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PUBLIC SECTOR CLOUD COMPUTING ADOPTION AND UTILIZATION DURING COVID-19: AN AGENDA FOR RESEARCH AND PRACTICE

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ABSTRACT

Cloud computing became a pivotal crisis response tool for many public sector organizations (PSOs) during the COVID-19 pandemic, sustaining public service delivery and public sector operations during times of extraordinary global turmoil. The technology's inherent strengths of flexibility, innovation, resilience, and collaboration prompted PSOs to aggressively pursue both the initial adoption of cloud and the expansion of already-existing cloud computing capabilities. Despite the importance of the emerging topic of crisis-driven public sector cloud adoption for future crisis response efforts and the post-crisis transition to regular public sector operations, academic literature and empirics are sparse and present a distinct knowledge gap. This article assesses crisis-driven public sector cloud computing adoption and expanded utilization and provides recommendations for the advancement of research and practice, supporting future research, collaboration, and evidence-based cloud computing implementation and utilization.

KEYWORDS

Cloud Computing, Government, Public Sector, COVID-19, Research and Practice

1. INTRODUCTION

The coronavirus (COVID-19) pandemic, a severe health emergency that rapidly morphed into a forceful global economic and social crisis, has severely challenged governments around the world. By March of 2022, the SARS-CoV-2 virus had reached more than 200 countries and territories, causing 447 million confirmed cases of coronavirus disease and resulting in 6 million deaths, as presented in Fig. 1 [1].

The pandemic, unprecedented in scale, severity, and the speed in which it evolved, forced governments across the globe to adopt swift and broad policy and operational changes [2]. Public health systems refocused efforts and expanded dramatically to conduct disease testing and contact tracing, treat critically-ill COVID-19 patients and, after vaccines became available, lead the vaccination campaigns necessary to combat the pandemic [3]. Containment and closure efforts by governments, aiming to slow the explosive transmission rates of the virus, resulted in widespread lockdowns and restrictions of civil liberties and economic activities [4], requiring extensive discretionary fiscal measures to aid citizens and businesses in weathering the economic and social effects of the pandemic [5].

The crisis response affected a wide range of functions within the public sector, including public finance administration [6], public sector employment [7], public sector procurement [8], regulatory practices [9], e-government [10], and public infrastructure [11].

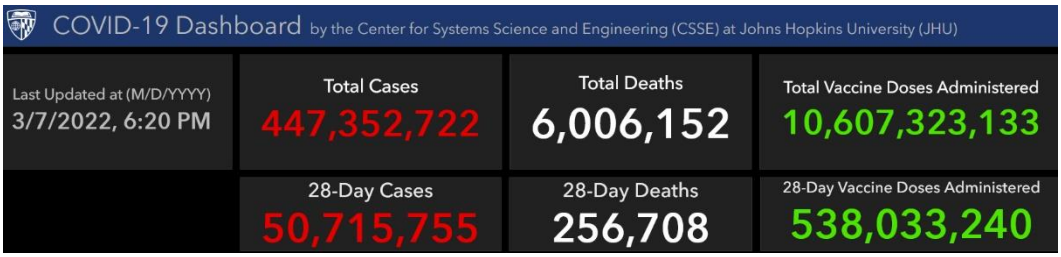

Figure 1. COVID-19: Cumulative Case, Mortality and Vaccination Data [1]

As public sector organizations (PSOs) scrambled to find new ways to deliver, scale and reconfigure public services while operating with employee populations that were working remotely, cloud computing emerged as a pivotal component for ensuring responsive and agile public service delivery while positioning the public sector to overcome the severe limitations of overloaded and antiquated information and communication technologies (ICTs). Cloud computing, the ubiquitous, expedient, and on-demand delivery of a wide range of pooled and configurable resources via computer network [12], enabled resilient and adaptive public service operations across a variety of areas, and supported a wide range of government activities including infection control and tracking, public communication and data sharing, public service delivery, social solidarity, crowdsourcing of pandemic resources and responses, and collective sense-making and knowledge creation and distribution. For PSOs that already had cloud capabilities available, pivotal inherent cloud advantages such as flexibility, innovation, resilience, and collaboration provided the foundation for a successful crisis response; for PSOs that lagged behind in cloud adoption, the pandemic further strengthened the case for initial or expanded cloud computing adoption [13].

