Algorithmic Bureaucracy

Managing Competence, Complexity, and Problem Solving in the Age of Artificial Intelligence

Thomas M. Vogl
Oxford Internet Institute, University of Oxford, Oxford, United Kingdom, thomas.vogl@oii.ox.ac.uk

Cathrine Seidelin
Computer Science, IT University of Copenhagen, Copenhagen, Denmark, cfre@itu.dk

Bharath Ganesh
Oxford Internet Institute, University of Oxford, Oxford, United Kingdom, bharath.ganesh@oii.ox.ac.uk

Jonathan Bright
Oxford Internet Institute, University of Oxford, Oxford, United Kingdom, jonathan.bright@oii.ox.ac.uk

ABSTRACT

In recent years, local government has been undergoing changes which are strongly influenced by the growing digitization of governmental operations. In this paper, we expand on the concepts of Digital Era Governance and its successor, Essentially Digital Government, by introducing the concept of Algorithmic Bureaucracy, which looks at the impacts of artificial intelligence on the socio-technical nature of public administration. We report on a mixed-method study, which focused on how the growth of data science is changing the ways that local government works in the United Kingdom. Under Algorithmic Bureaucracy, the direct and indirect effects of public administrative changes on the level of social problem solving may become positive in two cases: 1) where through artificial intelligence and isocratic administration the explainability of algorithmic processes increases individual and staff competence, and 2) where algorithms take on some of the role of processing institutional and policy complexity much more effectively than humans.

CCS CONCEPTS

• **Applied computing~E-government** • *Social and professional topics~Socio-technical systems* • Computing methodologies~Artificial intelligence • Information systems~Decision support systems

KEYWORDS

Algorithmic Bureaucracy, Digital Era Governance, Local Government, Socio-technical systems, Data Science

1 Introduction

The increased digitization of government operations has generated a wealth of administrative data on individual preferences and behaviours, which are analyzed more effectively than ever before. New sources of data, such as data from Internet of Things devices, social media and mobile phones are emerging [31]. At the same time, new analytical techniques have improved our ability to understand this data and use it (for example, the rise of predictive analytics, artificial intelligence and A/B testing) [29]. Finally, these new techniques are supported by developments in tool availability (for example, sophisticated, open source software, such as R and Python) which enable machine learning at low cost to those who have the necessary skills. These three overall changes challenge old ways of working and raise the possibility of new approaches to organizing in public administration.

We introduce the concept of Algorithmic Bureaucracy to encapsulate these three elements of change, which together offer a novel take on current conceptualizations of public administration and produce ways to overcome the challenges of competence and complexity, which often drive changes in public management regimes. As public sector service systems become more complex, the combination of digitization, data, and analytical techniques allow for some organizational practices previously based on office procedures to be carried out by algorithms. This leads to a socio-technical change. In this paper, Algorithmic Bureaucracy represents a new combined organizational environment in which office workers and algorithms can work together to comprehend the complex service context and optimize service provision for the individuals they serve [26].

In this paper, we explore how digitized data and the application of algorithms can improve social problem solving in two main ways: 1) by enhancing individuals' and public administrators' autonomy and competence; and 2) by dealing with greater institutional and policy complexity. We do so by presenting a mixed-methods study in which we analyzed the spread of 'data science' in local government in the United Kingdom (UK). We adopt an understanding of data science as the expansion of the types of data and analytical techniques used [3]. After a discussion of the background and methodology we explore some barriers to and opportunities from the implementation of artificial intelligence (AI) in local authorities. The paper concludes with the role that Algorithmic Bureaucracy can take in enhancing individual and administrator autonomy and competence, organizational ability to deal with institutional and policy complexity, and thus improve social problem solving.

2 Background

In this section, we briefly touch upon developments in public administration in order to contextualize how Algorithmic Bureaucracy can enhance competence and deal with complexity. Originally, Weberian bureaucracy was understood as a means to overcome partial decision-making and improve predictability and calculability within the state [34]. At the time, this was seen as the most sophisticated use of human, material, and organizational technology, but over time was perceived as cumbersome and inflexible [12]. In response, during the 1980s and 1990s, the New Public Management (NPM) was adopted in some jurisdictions, such as the UK, as a means to overcome these perceived deficiencies by applying market principles to the state including disaggregation, competition, and incentivization [10]. But since the 1980s and 1990s, there has been a parallel and dramatic change in networked information technologies.

