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Data Science or Process Science? How to Promote the Next Digital Transformation in the Public Sector

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Abstract. As citizen orientation and public value creation are more in the focus, how do we set priorities for the upcoming digital transformation in the public sector? Distinguishing data science and process science as paradigms that promote different directions for the transformation, this research seeks to improve the transparency of how IT-related decisions are directing projects and resources and thus promoting directions of public value production and delivery. Digital government research along this line may help constituents, IT experts and other stakeholders to engage in the needed discourse about the (not) wanted future of government performance and related technology usage.

Keywords: Data Science, Process Science, Digital Transformation, Public Sector, Public Value, Digital Government Research, Paradigm.

1 Introduction

Since the 1970s public administrations around the world are in a continuous process of adopting and adapting computer-based information and communication technology, leading to many organizational changes and re-shaping the government-citizen relationship. Nowadays CIOs, also in the public sector, are increasingly confronted with a plethora of data-driven innovations and applications, promising to open the door to the next level of computer-based organizational operation. Developments labeled under the paradigm of ‘data science’ certainly have a lot to offer for public administrations, especially for decision support. Hence, should public sector CIOs direct their strategic vision, their IT infrastructure, and their human and financial resources to focus on this paradigm? And similarly digital government research? Or does it still hold that electronic government is “a special case of ICT-enabled business process change” [28]? Which would imply that rather ‘process science’ should be (or remain) the leading paradigm to guide public sector IT developments, with data-driven innovations and applications just supporting the efforts to primarily improve the process performance.

Contrasting the choice between data science and process science and discussing the implications for research and practice follows the much debated paradigm construct as it was introduced by Kuhn to explain fundamental changes in the basic concepts and practices of a scientific discipline. The term embraces several dimensions, and here we confine to the meaning of a ‘disciplinary matrix’ as “the entire constellation of beliefs, values,

techniques, and so on shared by the members of a given community” ([15], p. 175), which has a “concrete problem solving ability” (p. 169), thus relating to society needs. The Kuhnian paradigm has been subjected to an extensive and longstanding debate also in Information Systems research. Here we adopt the stance of Hassan & Mingers [12] that the “received view of the paradigm concept in IS needs to be revisited, and the paradigms’ other more potent components reintroduced, in order for a transformative understanding to be realized.” Accordingly, the key terms are connoted as follows:

- A paradigm is considered as “a shared exemplar for scientific practice, which communities of scientists and researchers agree in part or completely, that provide models from which coherent scientific traditions may emerge.” [12] This implies emphasizing the more practical and problem-solving nature of scientific practice rather than focusing on the epistemological aspects of producing and transmitting knowledge.
- Scientific practice embraces not only the research methodologies but also the science-driven approaches to solving real-life problems. This implies the “community of scientists” to include also practitioners as far as they adopt and advance scientific techniques and methods.

Digital government research as a scientific community – as individuals, research groups, institutional research programs and funding – always makes choices about how to contribute to the digitally enabled transformation in the practice of administration. Contrasting data science and process science therefore aims to reflect about the choices in agenda setting, in educating graduates and in directing resources for the research of the years to come. And it may equally impact the practice of ICT application in the public sector through perspective building, research-practice alignment, projects and funding, artifact innovation and dissemination, training etc.

Asking for the path to take in digital government research is not meant to sideline any research effort in any corner. Presuming that digital government research always strives for relevance to practice, this discussion contributes to the reflection about why certain paradigms might be most appropriate to guide strategy building, IT resource allocation and usage as well as digital transformation processes in the public sector.

The structure of the paper reflects the flow of the argument: How do actors related to the public sector approach digital transformation nowadays? What do data science and process science entail as candidate ‘paradigms’? Given the expanding scope of digital transformation, how do we set priorities? The final section distinguishes the two paradigms along a set of characteristics and aligns them to impacts and outcomes, this way seeking to improve transparency, which helps constituents, IT experts and other stakeholders to engage in the needed discourse about the (not) wanted future of government performance.

