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Digital transformation and the public sector auditing: The SAI's perspective

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Abstract

The ongoing transformation of supreme audit institutions (SAIs) external environment is changing the demands and expectations of its stakeholders. The changing environment triggered by technological advancements, increased demand for accountability, and transparency means a change in the way auditing is done. The literature provides evidence of an ongoing technological innovation within the private sector audit. Private sector auditing research has focused mainly on technology adoption and use failing to address the umbrella concept of digital transformation (DT), some even consider processes of DT such as technology adoption and use to be DT. The public sector auditing literature is still yet to commence DT-related research. This study seeks to fill in this gap and after presenting what DT entails, we applied an exploratory approach through semistructured interview responses, together with other documents from SAIs, to understand how SAIs currently perceive DT and what are their current reactions or actions to transform. The paper analyzes and discusses how SAIs perceive and define the DT phenomenon. The results show that most SAIs still do not master the concept of DT, as they often refer to technology adoption or automation of auditing processes to be DT, notwithstanding a great majority acknowledges the need for

DT but lacks the right strategy and resources in place. We saw a few proactive SAIs who are futuristic on the contrary a majority are reacting to change when the need arises, especially during the audit process. The paper provides one of the first empirical investigations into the current DT of public audits. It also proposes a general framework suitable for analyzing the factors involved in the DT in SAIs.

KEYWORDS
auditing, digital transformation, supreme audit institutions, technological adoption

1 | INTRODUCTION

New public management has been associated with a rise in the demand for public sector auditing (Hyndman & Lapsley, 2016; Johnsen, 2019). The global financial crisis of 2008 and its impact have emphasized the need for greater transparency in public expenditures and value for money (Lonsdale, 2011). Accountability demands are expanding (Glynn & Murphy, 1996), coming from the citizens, the Parliament, the media, donor organization, and the international community at large (Brignall & Modell, 2000; Kloot & Martin, 2000; Johnsen, 2019) and influences the way auditing is conducted (Justesen & Skaerbaek, 2010).

Supreme audit institutions (SAIs) are faced with ever-increasing pressure and expectations from stakeholders to produce quality and impactful audits, as they are considered promoters of good governance ingredients such as transparency, accountability, and performance improvement (Cordery & Hay, 2019). This has also been triggered by parliamentary interest in audit findings (Skene, 1985; Guthrie & Parker, 1999; Hossain, 2010; Radcliffe, 1998), as well as by the societal at large requests for greater transparency (Sutherland, 2003; Kells, 2011; Morin, 2008; Tillema & Ter Bogt, 2010). SAIs' auditing activity is called to evolve to meet the contemporary demands of its society, as the amount of resources spent on auditing is far greater than what was envisaged decades ago (OECD, 1996; Pollitt, 2003; Pollitt & Bouckaert, 2000; Power, 1997). The ongoing transformation of SAIs' external environment is changing the demands and expectations of its stakeholders (Hay, 2019; Bonsón & Bednárová, 2019).

SAI plays a key role in enhancing public sector accountability and transparency (Cordery & Hay, 2019; Dye & Stapenhurst, 1998; Pollitt & Summa, 1997; Morin, 2011; Stapenhurst & Titsworth, 2002). They fulfill this role through three types of audits: compliance, financial, and performance audits (U.S. Government Accountability Office [GAO], 1972; OECD, 2011). According to The International Standards of Supreme Audit Institutions (ISSAIs) (100) compliance auditing is performed by assessing whether activities, financial transactions, and information are, in all material respects, in compliance with the authorities which govern the audited entity. Compliance audit focuses on whether a particular subject matter is in compliance with authorities identified as criteria. Financial audit focuses on determining whether an entity's financial information is presented in accordance with the applicable financial reporting and regulatory framework. Performance audit focuses on whether interventions, programs, and institutions are performing in accordance with the principles of economy, efficiency, and effectiveness and whether there is room for improvement. SAIs may differ in the way they operate that is their status and individual mandate but have been largely classified by previous literature into four models (Blume & Voigt, 2011; DFID, 2004; Cordery & Hay, 2019; Noussi & MAS, 2012; Sebastian et al., 2017), namely, Westminster model, court model, board or collegial model, and SAIs as a government department.

Regardless of their institutional structure and nature of auditing performed and the type of SAIs, digitalization is recognized to be of importance for the future of auditing (Lombardi et al., 2015; Hay, 2019). These changes in the

public sector challenge SAIs to assume new competencies and roles (Torres & Pina, 1999). SAIs are increasingly incorporating and adopting new technologies, such as big data analytics, artificial intelligence, machine learning, blockchain, the most pertinent question to be answered is are these technology leveraging actions just a case by case reaction to the pressure of disruptive innovations or its part of an overall strategy to transform sociotechnical aspects of their organizations.

