological innovation which can change the status quo of government (Fountain, 2001; West, 2005), we hold that innovative organizational culture encourages and rewards the smart motivated employees with entrepreneurial problem-solving capability and their experimental use of disruptive technologies. Hence, innovative culture is relatively free from bureaucratic red tapes and government departmental silos which are barriers to creating public values (Bannister, 2010). The factor-analytic empirical research suggests differential effects of organizational culture dimensions on organizational performance such as financial performance (Flamholtz and Kannan-Narasimhan, 2005). Specifically, on the one hand, innovative organizational culture was instrumental to successful execution of a new strategic marketing plan in the changing external environment (Ramaseshan et al., 2013). On the other hand, while the positive relationship between innovative organizational culture and the marketing strategy process was found, innovative culture did not exert a direct effect on organizational performance (Toaldo et al., 2013).

While much empirical research is required, in our revised framework we postulate that innovative organizational culture will likely have a positive effect on the government organization's capabilities in adopting and using big data. We found strong evidence of a positive impact of the City of Houston's innovative culture on adoption and use of big data across many departments for enhanced citizen-centric public services delivery. Our revised framework suggests that innovative organizational culture can exert a positive impact on mitigating the four types of big data organizational capability challenges. In contrast, the absence of innovative organizational culture (and the presence of bureaucratic organizational culture) will likely exert an opposite effect on accentuating the organizational capability challenges.

From our case analysis we noticed the different organizational cultures in San Antonio and Houston, with the latter city seems to embrace change more since government leadership encourages experimentation and accepts errors committed by the city employees as long as the same errors are not repeated. The organizational culture and climate seem to be radically different between the two city governments, with Houston displaying a more innovative organizational culture.

Conclusion

Despite the industry hypes on the power of big data for revolutionizing business and government, our extensive review of the literature on big data challenges found the paucity of empirical research in general and the clear lack of case study research on government use of big data and potential challenges in harnessing the power of big data for enhanced public service delivery. This research therefore has addressed the overarching research question on organizational capability challenges in transforming government through open and big data. In order to answer the question we have first developed an initial conceptual framework which identifies the four types of organizational capability challenges: socio-political, strategic, analytical and technical capability challenges. We then applied this initial conceptual framework to guide us to conduct two case studies of the city governments which have been using open and/or big data for a while. While the analysis and classification of the peer-reviewed journal articles applying the conceptual framework showed that nearly 67% of the organizational capability challenges in these publications were analytical and technical capability challenges, the strategic capability challenges such as decision making, data strategy, data sharing, data governance, and leadership were reported

much less by the authors. Furthermore, the two case studies on government big data use challenges reported no strategic capability challenges.

In contrast, our case study analysis findings show the critical role and impact of the absence or presence of the city government's strategic capability challenges in influencing the presence or absence of clear payoffs from the government investments in big data. In their pioneer work on computing in public organizations, Kremer and King (1986, p. 494) astutely observe that government computing is a complex social enterprise that would require the continuous mobilization of internal and external social forces to engage leadership, departmental managers, and end users for its intended effect on organizational performance. Our case interviews further indicated that big data public policy, political leadership structure, and innovative organizational culture had an impact on the four capability challenges. This was especially evident in Houston with the mayor taking on a leadership role in the adoption of data driven government. From our analysis we have provided fresh insights into the unique role of government in the big data ecosystem.

There are some practical implications of this research for public managers. First, our revised conceptual framework, shown in Figure 3, is a useful tool that local governments can use to identify some of the possible barriers that they need to overcome for effective big data implementation and use. Second, this research was able to provide unique insights into big data challenges for local governments, which are important to know since these governments typically have unique organizational cultures and constraints, and politics and policy must be navigated through for effective adoption of big data.

In the light of the paucity of empirical research, specifically case study research on government use of big data for transformation of and impact on enhanced public service delivery, we hope our case study research findings would make a contribution to the growing body of big data literatures in many disciplines including the IS research field. However, our research has some limitations including the number of the case study sites, the strategic selection of the two city governments in the fourth and the seventh largest cities in the United States which may not generalize to smaller city governments either in the developed or developing countries where the sustained fiscal and resource problems are apparent. Our future research directions therefore include a large-scale survey of city governments and further case studies of city governments both in developed and developing countries to test the validity and the utility of our conceptual framework developed in this research.