Because of the unique characteristics of PSOs, the application of "lessons learned" from the private sector is difficult or unviable. PSOs pursue matters of public interests that significantly diverge from those of private interests; they are accountable to citizens and voters and not to shareholders or owners; and they operate in a legal and constitutional environment that generally requires openness, transparency, impartiality, and the pursuit of the rule of the law [13]. The public sector's distinct missions, legal requirements, and culture translate into a range of organizational and operating-model challenges that are unique and affect cloud adoption in ways not observable in the private sector [13].

Considering the severe individual and societal effects of the pandemic and the wide-ranging responses it has created in the public sector, it is imperative that public sector cloud computing researchers and practitioners explore the crisis and its enduring implications for cloud computing adoption and utilization. Despite this importance, the academic literature and empirics on the emerging topic of crisis-driven public sector cloud adoption are currently sparse and present a distinct knowledge gap. This article aims to discuss and reflect on the deployment and utilization of public sector cloud computing capabilities during COVID-19, provides recommendations for the advancement of research and practice, and analyzes the implications of the crisis-driven increase in cloud computing for continuing public sector transformation.

2. PUBLIC SECTOR CLOUD COMPUTING DURING TIMES OF CRISIS: COVID-19

While an exhaustive investigation of use cases exceeds the aim and scope of this exploratory article, it is sensible to highlight some of the ways in which crisis-driven cloud computing adoptions and utilizations became key technological enablers for PSOs during their COVID-19 response efforts.

In order to underscore the variety of settings and application scenarios that have been characteristic of the cloud-powered crisis response efforts of PSOs, the vignettes that follow have been aligned with major, distinct categories of core government activities as internationally recognized and classified by the United Nations in its *Classification of the Functions of Government* [14]. They also reference traditional public sector hierarchical levels that include central, state, and local government as main identifiers [15], [16] to provide further contextual data. Additionally, the vignettes identify the main cloud benefit categories applicable to specific use cases, as compiled based on the extant academic literature (see Fig. 2).

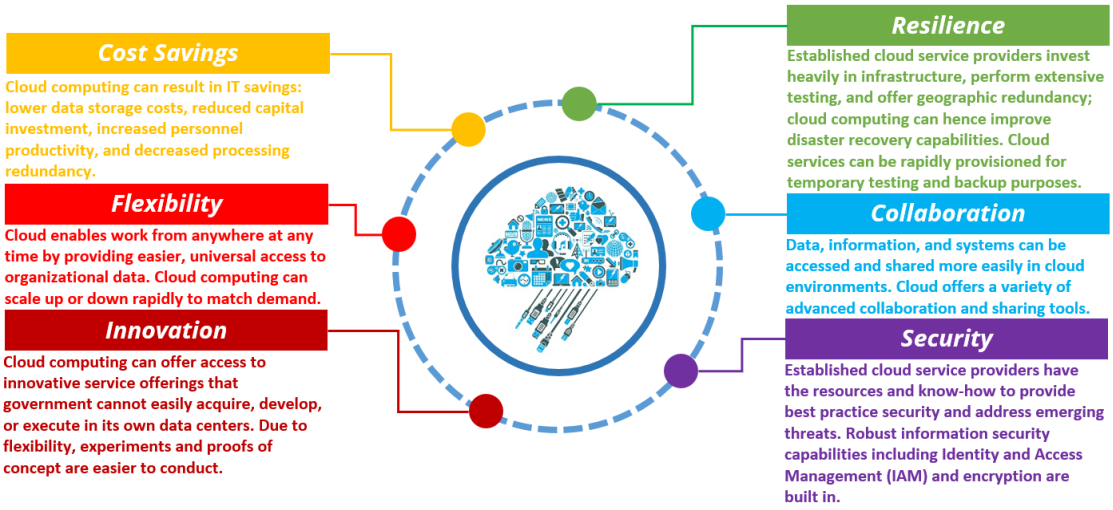

Figure 2. Key Public Sector Cloud Computing Benefits.
Compiled from [13], [17]–[24].