Today, writing is machine readable and computers, over internet protocols, can transfer and process information in real-time. In this context, it is possible to respond to contextual differences in predictable ways, to process greater complexity, deal with limitations in human information processing, and solve social problems. Undue focus on hierarchy and procedure can limit moves towards bottom-up and outcomes based digital change [11]. That being said, some of Weber's ideas about socio-technical systems and rationalization in public administration resonate today [5]. With these changes, researchers have argued that the NPM has met its end [10] and that a Digital Era Government (DEG) approach to public administration characterized by reintegration, digitization and needs-based holism is emerging [10, 23].

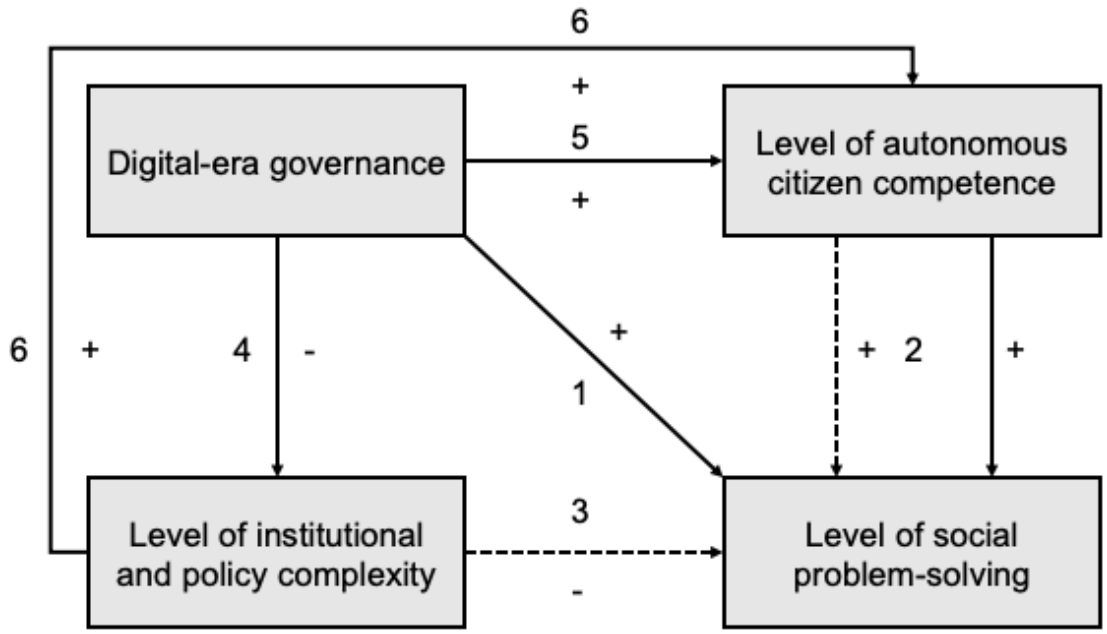

Figure 1. DEG and social problem solving. Adapted from [10]

DEG was seen to have a net positive impact on social problem-solving relative to NPM. Figure 1, above, illustrates not only the direct impact of DEG on the level of social problem-solving (flow 1), but also the numerous indirect effects (flows 4-6), as well as the direct effects from other sources (2-3). Flow 2 illustrates that autonomous citizen competence can have both a direct (solid line) and indirect (dotted line) increase on the level of social problem-solving.

Flow 3 illustrates that the level of institutional and policy complexity can have an indirect negative impact on the level of social problem-solving. Flow 4 illustrates that DEG changes have a direct effect on decreasing the level of institutional and policy complexity (through reintegration), which in turn has a direct effect on increasing the level of autonomous citizen competence (reversals from the impacts of the earlier NPM). Finally, flow 5 illustrates that DEG has a positive influence on the level of autonomous citizen competence (through disintermediation resulting from online services).

Recently there has been a shift from DEG to Essentially Digital Government (EDGE), which puts technology at the centre of government and which looks at what DEG can enable, including equality of outcomes, an organizational structure characterized by an intelligent center and devolved delivery, and isocratic service delivery (where individuals serve themselves online) [9]. As local authorities begin to adopt data science approaches, many of the features of DEG and EDGE are visible. However, there are also elements that are not captured under these paradigms. We argue that it is relevant to explore the influence of algorithms on bureaucracy and how it impacts the ability of public administration to deal with competence and complexity in social problem solving.