2 Transformation of the Public Sector

A 2015 survey, conducted among more than 1,200 public sector officials around the globe, revealed that 76% of the respondents perceive digital technologies as disrupting the public sector, while at the same time nearly 70% said their organization’s digital

capabilities lag behind the private sector [7]. The study found that the degree of maturity in mastering the disruption scales with the clearness and coherence of a “digital strategy” and the degree of including organizational aspects beyond the technicalities. On the basis of more than 140 interviews the authors also identified five factors shaping digital transformation: strategy, leadership, workforce skills, digital culture, and user focus. As developments in each of these factors highly depend on the mindset of the actors involved, it is even more important to clarify the perceptions and expectations related to ‘digital transformation’, also for the public sector.

2.1 From Digitization to Digital Transformation

The basic step of the digital disruption – often called digitization – is the conversion of information representation from a physical format to a digital one to be used by computers feeding information systems and automating processes. Digitization is an operational necessity, and sometimes the term is even used embracing business process standardization in order to make a difference to digitalization or digital transformation: “Digitization is an important enabler of digital, but all the digitization in the world won’t, on its own, make a business a digital company.” [26] Ross adds that a digital transformation involves rethinking the company’s value proposition and that a digital company innovates to deliver enhanced products, services, and customer engagement. Notably, she refrains from the term digitalization, which usually denotes the efforts towards creating a digital business. While often used synonymously, digital transformation emphasizes more the strategic approach to the needed transformational process.

Vom Brocke et al. [35] trace the research on IT-enabled organizational transformation back to the 1990s. They found it dominated by behavioral research approaches, but often not substantiated with theory. The vast majority of the examined studies (158 of 201) focused on higher levels of transformations, namely business process redesign, business network redesign and business scope redefinition.

Highlighting digital transformation as a fresh conceptualization, Wessel et al. [36] are keen to maintain the difference to IT-enabled organizational transformation. Both streams of activities are driven by technological change and based on a transformation agenda that leverages and iteratively refines the use of digital technologies. However, the conceptual difference relates to the value propositions: whereas for digital transformation, digital technology (re)defines the value proposition, in IT-enabled organizational transformation the digital technology supports the pre-existing value proposition. Accordingly, the digital transformation leads to a new organizational identity, while IT-enabled organizational transformation reinforces the existing organizational identity.

As digital transformation has gained momentum, the technical and organizational perspective is not sufficient to reflect the encompassing societal effects, opportunities and needs to shape and frame the ongoing changes. In view of unprecedented challenges to societal values related to digital transformation, Rowe [27] argues for a more philosophy-based embedded discourse “if we want IS scholarship to be relevant and critical.”

However, it remains questionable whether IS research on that level will really make a difference in the transformation practice. The language of the IT industry and the consultants is different as they are addressing directly the actors and drivers who decide about bringing the IT into the organization. For example:

- “Making time available to become an ‘evangelist’ on digital is crucial. [...] CIOs are in a perfect position to make the difference between being a victim of disruption and a digital leader.” [14]
- “The three waves of digitalization in the CFO function are: 1) Operational efficiency, 2) Business partnering and 3) Business transformation. Each wave outlines what digitalization means for the CFO function in terms of both actions and, more importantly, how the overall role of the CFO changes.” [2]
- “A recent published Gartner’s annual global survey of CIOs showed that the CIO role is transitioning from delivery executive to business executive, from controlling cost and engineering processes, to driving revenue and exploiting data.” [8]

At the beginning of this millennium Dennis [5] had conceded that “much IS research is irrelevant to practice” due to its focus on knowledge for exploration while hardly focusing on exploitation (which is the practitioner’s view). 20 years later not much has changed, and the debate how to improve the relevance of information systems research is still on (cf. e.g. [16]). For example, the MISQ editorial “Designing for digital transformation” [19] advises “IS researchers interested in societal or business change” to define the ICT artifact and to examine related affordances and constraints as well as the artifact’s unintended consequences. These researchers should “couple research findings with public policy and regulation recommendations where relevant”, but this does not reach out to the transformation logic of the practitioners.