References

Abbott, R. 2013. "Big Data and Pharma Covigilance: Using Health Information Exchanges to Revolutionize Drug Safety," *Iowa Law Review* (99:1), pp. 225-295.

Accenture. 2014. Big *Success with Big Data High Performance Delivered*, Executive Summary, https://www.accenture.com/t20150523T041530__w__/hk-en/_acnmedia/Accenture/Conversion-Assets/DotCom/Documents/Global/PDF/Industries_13/Accenture-Big-Data-POV.pdf#zoom=50.

Arora, P., and Predmore, C. E. 2013. "Social Media as a Strategic Tool: Going beyond the Obvious," *Advanced Series in Management* (11:1), pp.115-127.

Australian Government Department of Finance and Deregulation. 2013. *The Australian Public Service Big Data Strategy Improved Understanding through Enhanced Data-Analytics Capability*, August 2013, Canberra: AGIMO.

Bannister, F. 2010. "Deep E-Government Beneath the Carapace," in Hans J. Scholl (ed.) *E-Government Information , Technology, and Transformation*, Advances in Management Information Systems, Vladmir Zwass Series Editor, New York: ME. Sharpe, pp. 33-51.

Benbasat, I., Goldstein, D. K., and Mead, M. 1987. "The Case Research Strategy in Studies of Information Systems," *MIS Quarterly* (11:3), pp. 369-386.

Bertot, J. C., Ursula, G,, Paul T.G., Lindsay, C.S., and Heeyoon, C. 2014. "Big Data, Open Government and E-Government: Issues, Policies and Recommendations," *Information Polity,* (19:1-2), pp. 5-16.

Bhimani, A. and Willcocks, L. 2014. "Digitisation, 'Big Data" and the Transformation of Accounting Information," *Accounting and Business Research* (44:4), pp. 469-490.

Boyd, D., and Crawford, K. 2012. "Critical Questions for Big Data: Provocations for a Cultural, Technological, and Scholarly Phenomenon," *Information, Communication & Society* (15:5), pp. 662-679.

Bruns, A. 2013. "Faster than the Speed of Print: Reconciling 'Big Data' Social Media Analysis and Academic Scholarship," *First Monday* (18:10), pp.1-24.

Center for Data Innovation. 2014. State Open Data Policies and Portals, August 18, 2014, http://www.datainnovation.org/2014/08/state-open-data-policies-and-portals/.

Chang, R.M., Kauffman, R.J., and Kwon, Y. 2014. "Understanding the Paradigm Shift to Computational Social Science in the Presence of Big Data," *Decision Support Systems* (63), pp. 67-80.

Chen, H., Chiang, R. H., and Storey, V. C. 2012. "Business Intelligence and Analytics: From Big Data to Big Impact," *MIS Quarterly* (36:4), pp. 1165-1188.

Chen, M., Mao, S. and, Liu, Y. 2014. "Big Data: A Survey," *Mobile Networks and Applications* (19:2), pp. 171-209.

Chen, C.L Philip, and Zhang, C. 2014. "Data-Intensive Applications, Challenges, Techniques and Technologies: A Survey on Big Data," *Information Sciences* (275), pp. 314-347.

Chen, G. and Chen, X. 2013. "Based on Big Data Management Research Automobile Clutch Release Bearing Bdevelopment System," *Journal of Applied Sciences* (13:14), pp. 2688-2693.

Chiang, R.H.L., Goes, P., and Stohr, E.A. 2012. "Business Intelligence and Analytics Education, and Program Development: A Unique Opportunity for the Information Systems Discipline,"*ACM Transactions on Management Information Systems (TMIS)* (3:3), pp. 1-13.

Choi, C.G., Feiock, R.C. and Bae, J. 2013. "The Adoption and Abandonment of Council-Manager Government, " *Public Administration Review* (73:5), pp. 727-736.

Choudhury, S., Fishman, J.R., McGowan, M.L., and Juengst, E.T. 2014. "Big Data, Open Science and the Brain: Lessons Learned from Genomics," *Frontiers in human neuroscience* (8), pp.1-10.

City of San Antonio. 2013. *IT Strategic Plan FY10-FY13*, http://www.sanantonio.gov/.

City of Houston, Texas. 2013. *IT Strategic Plan 2014-2016 Investing for Tomorrow's Technology, Today*, http://www.houstontx.gov/hits/strategicplan/itstrategicplan.pdf.