3 Methodology

This research builds on empirical material, which was collected as a part of the Data Science for Local Government project [3]. This project aimed to understand how the growth of data science is changing the way that local government works in the UK. This section elaborates on the applied methods and analysis.

Our study is based on research that took place between November 2017 and December 2018. It adopts a similar methodological approach to other research in digital government change [13]. It reports on desk research, survey responses, and subsequent in-depth interviews conducted with people working in the area of local government data science in the UK. Personal email invitations to complete the survey were sent to at least one person in all of the (almost 450) local authorities in the UK. Individuals who were invited to participate were selected because they worked in areas related to data science such as information technology, business intelligence, analytics, open data, and government digitization. Local authority organizational charts and contact lists were used wherever possible. The survey was at least partially completed (29% or more of the survey was completed) by 118 respondents. Based on respondents who volunteered their local authority, at least 64 different local authorities were represented. Audio recorded semi-structured interviews were conducted with individuals who were selected based on their survey responses or their online profile found during the earlier desk research and who were either working in UK local authorities, central government, or in enterprises providing data science services to these authorities. Of those contacted, 34 were interviewed by phone or over Skype. We collectively reviewed interview recordings in order to identify key themes and quotes, which were noted or transcribed. These three steps - desk research, survey results, and interview responses - were used to triangulate common themes and form more nuanced understandings. While a multi-method qualitative approach can offer opportunities to corroborate information and enhance credibility [21, 30], the limitations are that we could not control who responded to the survey and that the individuals involved responded in a personal capacity. As a result, the findings from the survey and interview should be considered indicative rather than conclusive.

4 Findings

In presenting the findings of this study, we first elaborate on five identified challenges to digital changes in local authorities. Then, we review different examples of AI currently being used in local government in the UK, which illustrate shifts towards DEG and EDGE, and describe their role in dealing with complexity, enhancing competence, and improving social problem solving.

4.1 Challenges to digital changes in local authorities

This section presents five challenges to digital changes in local authorities. The first challenge constitutes the fundamental need to ‘make the case’ to senior management in order to get them to buy in and allocate time to data science projects. Staff still need to seek approvals up the hierarchy to move projects forward. In our survey research respondents referred to a lack of commitment to developing a culture that fosters the use of data analytics in creative ways. A researcher in social data analytics said that “*part of my job is to bridge the gap between the technology and the leadership because it is all too easy for technology to end up in the corner, gathering dust, and never getting used. Getting leadership buy in is a huge challenge with this type of work*” (Skype interview, 3rd quarter, 2018).

The second challenge revolves around gaming. Our study includes a number of examples of cases where technological changes are having impacts influencing the behaviour of the socio-technical system. For example, there is also the question of how people who are generating the input data for the tool will respond to its introduction. One

interviewee who works as a data scientist explained that: "*it's very important that any kind of tool or decision aid that comes about as a result of this work is not used as a performance management tool, or anything to beat social workers about the head with because the moment you do that, then it starts to open the possibility that they will begin to game the predictions ... so the tool itself will not be making effective recommendations because it's being fed information that's designed to trick it.*" (Phone interview, 3rd quarter, 2018). Focusing on performance management without being cognizant of the socio-technical nature of the system could cause issues because of the risk of perverse incentives [18].

Expertise represents the third challenge for local authorities. NPM and its focus on competition reduced internal IT capacity both for development, maintenance, and procurement. Thus, government may lack key skills and knowledge during the procurement process. Part of the problem here is that, like many types of technology, 'data science' as a concept is sometimes hard to separate from the hype surrounding it, something that decision makers feel the need to use 'in order to remain competitive' [26]. However, the situation may be improving. As one interviewee, who is part of a company that works with local authorities to help them to use data to improve their services commented: *"I hope we are moving towards a moment when government agencies are intelligent buyers and users of this technology"* (Phone interview, 3rd quarter, 2018).