2.2 Digital Transformation in Government

Selling IT to governments and administrations is an ever growing business. Major consultancy firms also engage in this sector, coining the government’s digital transformation e.g. as the “digital technology’s ability to fundamentally transform the way the public sector operates and delivers services to customers” [4]. The consultancy often relies on roadmaps, pointing to building blocks such as continuous budgetary support, coordination and governance, open data and technology platforms, and human capabilities as key enablers for the digitalization of government services [6]. Other efforts seek to understand and categorize their public customers: for example, Eggers & Bellman [7] conducted a survey based on a “digital maturity estimation framework” and found that most government organizations still lack the strategy to achieve digital transformation, the lack of digital workforce skills represents a major obstacle to transformation, and most agencies lack key elements of a “digital mindset”.

Meanwhile, the scope of selling IT to governments has been extended much beyond administrative process automation, emphasizing that a “successful digitalization approach should be viewed from the citizens’ experience perspective” ([6], p. 3). This is in line with government agencies pointing mainly to citizen demands as well as cost and budget pressures as the key drivers of digital transformation [7].

While some years ago it was conceded that digital transformation is still “to a large extent a promise yet to be realized for many government organizations” [38], digital government research is nowadays keen to gather empirical evidence. For example, Mergel et al. [21] seek to go beyond consultancy reports and provide systematic insight into how public administrators themselves define digital transformation in their own practices, how

they are approaching digital transformation projects, and what they expect as outcomes. Their expert interviews revealed that the drivers for change mainly come from the external environment (similarly confirmed by [29]), the main objects of transformation are processes and services, “using new technology” seems to be the leading idea of transformation processes, and the main result to be achieved are rather related to long-term impacts than to measurable, concrete outputs.

Since the focus of digital transformation has shifted more towards servicing the citizens, the citizen-government relationship and the digitalization of public services have climbed up on the agenda of digital government research. Focusing on the interaction between citizens and public officials, Lindgren et al. [17] identify problem areas and research gaps arising from digitalizing the “public encounter”, including the “double nature” (benefits vs. risks) of digital public services, the changing place of citizen-government interaction, the “casting and roles” of the actors involved, and the unexplored lateral dimensions of the services and related technologies. As the “public encounter” seems to shift from man to machine, the authors raise questions and ethical concerns regarding accountability and reskilling of both citizens and public officials.

Digitalization is moving in “waves”, each combining new technologies plus new application potentials plus new products and/or services along with supporting cognitive perspectives and a stimulating hype. As the far-reaching consequences gain more attention, Mergel et al. [22] assert that digital transformation “describes the departure from digitization efforts to a full stack revision of the policies, processes and services in order to create simpler user experiences for citizens and frontline workers.” In contrast to previous waves of digitization aiming to increase efficiency and effectiveness of government services, government services are now redesigned and reengineered “from the ground up to fulfill changing user needs.”

The need for a digitalization strategy is undisputed as administrations need visions and (scientific?) guidance for their digital transformation. Yet, so far very few publications seek to support the actual transformation process. Notable exceptions include Ylinen & Pekkola [37], who propose a process model for public sector IT departments to adjust their operations as a response to digitization efforts, and Gong et al. [10], who seek to assist practitioners in anticipating what adaptations may arise while enacting digital technologies to create infrastructures and process flexibility. As the strategy development itself is left to the stakeholders on the ground, it seems that digital government research concerned with digital transformation faces the same dilemma as IS research in general, i.e. struggling to integrate critical reflection and relevance to practice.

As we witness the citizen-government relation undergoing substantial changes, we are certainly well advised to avoid any premature closure and to apply multiple perspectives to guiding the digital-driven transformation processes. For example, could “citizen orientation” be the leading idea to guide the next digital transformation in administration? For reflecting about which paradigm might be most appropriate to guide the strategy building and digital transformation processes in the public sector, the next section investigates two candidates that center on critical objects of transformation.