City of Houston, Texas. 2015. *Houston Information Technology Services*, http://www.houstontx.gov/hits/.

Davenport, T. H. 2014. *Big Data @Work Dispelling the Myths, Uncovering the Opportunities*, Boston: Harvard Business Review Press.

Davenport, T.H., and Patil, D.J. 2012. "Data Scientist: the Sexiest Job of the 21st Century," *Harvard Business Review* (90:10), pp 70-76.

Demirkan, H., and Delen, D. 2013. "Leveraging the Capabilities of Service-Oriented Decision Support Systems: Putting Analytics and Big Data in Cloud," *Decision Support Systems* (55:1), pp. 412-421.

Eisenhardt, K. M. 1989. "Building Theories from Case Study Research," *The Academy of Management Review* (14:4), pp. 532-550.

Fattah, A. 2014. "Going Beyond Data Science Toward an Analytics Ecosystem: Part 1 Mount a Strategic, Practical, and Sustainable Approach for Big Data Analytics," *IBM Data Management Magazine* (3), pp. 1-3.

Fawcett, S.E., and Waller, M.A. 2014. "Can We Stay Ahead of the Obsolescence Curve?: On Inflection Points, Proactive Preemption, and the Future of Supply Chain Management," *Journal of business logistics* (35:1), pp. 17-22.

Flamholtz, E., and Kannan-Narasimhan, R. 2005. "Differential Impact of Cultural Elements on Financial Performance," *European Management Journal* (23:1), pp. 50-64.

Fountain, J. 2001. *Building the Virtual State: Information Technology and Institutional Change*, Washington, D.C.: Brooking Institution Press.

French, M. 2014, "Gaps in the Gaze: Informatic Practice and the Work of Public Health Surveillance," Surveillance & Society (12: 2), pp. 226.

Frederickson, H.G., Johnson, G.A., and Wood, C. 2004. "The changing structure of American cities: A study of the diffusion of innovation," *Public Administration Review* (64:3), pp.320-330.

Gabel, T., and Tokarski, C. 2014. "Big Data and Organization Design," *Journal of Organization Design* (3: 1), pp. 37-45.

Gleditsch, K.S., Metternich, N.W.,and Ruggeri, A. 2014. "Data and Progress in Peace and Conflict research," *Journal of Peace Research* (51:2), pp. 301-314.

Godfrey, P., Crick, R. D., and Huang, S. 2014. "Systems Thinking, Systems Design and Learning Power in Engineering Education," *Engineering Education* (30:1), pp. 112-127.

Goes, P. B. 2014. "Editor's Comments Big Data and IS Research," *MIS Quarterly* (38:3), pp. iii-viii.

Government of Canada. 2013. *Capitalizing on Big Data: Toward a Policy Framework for Advancing Digital Scholarship in Canada*, 16 October, 2013, www.data.gc.ca.