Fourth, several of our interviewees addressed the significant financial cutbacks in recent years in local government administrations and emphasized the negative impact budget saving and statutory requirement incentives have on decision makers. Many of these cutbacks have fallen on non-frontline staff, which can often mean people with analytical skills. A Digital Geographic Information System Solution manager expressed how the ability to make use of data in new and valuable ways is highly dependent on staff: *"while some of the materials are recorded, the actual knowledge capital of interpretation and context could be lost, and you have to start from scratch, even when the data is there. So, the question is how do you build on these pieces of work*" (Phone interview, 3rd quarter, 2018). This indicates that while a desire to preserve frontline staff, at the expense of back-office analytics staff, is understandable, these cuts may end up being counterproductive in the long term.

Finally, the fifth challenge touches upon fragmentation and data sharing. The ability to share data (between different branches of an agency, between different agencies within a local authority and even between local authorities) is a fundamental enabler of some information processing with AI; it is also one of the most difficult challenges for local authorities to overcome. In our survey, 53% of the respondents reported that difficulties with 'data silos' and interoperability of datasets were the most frequently mentioned barrier to data science projects. One interviewee, who works as Head of an Intelligence Unit in a local council highlighted this challenge by using an example from her own work: *"we use eleven different systems, none which talk to each other, and most of which don't use the same unique identifier. We were getting increasingly frustrated that we thought there was value in the data, but we couldn't make people understand that value, because they can't physically see the information, because it's all hidden in these systems*" (Phone interview, 3rd quarter, 2018). The challenges and issues which recur in projects that require integrated data are well known [14, 15, 36]. Many councils may lack a comprehensive understanding of their data holdings across departments and may have different levels of maturity when it comes to who is responsible for owning and managing them [31]. After getting access to data there can be additional challenges when connecting and merging data which may be held in many different, and potentially incompatible, formats [16, 17, 37].

4.2 Artificial Intelligence in the UK

In this section, we review examples of AI which are currently being used in local government in the UK. Through these examples, we will look at how components of DEG and EDGE are manifesting through the use of data, algorithms, and AI to help alleviate some of these challenges, or to provide a supplement to existing services.

One way that AI is beginning to be applied in local government is through the introduction of predictive analytics and decision support technologies [4]. Based on our empirical data, these technologies are typically computerised systems which aim to support public servants making service intervention decisions. The most predominant manifestations of these types of systems is in the use of machine learning techniques to produce predictions or risk scores for geographic areas or individual cases: 20 of our survey respondents (16%) reported that their local authority is experimenting with some kind of predictive analytics or decision support [4]. Machine learning involves making use of past service data to derive algorithms that are constantly adapting to new data inputs, and which are used to support the prediction of future outcomes. Rather than being explicitly programmed, parameters of the algorithm are learnt, and the predictions can be used as a decision-making aid. Systems such as those provided by machine learning technologies offer an opportunity to move away from procedural equality towards equality of outcomes as greater degrees of complexity can be incorporated into the decision-making process.

Using predictive analytics to improve the efficiency of inspection operations offers another example. A variety of different branches of local government need to enforce local rules. For example, authorities need to make sure that council tax is paid correctly or to find Houses of Multiple Occupation (HMOs). Inspections are a key element of

enforcement and they depend on an inspector's ability to process and use information. The city of Belfast contracted a company to develop a tool to more accurately identify properties paying incorrect business rates. The software improved the efficiency of inspection teams by more than 200% and found almost £400,000 of unclaimed rates in just the first weeks of operation [1]. Here predictive analytics helped to overcome human limitations in complex information processing.

The concept of an organizational structure with an intelligent centre and devolved delivery depends on the ability of digital technology to at once centralize and decentralize information. Data in the system can be equally used by front-line workers to make local decisions based on individual data, or by senior leaders to make strategic decisions based on aggregate and trend data. Local government has always had a need for forecasting and prediction. However, forecasting has previously largely taken place at a policy or strategic level using aggregate data reported at regular intervals [28]. Our data shows how digital data can bring together the insights of a network of carers to build a collective intelligence that can inform decision making. For example, one interviewee highlighted the particular importance of this type of individualized prediction: "*We have been doing some work on risk of homelessness … the problem is not knowing how many homeless people will there be in general, it's which people will it be, or what pathways will have led them to the stage? That is a more important question ... and this is where machine learning approaches become really useful*" (Skype interview, 2nd quarter, 2018). With the processing of administrative data from front line services there is a blurring of the line between what data should be used to inform front line service delivery and what data should be used to inform strategic policy and planning. Often the tools and dashboards at each level are based on the same underlying data. As a Head of an Intelligence Department explained: "*There is a bit of blurring going on in research and intelligence, between what's performance information and what's business intelligence - who is the customer of data science? The manager or frontline workers?*" (Phone interview, 3rd quarter, 2018). One program for emergency planning links data between 30 providers in health, emergency, and local authority services under a data governance policy. The system includes a unique patient identifier and an address for Global Positioning System mapping, so that the location of the vulnerable individuals can be visualized on a dashboard with an interactive map providing lists for both front-line and strategic decisions [8, 35].