3 Data Science Versus Process Science

Data and processes are at the core of all IS-related efforts, also in the public sector. Both types of objects in the center of the digital transformation gave rise to distinct communities of scientists, each sharing practices along with constellation of beliefs, values, techniques, and each with a concrete problem solving ability. However, these communities do not seem to be on an equal footing: Searching for “data science” in the title, Scopus returns 1,742 articles since 2016, for “process science” the corresponding list includes only 6 articles (in January 2021). Yet, both communities, with only little communality, build on decades of influential scientific practice in each of their related fields and strive to make a distinct real-world impact.

3.1 Data Science

The first appearance of ‘data science’ in the scientific community (proposed as an alternative name for computer science) is attributed to Peter Naur in 1974 [3]. And the Data Science Journal as well as the Journal of Data Science were already launched in the early 2000s. However, the term data science has gained popularity only in 2010 to denote what “data scientists” do: a new type of IT professionals who started to organize themselves online just a year before [25].

Data science embraces different subdisciplines and numerous practical approaches (see also figure 1) that serve four categories of aims: reporting (what happened?), diagnosis (why did it happen?), prediction (what will happen?), and recommendation (what is the best that can happen?) [31] While defining data science, Cao [3] denotes the “ultimate data products of value [as] knowledge, intelligence, wisdom, and decision.”

Data science qualifies as a ‘paradigm’ (as introduced above) because we find a scientific practice shared by the data scientists to solve concrete and relevant problems. The techniques mainly relate to analytics, including statistics, mining algorithms and computerized tools. The community shares the belief that data-driven discovery delivers value for business and society, assuming that data analysis will provide relevant answers, even if we do not know the (exact) question. From the epistemological perspective Jim Gray even imagined “data-intensive science” as a fourth paradigm of science (in addition to, or integrating, empirical, theoretical, and computational science) [18].

3.2 Process Science

Van der Aalst & Damiani [33] have coined the term process science as “the broader discipline that combines knowledge from information technology and knowledge from management sciences to improve and run operational processes”, referring to the work of Frederick Taylor as the starting point of scientifically managing processes.

Embracing scientific branches such as Operations Research or Workflow Management, most of the “process scientists” nowadays flock to the area of Business Process Management (BPM). The “concrete problem solving ability” is enormous because all organizations seek to computerize the automatable parts of their business processes and to control the whole process life cycle through modeling, implementation, enactment, monitoring, analysis and redesign. The token-based semantics adopted from Petri nets is the

mostly cited theoretical basis for such endeavors, followed by queuing theory and Markov analysis. While the BPM community itself is vivid and well established, the expansion towards a larger community of “process scientists” still seems to be underway. For example, Mendling [20] discusses “how BPM research can be further developed towards a true process science” in order to provide insights for practitioners on “how to apply scientific process management”.

The website process-science.net claims: “So far, processes have been investigated from the lens of single disciplines [...]. We cannot rely on a single discipline if we want to obtain a full picture of processes. We need to bundle and synthesize contributions, theories and methods from multiple disciplines.”

On the basis of this, Vom Brocke [34] answers the question “what does a Process Scientist do?” as discovering and implementing new ways to do things, in particular analyzing and automating processes as well as designing effective interventions, while applying distinct strategies (evidence-based, multi-sourced, context-sensitive, impact-oriented). From that perspective, process science points to shared scientific practice to solve concrete and relevant problems, based on the belief that process management is the key to deliver business value and/or public value. In principle, process science may qualify as a ‘paradigm’ (as introduced above). However, it seems that the term has been purposely constructed to contrast data science, yet it (still) lacks the comparable popularity among proponents to identify themselves as “process scientists”.