Groves, W., Collins, J., Gini, M., and Ketter, W. 2013. "Agent-Assisted Supply Chain Management: Analysis and Lessons Learned," *Decision Support Systems* (57), pp. 274-284.
Holtgrewe, U. 2014. "New New Technologies: The Future and the Present of Work in Information and Communication Technology," *New technology, Work and Employment* (29:1), pp. 9-24.
Hu, M. 2013. "Biometric ID Cybersurveillance," *Indiana Law Journal* (88:4), pp. 1475-1558.
Iivari, J., and Huisman, M. 2007. "The Relationship between Organizational Culture and the Deployment of Systems Development Methodologies," *MIS Quarterly* (31:1), pp. 5-58.
Jetzek, T., Michel, A., and Andersen, N.,B. 2014. "Data-Driven Innovation through Open Government Data," *Journal of Theoretical and Applied Electronic Commerce Research* (9:2), pp.100-120.
Katal, A., Wazid, M., and Goudar, R.H. 2013. "Big Data: Issues, Challenges, Tools and Good Practices," *IEEE*, pp. 404-409.
Khansa, L., Forcade, J., Nambari, G., Parasuraman, S., and Cox, P. 2012. "Proposing an Intelligent Cloud-Based Electronic Health Record System," *International Journal of Business Data Communications and Networking (IJBDCN)* (18:3), pp.57-71.
Kraemer, K., and King, J.L. 1986. "Computing in Public Organizations," *Public Administration Review* (46:Special Issue), pp. 488-496.
Kwon, O., and Sim, J. M. 2013. "Effects of Data Set Features on the Performances of Classification Algorithms," *Expert Systems with Applications* (40:5), pp.1847-1857.
Kwon, O., Lee, N., and Shin, B. 2014. "Data Quality Management, Data Usage Experience and Acquisition Intention of Big Data Analytics," *International Journal of Information Management* (34:3), pp. 387-394.
Lee, C., and Chien, T. 2013. "Leveraging Microblogging Big Data with a Modified Density-Based Clustering Approach for Event Awareness and Topic Ranking," *Journal of Information Science* (39:4), pp. 523-543.
Lim, E., Chen, H., and Chen, G. 2013. "Business Intelligence and Analytics: Research Directions," *ACM Transactions on Management Information Systems (TMIS)* (3:4), pp. 1-10.
Lomotey, R. K., and Deters, R. 2014. "Analytics–as–a–Service Framework for Terms Association Mining in Unstructured Data," *International Journal of Business Process Integration and Management* (7:1), pp.49-61.
Manyika, J., Chui, M., Brown, B., Bughin, J., Dobbs, R., Roxburgh, C. , and Byers, A. H. 2011. "Big Data: The Next Frontier for Innovation, Competition, and Productivity,"*McKinsey Global Institute*.
Marx, V. 2013. "Biology: The Big Challenges of Big Data," *Nature* (498:7453), pp. 255-260.
Mayer-Schönberger, V., and Cukier, K. 2014. *Big Data*, New York: *Houghton Mufflin Harcourt*.
McAfee, A., and Brynjolfsson, E. 2012. "Big Data: The Management Revolution," *Harvard Business Review* (90:10), pp. 60-68.
Meta Group. 2001. "3D Data Management: Controlling Data Volume, Velocity, and Varity," Application Delivery Strategy, February 1, 2001, http://blogs.gartner.com/doug-laney/files/2012/01/ad949-3D-Data-Management-Controlling-Data-Volume-Velocity-and-Variety.pdf.
Miller, H.J. 2013. "Beyond Sharing: Cultivating Cooperative Transportation Systems through Geographic Information Science," *Journal of Transport Geography* (31), pp. 296-308.
Mintzberg, H., Lampel, J., Quinn, J.B. and Ghoshal, S. 2003. *The Strategy Process Concepts Contexts Cases*. Case 14 The London Free Express (A) – Strategic Change, pp. 146-155.
Moon, M.J., and Norris, D. F. 2005. "Does managerial orientation matter? The adoption of reinventing government and e-government at the municipal level," *Information Systems Journal* (15:1), pp. 43-60.
Moon, M. J. 2002. "The evolution of e-government among municipalities: rhetoric or reality?," *Public administration review* (62:4), pp.424-433.
O'Leary, D.E. 2013, "Exploiting Big Data from Mobile Device Sensor-Based Apps: Challenges and Benefits," *MIS Quarterly Executive* (12:4), pp. 179-187.
Open Government Partnership. 2015. *The Open Government Partnership*. Accessed 27/2/2015 and Available from: http://www.opengovpartnership.org/.
Procter, R., Vis, F. and, Voss, A. 2013, "Reading the Riots on Twitter: Methodological Innovation for the Analysis of Big Data," *International Journal of Social Research Methodology* (16:3), pp.197-214.
Qu, X., Latino, D.A., and Aires-de-Sousa, J. 2013. "A Big Data Approach to the Ultra-Fast Prediction of DFT-Calculated Bond Energies," *Journal of Cheminformatics* (5:34), pp.1-13.
Rajagopalan, N., and Spreitzer, G. M. 1997. "Toward a theory of strategic change: A multi-lens perspective and integrative framework," Academy of Management Review (22:1), pp. 48-79.