With machine learning techniques, some blunt procedural approaches to individual services can be replaced by more nuanced approaches. To help achieve a positive outcome, these tools may suggest different interventions depending on the context and characteristics of the person in question. These tools can easily process a greater degree of informational complexity than any individual. Emergency services are beginning to explore the potential offered by such analytics. In the context of criminal justice, the United States is using predictive algorithms to inform bail hearings, sentencing and parole decisions [2, 20, 22]. In the UK, similar applications are beginning to appear, but they are much more experimental in nature. One example is provided by the Harm Assessment Risk Tool (HART) in Durham. The HART tool provides a risk score for custody officers when processing individuals who have been arrested [25, 32]. The tool makes use of data on past offending as well as demographic characteristics and divides offenders into low, moderate and high-risk categories. These categories allow custody officers to make different decisions about offenders with different risk levels, for example moderate risk individuals may be eligible for out-of-court rehabilitation programmes. The tool can be used to bring more consistent yet contextual decision making to front line workers whether they are new or seasoned veterans. This illustrates an organizational shift from procedures to outcomes, where a human is responsible for the decision and the machine can take on some of the complexity, such as a search of history in previous records, and offer an initial assessment of risk.

These examples illustrate how the use of algorithms may overcome limitations in human information processing capabilities and allow for increasingly complex rule sets that better determine service needs based on the unique characteristics of each client. As Cuccaro-Alamin et al. have noted: "Practitioners have difficulty processing large amounts of available information and often used flawed heuristic strategies instead of rational models. Practitioners' personal beliefs and biases and the culture of the agency can also affect assessment" [6]. Further, one respondent said: "*I used to say that we don't make predictions about individuals. This is increasingly untenable as a position because of the potential benefits. The moral obligation is to do it but be really careful.*" (Skype interview, 2nd quarter, 2018). The need for written procedures and elaborate information retrieval may decrease as algorithms carry some of this load, allowing workers to focus on their strengths of engaging with clients and providing needed services [6].

Some machine learning techniques are quite obscure, sometimes referred to as 'black boxes' [24, 33], and this can make it difficult to discern the precise reasons for decisions. This opacity is seen by some researchers as a threat to transparency and accountability [7, 19, 27]. However, there are techniques that can be more transparent: for example, one data scientist explained how his team has created a prototype tool, which uses a 'structured topic model' to point to specific passages in case notes which it uses to support its prediction (Phone interview, 3rd quarter, 2018). The explainability of these tools is important in building trust, but also in trying to deal with bias and in trying to understand why certain decisions are suggested, building administrator competence.

Isocratic administration is an idea where individuals can manage their affairs independently of interactions with government staff by using internet-based platforms to solve their own problems. There are some examples of this approach in local authorities, for example chatbots for routine communication. Chatbots are often part of larger 'channel shift' strategies to get more people making transactions online, but they can also support individual competence in problem solving. They can provide a more interactive way to fill out administrative forms, which some people may prefer, where they respond to questions and the software populates the form. Chatbots also open the possibility of allowing for simple interactions to be conducted in the language of choice, something which is of increasing relevance for local authorities with international populations. One interviewee highlighted that individuals seem to appreciate that chatbots (as opposed to telephone or face to face interactions) have the ability to provide an audit trail, which documents that an interaction took place. This technology may save resources, but may also enhance the service, as we saw above with interactive forms, language options, and auditability.

5 Discussion

This paper has argued that AI is shifting the paradigm in public administration. A new type of Algorithmic Bureaucracy is opening new opportunities to deal with complexity, enhance competence, and improve social problem solving.