3.3 Maintaining Disjunctive Identities

After contrasting data science and process science, Van der Aalst & Damiani [33] continue advocating that process mining shall bridge the gap between these two (figure 1). Process mining makes use of event logs and mainly aims for process discovery, conformance checking, and performance analysis [32]. It could even reach beyond the mere process view and, for example, support theorizing about organizational change [11].



Fig. 1. Process mining as the bridge between process science and data science [33]

Process mining originated in the BPM community and flourished first in a world of rather small data [9]. Only throughout the last decade huge data pools representing process events emerged, and their exploitation now requires data science approaches and techniques, while the objective of using these and the subsequent calibration and control remain related to process science. For succeeding in process mining projects it usually needs collaboration of experts from both fields [9]. In that sense it is an interdisciplinary endeavor indicating that distinct ingredients from two different paradigms are essential, and there is no sign of disciplinary merge and community building beyond the establishment as a subset of both fields.

4 Creating Public Value Through Managing Process Portfolios

Since the focus of digital transformation in the public sector has shifted from improving efficiency more towards servicing the citizens, the basic question is even more in the focus: what are governments and administrations doing (or should be doing) to create public value? The impact reaches far beyond saving resources through efficiency gains, and the role of technology is subject to debate in the digital government community. Accordingly, any debate about which path to take in digital government research and practice must take into account the changing expectations regarding what digital government should deliver.

Twizeyimana & Andersson [30] identify improved public services, improved administration, and improved social value as the three overarching (and also overlapping) dimensions of the public value of e-government. For them, achieving public value in e-government should be understood as “the ability of e-government systems to provide improved efficiency in government, improved services to citizens, and social values such as inclusion, democracy, transparency, and participation.”

Ability refers to capability, and here Pang et al. [24] were the first to theorize the relationship between IT resources, organizational capabilities, and organizational performance in the public sector. They found that IT resources contribute to creating public value through five organizational capabilities in government agencies: the capabilities for public service delivery, public engagement, co-production, resource-building, and public-sector innovation. Notably, governments and administrations strive to fulfill a variety, often even competing values concurrently, which do not combine into one single value as a target (e.g. sales or profits). Therefore, the authors introduce the construct of the “public-value frontier”, which they define as “the set of maximum multiple public values that is achievable given available resources and the constraints among certain values.” In conclusion, they see the role of IT in supporting the public sector organizations in advancing their frontier to a higher level.

Panagiotopoulos et al. [23] argue in the same line: “Public value creation can be considered the outcome of a production process of different public services pursued by public agencies to fulfil the collective goals that citizens define in the democratic process [...]” Additionally they emphasize that “citizens do not value services per se but rather value what services deliver when consumed,” i.e. it needs an integrated view of public value creation that perceives value creation from the citizen perspective. To support this public value production process, it needs organizational capabilities as dynamic capabilities (i.e. the ability to integrate, build, and reconfigure resources and competences to adapt to changes), which are distinct from operational capabilities referring to the systematic use of resources to perform core tasks and execute business processes.

In order to make this process, or rather, processes of public value production manageable, Alford & Yates [1] proposed modeling these processes starting from the core activities (by public sector and others) to produce a particular value and enhancing business-process-like models with outcomes, (potential) actors, influencing factors and various relationship types between the model elements. Such “public value process maps” are designed for policy analysts and public managers in order to clarify valuable outcomes as well as to identify and prioritize the actors and activities (or sub-processes) involved.

Taking the practitioner’s perspective, Kirchmer et al. [13] also identify “the transfer of the strategy of an organization into the appropriate portfolio of process improvement initiatives” as a key digitalization gap.

Summarizing the perspective of public value production, it is all about creating organizational and operational capabilities on the basis of which public managers manage a portfolio of value creation processes aiming to improve the balanced perception of values on the side of the constituencies.

5 Choices in the Driving Seat

In practice, choices have to be made for hiring, resource allocation, strategic alignment, project management etc. We assume that building and maintaining identities of the IT experts involved will make a difference in the outcome of the digital transformation. Given the expanding scope of digital transformation, also in the public sector, how do we set appropriate priorities? Distinguishing the two paradigms along a set of dimensions, we aim to contribute to the basis for making informed choices in digital government research and practice.