In Spain, the autonomous community of Madrid collaborated with local technology companies to create *Asistencia COVID-19*, a cloud-based web and mobile application empowering local citizens to self-evaluate COVID symptoms and obtain validated public health information [25], [26]. Responding to an overwhelming demand for public health information that congested public service call centers and local public health authorities, the cloud-based *Asistencia COVID-19* application was developed and deployed in seven days, aiding authorities in reducing the pressures placed on public health systems and other public agencies supporting pandemic response efforts [27]. *Asistencia COVID-19* falls within the *health* function of government, occurred at the state level of government, and was driven by the public sector cloud computing benefits collaboration, flexibility, and innovation.

The national judiciary of Peru transitioned to a cloud-based virtual court hearing system within 15 days of the Peruvian government declaring a national lockdown in March of 2020, enabling the courts to continue judicial operations despite a national mandate for remote work [28]–[30]. *Google Meet*, relying on Google's cloud infrastructure, enabled Peru's Supreme Court and its'

Superior Courts to conduct hearings and administrative functions by video conferencing, directly enabling the *public order and safety* function of government at the central government level . The adoption of *Google Meet* was driven by the public sector cloud computing benefits security, collaboration, flexibility, and innovation.

In China, avoiding the limitations of existing, manual public health surveillance systems, government and public health subject matter experts in the city of Honghu responded to a critical need for localized pandemic infection control and tracking by creating a cloud-based COVID-19 tracking system [31]. The system was designed and successfully deployed in 72 hours, covered a local population of over 900,000 people, and collected automated daily syndromic survey information from a majority (>95%) of the city's inhabitants via a mobile-phone based social media platform [31]. Collected data was merged with clinical data from nine public hospitals and public laboratories, providing near real time public health data that supported policy-making decision support and clinical decision support [31]. The advantages of cloud computing allowed the public health officials in Honghu to overcome a shortage of local tech support, the unavailability of subject matter experts and local computing resources due to COVID-19 induced lockdowns, and provided the capacity to rapidly upscale resources to cover a large population [31], directly supporting the government function of *health* at the local level of government. Associated public sector cloud computing benefits were resilience, collaboration, flexibility, and innovation.

The Bali Provincial Government in Indonesia struggled to provide a safe working environment for public employees during COVID-19 and transitioned its 19,000 employees to remote work [32]. As on-premise data centers could not support the dramatic increase in demand caused by the change in operations, the cognizant government organization *Diskominfos* quickly adopted cloud-based virtual office, email, and attendance solutions to meet public service requirements [33]. This adoption of cloud solutions in Bali supported the *general public services* function of government at the local government level, linking to the public sector cloud computing benefits of cost savings, collaboration, and flexibility.

Brazil's Federal Senate, the upper house of Brazil's National Congress, responded to the difficulties and risks involved in holding in-person legislative sessions during COVID-19 by adopting a cloud-based *Remote Deliberation System* that merged existing commercial videoconferencing technology with a proprietary remote voting solution to enable reliable, secure, easily accessible virtual legislative sessions [34], [35]. The innovative system enabled Brazil to become the first country conducting virtual parliamentary deliberative sessions and was developed and deployed in one week; it consists of distinct components that offer videoconferencing, legislative protocol, and remote voting capabilities [36], [37]. This adoption of a cloud-based remote deliberation solution supported the *general public services* function of government at the central government level and links to widely recognized public sector cloud computing benefits of resilience, flexibility, collaboration, and innovation.