These opportunities can be best understood in the context of Dunleavy et al.'s direct and indirect effects of changes in public management regimes [10]. With Algorithmic Bureaucracy, the polarities in Dunleavy et al.'s mapping of the direct and indirect effects of public administrative changes on the level of social problem solving may reverse in two cases: 1) where through AI and isocratic administration the explainability of algorithmic processes increase individual and staff competence, and 2) where algorithms take on some of the role of processing institutional and policy complexity much more effectively than humans.

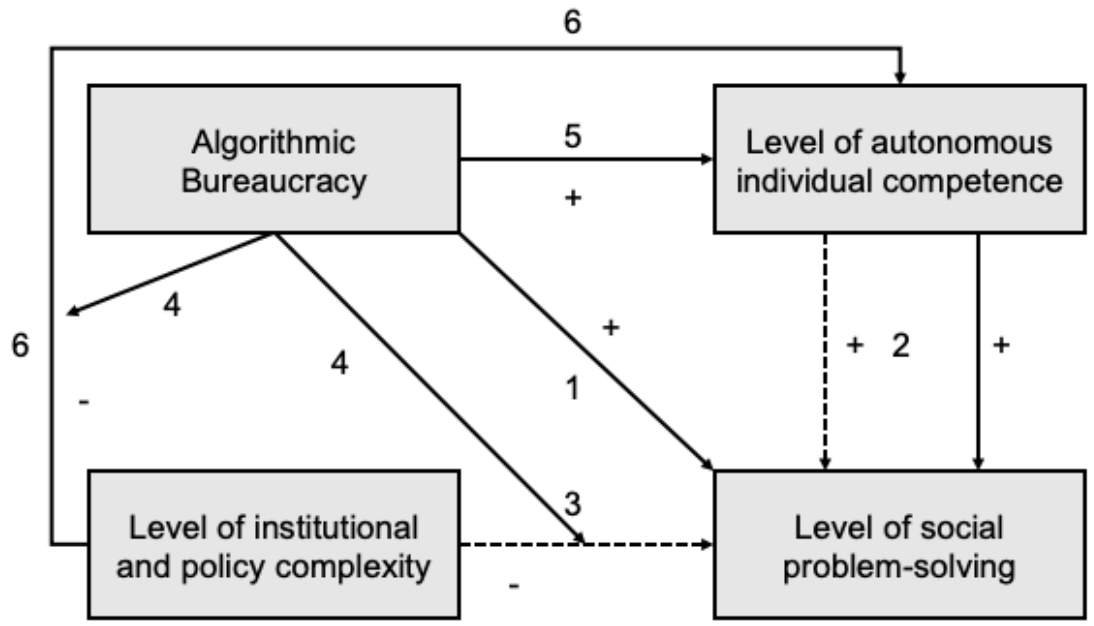

Figure 2: Algorithmic bureaucracy and social problem solving. Adapted from [10]

Figure 2 illustrates not only the direct impact of algorithmic bureaucracy on the level of social problem-solving (flow 1), but also the numerous indirect effects (flows 4-6) and direct effects from other sources (2-3). Flows 2 and 3 are the same as in Figure 1. Flow 4, unlike the flow in Figure 1, allows for the level of institutional and policy complexity to be independent from the form of public administration in place. Flow 4 illustrates instead that Algorithmic Bureaucracy (through information processing and decision support) has a direct effect on mitigating the negative impacts that the level of institutional and policy complexity has on the level of autonomous individual competence (flow 6) and the level of social problem solving (flow 3). Finally, flow 5 illustrates that Algorithmic Bureaucracy has a positive influence on the level of autonomous individual competence (through isocratic service

delivery, transparency via explainability, and decision support technologies for decision-makers and front-line service providers).

Algorithmic Bureaucracy could increase individual competence through explainability and isocratic administration, and it can handle greater institutional and policy complexity by building rules into code and using algorithms to parse vast sets of data. By altering these two factors it can increase the level of social problem solving by means of AI tools.

6 Conclusion

Local authorities face challenges to the introduction of algorithms. However, our study shows that many local authorities are overcoming those challenges and are implementing projects that align with elements of DEG and EDGE. Through applying the notion of Algorithmic Bureaucracy several aspects become visible in this regard: Once algorithms are introduced, they have unique impacts on the socio-technical systems of public administration. While change in policies and institutions may increase complexity, algorithms may be used to process this complexity such that it does not reduce the level of social problem solving. Further, while algorithms may also be able to directly influence the level of autonomous individual competence, by building in explainable results, they can also help individuals and administrators to better understand the growing complexities of contemporary public administration.