Table 1. Paradigm characteristics

Data Science	Characteristic	Process Science
analytic	<i>perspective</i>	functional
statistics, data mining	<i>core community</i>	business process management
data-driven discovery creates business value / public value	<i>essential belief</i>	processes & process management create business value / public value
reporting, diagnosis, prediction, recommendation	<i>activities & aims</i>	discovering and implementing new ways to do things
advanced analytics (statistics, mining, machine learning etc.)	<i>techniques</i>	process modeling, implementation, enactment, monitoring, analysis, redesign
support and automation of decision making	<i>main use case</i>	analyzing and automating processes, designing effective interventions
knowledge, intelligence, wisdom, and decision	<i>products of value</i>	process improvements

The two paradigms in focus can be distinguished along their characteristics regarding main perspective, core community, essential belief, activities and aims, techniques, use cases, and products of value (see section 3 and table 1). Both paradigms and communities coexist in guiding distinct efforts of research and development. However, IT managers in public administration do not go by paradigms, but make their choices according to a number of factors such as a given digital transformation strategy, service demands and requirements, investment frame, legacy systems and infrastructure, available know-how etc. (cf. [13]). Therefore, choices in terms of input such as research, development and resource allocation (if linked to one of the paradigms) should be related to the impacts and outcomes, i.e. the direct effects and the long-term results (see table 2).

In the process of digital transformation, data science focusses on data-driven decision making, whereas process science targets the concatenation of functionality in

administrative service production. While citizens relating to government and administration will always experience a combination of various transformation efforts, changes driven by data science intensify encounters of algorithmic decisions, while those driven by process science rather intensify encounters of automated services.

Table 2. Paradigm-related impacts and outcomes in public administration

<i>Impact/outcome</i>	Data Science	Process Science
<i>transformation focus</i>	data-driven decision making in government and administration	processes enabling administrative service production
<i>citizen experience</i>	encounter of algorithmic decisions	encounter of automated services
<i>public value production</i>	analyze outcome	improve processes
<i>capabilities for public value</i>	public engagement, public-sector innovation, public service delivery	public service delivery, co-production, public engagement

If we seek to link digital government research and development to public value production, we find that the two paradigms point to different directions. Based on their characteristics, data science may rather guide analyzing outcomes of public value production, while process science may help leading process improvements. And focusing on the IT resources feeding into the organizational capabilities needed to push the public value “frontier” to a higher level (according to the theoretical model of [24], see section 4), both digitized processes and data analytics can make their contributions. Yet, we can assume that process science sets the focus on processes supporting public service delivery, co-production, and public engagement, while data science relates rather to public engagement, public-sector innovation and only secondarily to public service delivery.

Notably, the conceptualization of paradigm used here emphasizes the more practical and problem-solving nature of scientific practice rather than focusing on the epistemological aspects of producing and transmitting knowledge. Accordingly, scientific practice embraces not only research methodologies but also science-driven approaches to solving real-life problems, thus including also practitioners as far as they adopt and advance scientific techniques and methods. This may be a contribution to reducing the gap between IS research and practice (also in the area of digital government), but at the same time it is a limitation because this conceptualization is not fully compatible with most of the extant discourse on paradigms in IS research.

Contrasting the paradigms of data science and process science is just one possible starting point, and the shortened paradigm analysis is certainly another limitations of this research. However, it seems that currently we can only speculate how IT-related decisions driven by certain paradigms are directing projects and resources and thus impacting the public value production and delivery. As public agencies seek to fulfil the collective goals defined, the value production process and the IT resource allocation and usage should be as transparent as possible. Future digital government research should therefore seek to understand this relation in much more detail. This would help the constituents, the IT experts and other stakeholders to engage in the needed discourse about the (not) wanted future of government performance and related technology usage.

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