Ramaseshan, B., Ishak, A. and Kingshott, R.P. J. 2013. "Interactive Effects of Marketing Strategy Formulation and Implementation upon Firm Performance," *Journal of Marketing Management* (29:11-12), pp. 1224-1250.
Rothberg, H.N., and Erickson, G.S. 2013. "A Strategic Approach to Knowledge Development and Protection," *The service industries journal* (33:13/14), pp. 1402-1416.
Roy, J. 2007. "E-Government in Canada: Transition or Transformation," in Donald F. Norris (ed.), *Current Issues and Trends in E-Government Research*, Hershey, PA: Cyber Tech Publishing, pp. 44-67.
Royster, S. 2013. "Working with Big Data," *Occupational Outlook Quarterly* (57:3), pp.1-10.
Schein, E. H. 2004. *Organizational Culture and Leadership*, 3rd Edition, San Francisco, California: Jossey-Bass.
Schein, E. H. (1996) Three cultures of management: The key to organizational learning, *MIT Sloan Management Review* (38:1), pp. 9-20.
Schermann, M., Hemsen, H., Buchmüller, C., Bitter, T., Krcmar, H., Markl, V., and Hoeren, T. 2014. "Big Data," *Business & Information Systems Engineering* (6:5), pp. 261-266.
Schroeck, M., Shockley, R., Smart, J., Romero-Morales, D., and Tufano, P. 2012. "Analytics: The Real-World Use of Big Data," *IBM Global Business Services*.
Shen, Y. and, Varvel Jr, V. E. 2013. "Developing Data Management Services at the Johns Hopkins University," *The Journal of Academic Librarianship* (39:6), pp. 552-557.
Shen, Y., and Zhang, Y. 2014. "Transmission Protocol for Secure Big Data in Two-Hop Wireless Networks with Cooperative Jamming," *Information Sciences* (281), pp. 201-210.
Stewart, G., and Valentine, E.L.H. 2013. "The Emerging Role of the Board of Directors in Enterprise Business Technology Governance," *International Journal of Disclosure and Governance* (10:4), pp. 346-362.
Sukumar, S.R. and Ferrell, R.K. 2013. "Big Data" Collaboration: Exploring, Recording and Sharing Enterprise Knowledge,"*Information Services & Use* (33:3-4), pp. 257-270.
Tallon, P. P., Ronald, V. R., and James, E. S. 2014. "The Information Artifact in IT Governance: Toward a Theory of Information Governance," *Journal of Management Information Systems* (30:3), pp. 141-178.
Tallon, P., Short, J., and Harkins, M.W. 2013. "The Evolution of Information Governance at Intel," *MIS Quarterly Executive* (12:4), pp. 189-198.
Toaldo, A.M.M., Didonet, S.R., and Luce, F.B. 2013. "The Influence of Innovative Organizational Culture on Marketing Strategy Formulation and Results," Latin American Business Review (14:3-4), pp. 251-269.
Tufekci, Z. 2014. "Engineering the Public: Big Data, Surveillance and Computational Politics,"*First Monday* (19:7), pp.1-17.
UK HM Government. 2013. *Seizing the Data Opportunity. A Strategy for UK Data Capability*, October 2013, London: Department for Business, Innovation and Skills, *www.gov.uk/bis*.
US Executive Office. 2009. *Open Government Directive*, December 8, 2009, http://www.treasury.gov/open/Documents/m10-06.pdf.
US Executive Office of the President. 2014. Report to the President. Big Data and Privacy: A Technological Perspective, May 2014, www.whitehouse.gov/ostp/pcast.
Webster, J., and Watson, R.T. 2002. "Analyzing the Past to Prepare for the Future: Writing a Literature Review," *MIS Quarterly* (26:2), pp. xiii-xxiii.
Weiss, R., and Zgorski, L. 2012. "Obama Administration Unveils "Big Data" Initiative: Announces $200 Million in New R&D Investments," Washington, D.C.: Office of Science and Technology Policy.
West, D. M. 2005. *Digital Government Technology and Public Sector Performance*, Princeton, NJ: Princeton University Press.
White, M. 2012. "Digital Workplaces: Vision and Reality,"*Business Information Review* (29:4), pp. 205-214.
Wiedemann, G. 2013. "Opening Up to Big Data: Computer-Assisted Analysis of Textual Data in Social Sciences," *In Forum Qualitative Sozialforschung/Forum: Qualitative Social Research* (14:2), pp.1-24.
Wikipedia 2015. List of United States Cities by Population, https://en.wikipedia.org/wiki/List_of_United_States_cities_by_population.
Zhang, D. 2013."Granularities and Inconsistencies in Big Data Analysis," *International Journal of Software Engineering and Knowledge Engineering* (23:6), pp. 887-893.