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REFERENCES

[1] Belfast City Council Case Study: *http://www.analyticsengines.com/case-studies/belfast-city-council-case-study/*. Accessed: 2019-01-27
[2] Berk, R.A., Sorenson, S.B. and Barnes, G. 2016. Forecasting Domestic Violence: A Machine Learning Approach to Help Inform Arraignment Decisions. *Journal of Empirical Legal Studies*. 13, 1 (2016), 94–115. DOI:https://doi.org/10.1111/jels.12098.
[3] Bright, J., Ganesh, B., Seidelin, C. and Vogl, T. 2019. *Data Science for Local Government: Challenges and Opportunities*. Oxford Internet Institute, University of Oxford. Available from: https://smartcities.oii.ox.ac.uk/data-science-for-local-government-report/.
[4] Catalyst Project - Improving community services for vulnerable people: *https://www.essex.ac.uk/research/showcase/catalyst-project*. Accessed: 2019-01-26.
[5] Cordella, A. and Tempini, N. 2015. E-government and organizational change: Reappraising the role of ICT and bureaucracy in public service delivery. *Government Information Quarterly*. 32, 3 (Jul. 2015), 279–286. DOI:https://doi.org/10.1016/j.giq.2015.03.005.
[6] Cuccaro-Alamin, S., Foust, R., Vaithianathan, R. and Putnam-Hornstein, E. 2017. Risk assessment and decision making in child protective services: Predictive risk modeling in context. *Children and Youth Services Review*. 79, (Aug. 2017), 291–298. DOI:https://doi.org/10.1016/j.childyouth.2017.06.027.
[7] Danaher, J. 2016. The Threat of Algocracy: Reality, Resistance and Accommodation. *Philosophy and Technology*. 29, 3 (2016), 245–268. DOI:https://doi.org/10.1007/s13347-015-0211-1.
[8] Datactics Surrey County Council: Vulnerable People Emergency Response Programme. *Datactics*.
[9] Dunleavy, P. and Margetts, H. 2015. Design principles for essentially digital governance. 111th Annual Meeting of the American Political Science Association, 3 - 6 September 2015, American Political Science Association (San Francisco, USA, Sep. 2015).
[10] Dunleavy, P., Margetts, H., Bastow, S. and Tinkler, J. 2006. New Public Management Is Dead - Long Live Digital-Era Governance. *Journal of Public Administration Research and Theory*. 16, 3 (2006), 467–494.
[11] Dunleavy, P., Margetts, H., Bastow, S. and Tinkler, J. 2006. The Theory of Modern Bureaucracy and the Neglected Role of IT. *Digital era governance: IT corporations, the state, and e-government*. Oxford University Press.
[12] Elgin, D. and Bushnell, R.A. 1977. The Limits to Complexity: Are Bureaucracies Becoming Unmanageable? *The Futurist*.
[13] Eynon, R. and Dutton, W.H. 2007. Barriers to Networked Governments: Evidence from Europe. *Prometheus*. 25, 3 (Sep. 2007), 225–242. DOI:https://doi.org/10.1080/08109020701531361.
[14] Gasser, U. and Palfrey, J. 2007. Breaking Down Digital Barriers: How and When ICT Interoperability Drives Innovation. (2007).
[15] Gil-Garcia, J.R. and Sayogo, D.S. 2016. Government inter-organizational information sharing initiatives: Understanding the main determinants of success. *Government Information Quarterly*. 33, 3 (Jul. 2016), 572–582. DOI:https://doi.org/10.1016/j.giq.2016.01.006.
[16] Gottschalk, P. 2009. Maturity levels for interoperability in digital government. *Government Information Quarterly*. 26, 1 (Jan. 2009), 75–81. DOI:https://doi.org/10.1016/j.giq.2008.03.003.
[17] Henning, F. 2018. A theoretical framework on the determinants of organisational adoption of interoperability standards in Government Information Networks. *Government Information Quarterly*. 35, 4, Supplement (Oct. 2018), S61–S67. DOI:https://doi.org/10.1016/j.giq.2015.11.008.
[18] Hood, C. 2006. Gaming in Targetworld: The Targets Approach to Managing British Public Services. *Public Administration Review*. 66, 4 (Jul. 2006), 515–521. DOI:https://doi.org/10.1111/j.1540-6210.2006.00612.x.
[19] Janssen, M. and Kuk, G. 2016. The challenges and limits of big data algorithms in technocratic governance. *Government Information Quarterly*. 33, 3 (Jul. 2016), 371–377. DOI:https://doi.org/10.1016/j.giq.2016.08.011.
[20] Kehl, D.L., Kessler, S.A. and Guo, P. 2017. Algorithms in the Criminal Justice System: Assessing the Use of Risk Assessments in Sentencing. *Responsive Communities Initiative, Berkman Klein Center for Internet & Society, Harvard Law School*. (2017).
[21] Lincoln, Y.S. and Guba, E.G. 1985. Establishing Trustworthiness. *Naturalistic inquiry*. Sage.
[22] Liptak, A. 2017. Sent to Prison by a Software Program's Secret Algorithms. *The New York Times*.
[23] Margetts, H. and Dunleavy, P. 2013. The second wave of digital-era governance: a quasi-paradigm for government on the Web. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences*. 371, 1987 (Feb. 2013). DOI:https://doi.org/10.1098/rsta.2012.0382.
[24] Mittelstadt, B.D., Allo, P., Taddeo, M., Wachter, S. and Floridi, L. 2016. The ethics of algorithms: Mapping the debate. *Big Data & Society*. 3, 2 (Dec. 2016), 2053951716679679. DOI:https://doi.org/10.1177/2053951716679679.
[25] Oswald, M., Urwin, S., Barnes, G.C. and Grace, J. 2018. Algorithmic risk assessment policing models: lessons from the Durham HART model and 'Experimental' proportionality. *Information & Communications Technology Law*. 27, 2 (May 2018), 223–250. DOI:https://doi.org/10.1080/13600834.2018.1458455.
[26] Paulin, A. 2018. *Smart City Governance*. Elsevier.