Following the declaration of a state of emergency in Rhode Island due to COVID-19, the state's Department of Labor and Training (DLT) was faced with an unprecedented flood of unemployment insurance (UI) claims intended to provide temporary income support to state residents [38]. Further compounding this operational capacity challenge, pandemic-related emergency policy measures drastically altered the UI claims process; a development that would have required an extensive recoding of the state's legacy UI software [39]. With a 30-year old, COBOL-based mainframe legacy infrastructure in place, an update to the software and the addition of supplementary on-premise compute capacity to handle the surge in demand was deemed to be impossible [40]. A cloud-based UI claims processing solution for pandemic unemployment payments, set up in one week, provided a rapidly available and scalable solution

for DLT's problems and ensured that much-needed unemployment benefits were available to eligible citizens in a timely manner. This adoption of cloud in Rhode Island supported the *social protection* function of government at the state government level, linking to the public sector cloud computing benefit of flexibility.

3. RAMIFICATIONS FOR RESEARCH

The adoption and utilization of cloud computing as a crisis response tool during the COVID-19 pandemic raises important questions about the organizational culture, personnel, and operational practices of public sector organizations. To assist in examining these central issues, the scholarly community would benefit from applying a socio-technical systems (STS) perspective to facilitate a meaningful exploration of the scope and nature of change that the crisis-driven introduction of cloud computing in public sector environments has triggered [41].

STS theory has been a subject of study and application for more than sixty years, both in the academe and in the professional sector [42]. The fundamental framework of STS, accepting the integrated development and enhancement of systems in organizations (relying on both social and technical components), has demonstrated its real-world significance and has experienced growing attention and recognition by researchers and practitioners in a variety of fields of inquiry [43], including the information technology arena [42].

STS theory relies on the analysis of three elements that constitute an organizational system: the social sub-system, the technical subsystem, and the environment that prompts and shapes change and in which the social and technical elements interact. STS theory, therefore, allows for the effective and meaningful analysis of the intricate interactions between the organization, the individuals carrying out operational processes, and the information technology that facilitates these operational processes [42].

In a further departure from more traditional information technology adoption approaches that endorse an entitative stance on information systems, research would also benefit from including a sociomaterial perspective in the analysis of the adoption and utilization of public sector cloud computing as a crisis response tool. Sociomateriality has found increasing application in the information systems arena and offers a relational approach to individuals, organizations, technologies, and the processes they relate through [44]–[46].

At its core, sociomaterialism posits that everything comes into being and continues to be because of relational processes [47]. Under this view, individuals, organizations, items, and technologies do not possess independent and intrinsic properties that then prompt and shape interactions [48]. Conversely, this relational perspective treats relations and relational processes as the principal element in everything, and relegates entities to a subordinate status [49]. Relations and relational processes create everything that *is* and that our construction of the world around us enables us to detect and observe. Entities—the components of the phenomena we can observe—are not intrinsically distinct but are constantly generated through intra-actions [50].

The adoption and utilization of cloud computing as a tool for crisis response by the public sector as part of COVID-19 also raises a vital question regarding how well the addition of this new technology to public sector information technology (IT) portfolios supports long-term organizational policies and objectives. As captured in the concept of IT alignment, this idea pertains to the extent to which an organization's IT objectives are in line with its strategic objectives, and to what extent its management and IT staff are committed to achieving these objectives [51]. IT alignment is widely recognized as a critical factor in determining how

organizations can derive the full benefit from their IT investments, an element that ultimately affects their organizational effectiveness and success [51], [52].

The question of IT alignment has been widely studied in the commercial sector but still lacks sustained attention by IS researchers in terms of the public sector [53]. For cloud computing alignment in the public sector specifically, there is a significant shortage of available IS research and further attention by the scholarly community is warranted [54]. From an analytic perspective, the exploration of cloud alignment issues in the public sector context needs to advance the scientific understanding of the central dimensions that affect alignment, including issues touching upon organizational agility, culture, structure, and staff skills [53].