[27] Peeters, R. and Widlak, A. 2018. The digital cage: Administrative exclusion through information architecture – The case of the Dutch civil registry's master data management system. *Government Information Quarterly*. 35, 2 (Apr. 2018), 175–183. DOI:https://doi.org/10.1016/j.giq.2018.02.003.
[28] Reddick, C.G. 2004. Assessing Local Government Revenue Forecasting Techniques. *International Journal of Public Administration*. 27, 8–9 (Jul. 2004), 597–613. DOI:https://doi.org/10.1081/PAD-120030257.
[29] Sanders, M., Lawrence, J., Gibbons, D. and Calcraft, P. 2017. *Using Data Science in Policy*. Behavioural Insights Team.
[30] Seale, C. 2002. Quality Issues in Qualitative Inquiry. *Qualitative Social Work*. 1, 1 (Mar. 2002), 97–110. DOI:https://doi.org/10.1177/147332500200100107.
[31] Symons, T. 2016. Wise Council: Insights from the Cutting Edge of Data-Driven Local Government. Nesta.
[32] Taylor, S. 2018. *BBC Daily Politics Show 23rd April Alexa Full Version*.
[33] Wachter, S. and Mittelstadt, B. 2018. *A Right to Reasonable Inferences: Re-Thinking Data Protection Law in the Age of Big Data and AI*. Technical Report #ID 3248829. Social Science Research Network.
[34] Weber, M. 1968. *Economy and society: an outline of interpretive sociology*. Bedminster Press.
[35] Winners of the 2016 Digital Leaders 100 Awards announced: *https://www.computerweekly.com/news/450298528/Winners-of-the-2016-Digital-Leaders-100-Awards-announced*. Accessed: 2019-01-27.
[36] Yang, T.-M. and Maxwell, T.A. 2011. Information-sharing in public organizations: A literature review of interpersonal, intra-organizational and inter-organizational success factors. *Government Information Quarterly*. 28, 2 (Apr. 2011), 164–175. DOI:https://doi.org/10.1016/j.giq.2010.06.008.
[37] Zinszer, K., Tamblyn, R., Bates, D.W. and Buckeridge, D.L. 2013. A qualitative study of health information technology in the Canadian public health system. *BMC Public Health*. (2013). DOI:https://doi.org/10.1186/1471-2458-13-509.