An additional theoretical perspective that holds promise for the deeper exploration of how public sector organizations adopted and used cloud computing during COVID-19 is the dynamic capability approach. The concept of dynamic capabilities—broadly understood as an organization's capacity to develop, integrate, and modify internal and external resources to cope with quickly evolving conditions [55], [56]—has found frequent use in the academic literature focusing on the private sector but are lacking similar attention in the public sector literature [57]. Several dynamic capability elements—including organizational learning [58], the creation of new services and processes [59], inter-organizational collaboration [60], and strategic decision-making [61]—have been identified in the existing research literature and offer explanatory potential for dynamic capability in public sector environments. In terms of public sector cloud computing adaption during COVID-19, organizational reshaping capabilities that include concepts such as engagement, development, and performance management [62], constitute particularly resonant dynamic capabilities that deserve further study.

Finally, a stream of research exploring the concept of organizational ambidexterity has the potential to provide a more comprehensive picture of how public sector organizations managing the impact of COVID-19 were able to achieve organizational efficiency while undertaking rapid innovation initiatives at the same time. Organizational ambidexterity, commonly understood as the concurrent execution of existing operational activities and quickly emerging new activities, implies that organizations must pursue an appropriate equilibrium between competing aims of operational efficiency and innovation [63]. An in-depth exploration of the concept of public sector cloud computing ambidexterity, hereby conceptualized as the ability to constantly and adaptively integrate exploration and exploitation activities to manage conflicting demands during the deployment of a cloud computing infrastructure, is sensible and would provide impactful insights on how public sector organizations can increase ambidexterity by means of pivotal capabilities and supporting leadership and structural factors. Such insights would support the initiation, cultivation, and growth of cloud computing capabilities in the public sector and could position organizations to weather the next crisis and more effectively pursue long-term innovation.

4. RAMIFICATIONS FOR PRACTICE

PSOs responded to the significant demands posed by COVID-19 by implementing cloud computing at unprecedented rates and with unprecedented energy. Cloud computing's inherent strengths of flexibility, innovation, resilience, and collaboration empowered PSOs to confront the critical operational challenges imposed by the pandemic, including the rapid growth of the need for the delivery of key public services and the abrupt transition to remote learning and working. Consequently, PSOs at all levels of government made substantial investments in cloud computing and now need to assess how to sustain, leverage, and enhance these cloud-oriented expenditures.
While cloud computing adoption is not a new phenomenon in PSOs and did increasingly take place prior to COVID-19, the pandemic forced a dramatic change in those organizations that did

not already have a cloud first strategy in place. Almost instantly, cloud computing was no longer merely a peripheral priority among numerous others. Instead, cloud emerged as a central enterprise capability that extensively sustained public service delivery and PSO operations during times of crisis. With some of the most dramatic challenges caused by the pandemic now beginning to fade, the public sector IT priorities that were displaced by the crisis-driven focus on cloud capabilities are beginning to re-emerge and will enter the resource allocation process again. PSO technology leaders must confront hard questions related to what was successful during the crisis, what should be retained, what needs to be improved, and what should be eliminated from technology portfolios.

COVID-19 not only changed the quantity of cloud computing in the public sector, it also changed the way that cloud is utilized by PSOs. In addition to those PSOs that turned to cloud computing for the first time to meet their critical needs, even those organizations that had previously adopted cloud now aggressively pursued cloud computing as a means to advance digital transformation initiatives and enhance core service delivery and operations [64]. In light of these changes, it will take more than just the presence of cloud capabilities to take full advantage of the rapid technological changes the pandemic has spurred. Attitudes in regard to personnel, PSO culture, and the way cloud supports operational activities and enables additional technologies, need to be recalibrated and adjusted. These modifications and organizational adaptations will position PSOs to fully leverage cloud technology to accelerate their digital transformation and innovation agendas.

For PSO technical leaders, the practical implications of the adjustments now required to formally integrate crisis-driven cloud computing advances during the COVID-19 pandemic include several challenges. Despite the pragmatic flexibility that PSOs displayed during the crisis, achieving long-term change in the public sector is a complex endeavor and needs to address technical, procedural, and structural issues.

On the operational and strategic planning front, PSO technical leaders need to ensure that a robust, holistic cloud adoption roadmap is in place. The main objective of the roadmap is to identify appropriate cloud investments and to provide a foundation for achieving PSO cloud ambitions. The roadmap should provide a framework for analyzing and discussing PSO cloud adoption pursuits and execution plans with the relevant actors in the PSO, assist with mapping the PSO's cloud adoption course and the milestones that are necessary to make it to the finish line, and aide with tracking the gains that have already been achieved. A roadmap should inform decision makers and provide insights into how cloud advances the PSO mission and whether distinct legacy applications are able to and should be migrated to the cloud.

PSO technical leaders also need to carefully and holistically analyze their cloud computing environments and identify the stakeholders and the long-term cloud computing impacts that the rapid and pronounced shift towards cloud computing capabilities has created. Cloud affects PSOs widely, impacting budgeting, procurement, legal, HR, and front-line public service operations. Technical leaders and operational leaders need to collaborate to investigate cloud-driven operational opportunities and challenges in order to promote long-term organizational health and success. PSO technical leaders also need to improve their understanding of the external environment and concentrate on the major cloud vendors and their associated operational and service profiles. The main cloud vendors differ in their customer orientation, vision, product provision, end user orientation, and technology stack strengths, and PSOs need to strategically optimize vendor utilization based on these distinct differences and their specific organizational, mission, and use case scenarios.

Additionally, cloud needs to be deeply embedded in PSO operations and stakeholder decision making. If PSOs aim to advance long-term mission execution with cloud capabilities, the stakeholders that head specific mission areas should be consulted on cloud adoption from the beginning. With the big, cloud-driven wins that PSOs scored across the public service spectrum during COVID-19, championing cloud adoption has become easier and is further strengthened if PSOs merge central operational functions including planning, acquisitions, and finance to achieve the injection of financial accountability to the variable spend model of the cloud [65]. This concept of cloud financial management—or *FinOps*—is key to empowering decision makers to fully appreciate the compromises that cloud presents in terms of expenses, value, and operational tempo.

For PSOs, it is also instrumental to hire, train, and retain the appropriate cloud talent for their organizations. People are at the center of a cloud enterprise and PSOs should provide appropriate resources to recruit or upskill technical specialists to sustain the cloud adoption agenda. Organizational cloud adoption planning must address relevant human resource factors and promote a work environment that encourages psychological workplace safety, offers training and growth, and reduces the barriers that prevent staff from performing their duties. These human resources activities should not only focus on technical talent; all PSO employees should improve their cloud literacy and attain the skills and motivation to become more collaborative within their organizations.

5. CONCLUSIONS

This article highlighted how cloud computing emerged as a crucial crisis response tool for many PSOs during the COVID-19 pandemic and demonstrated how cloud computing's inherent strengths of flexibility, innovation, resilience, and collaboration prompted PSOs to extensively adopt both initial and expanded cloud solutions to confront daunting public service challenges.
Because of a distinct knowledge gap regarding crisis-driven public sector cloud adoption in both research and practice, this article proposes the utilization of socio-technical systems theory, sociomaterialism, IT alignment, dynamic capabilities, and organizational ambidexterity to enhance the understanding of cloud computing adoption in PSOs during times of crisis. In preparation for future crises and in order to position PSOs to transition crisis-driven cloud adoption gains to a post-pandemic environment, a better understanding of crisis-driven cloud adoption is critical and overdue.

Aimed at practitioners, this article also discussed modifications and organizational reforms that will be essential in order to enable PSOs to successfully transition their pandemic cloud investments to a steady post-pandemic state.

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