Auditing research has focused mainly on technology adoption/incorporation and use failing to address the concept of digital transformation (hereafter DT) as a whole (Manita et al., 2020; Warren et al., 2015; Al-Htaybat & Von Alberti-Alhtaybat, 2017; Brown-Liburd et al., 2015; Vasarhelyi et al., 2015; Zhang et al., 2015; Pendharkar, 2005; Raphael, 2017). DT in the public sector is not just another technical iteration but also it may represent a transformation of how the public sector auditing is organized, how decisions are made, implemented, and enforced (Bonsón & Bednárová, 2019; Schmitz & Leoni, 2019).

However, to date, the literature on how SAIs approach DT and leverage technology during audits is limited. Much of the research on DT and related concepts has focused on private sector auditing specifically focusing on investigating the impact and adoption or leveraging of emerging technologies (Zhang et al., 2015; Raphael, 2017, Krahel & Titera, 2015; Cao et al., 2015; Brown-Liburd et al., 2015; Vasarhelyi et al., 2015). In the public sector, there is a dearth of DT research in auditing, while it appears as a growing theme in professional journals and or periodicals from SAI organizations of both local and supranational nature (e.g., *ECA Journal*, *INTOSAI Journal*).

Thus, ceteris paribus, this paper serves as a pioneering exploratory work looking at the core dimensions and implications of the DT phenomenon. In particular, we aim to explore how SAIs interpret and approach DT to uncover the implications for the future of public sector auditing from the experiences of auditors and experts. On a more granular level, the aims and objectives were broken down into the following research questions:

RQ1: According to SAI's what is DT?
RQ2: What are SAI's experiences and how do they initiate and or react to DT-related pressures?

In addressing the research aim and answering our research questions, we first look at why SAI's should adopt DT, what is DT and after presenting what DT entails, we applied an exploratory multi methods approach by analyzing semistructured interview responses, together with documents analysis from SAIs to understand how SAIs currently perceives DT and what are their current reactions or actions to transform public sector auditing. We found that the level of an SAI government's technological and digital advancements influences the way SAIs perceive and define the DT phenomenon. Thus, the contribution of this work lies in the fact that it provides one of the first empirical investigations into the current DT of public audits. The paper also contributes by proposing a general framework suitable for analyzing the factors involved in the DT in SAIs.

The rest of this study is structured as follows: first, we present the theoretical background of our research, we then present our methodology, next we present our analysis, and, finally, we discuss our deduced findings and conclude our study with recommendations while emphasizing our limitations.

2 | CHALLENGES AND OPPORTUNITIES OF DIGITAL TRANSFORMATION IN SUPREME AUDIT INSTITUTIONS

DT has the potential to change the way public sector audits are performed (International Organization of Supreme Audit Institutions [INTOSAI], 2019), going beyond the still largely used manual auditing (Moffitt et al., 2018; Cohen et al., 2019). Technologies such as big data analytics, natural language processing, and semantic document search are considered able to allow the processing of unstructured textual data resulting from activities such as public tenders, procurement, and aid packages (ECA, 2020). Adopting these and other technologies in SAIs auditing work has the potential of improving the effectiveness and efficiency of the audit, and its reliability too (Curtis & Payne, 2008), particularly in critical and challenging tasks (Zhang, 2019), such as performance audits (INTOSAI (2019), IDI

(2020); Funkhouser, 2011). Performance auditing traditionally pays much attention to evaluating the effectiveness of a program or a policy (English & Skærbæk, 2007). For instance, in auditing climate and environmental policies (Rika & Jacobs, 2019) or corruption (Jeppesen, 2019), auditors would be able to assess in real-time actual changes or improvements in greenhouse emissions as a result of the government policy.

Over the years, different technological tools have been proposed by both researchers and practitioners. Appelbaum and Nehmer (2017) illustrated an audit automation framework where certain audit jobs can be handled by automated systems. A typical example is using drones for conducting inventory inspection, counting, and or observation in a large warehouse or open-air inventory (PwC, 2019). Robotics process automation (RPA) can be used in performing repetitive manual tasks such as reconciliations, internal control testing, and detail testing (Moffitt et al., 2018; Huang & Vasarhelyi, 2019). Dai and Vasarhelyi (2017), focusing on blockchain, presented an accounting ecosystem where these technologies would assist in real-time monitoring and verification (Bonsón & Bednárová, 2019). Several scholars have also focused on ways of developing and incorporating different types of machine learning and artificial intelligence-based methods (Jans et al., 2014; Humpherys et al., 2011; Issa & Kogan, 2014; Yoon et al., 2015; Vasarhelyi et al., 2015). The new data ecosystem requires auditors to employ other nonstandard metrics (e.g., non-IPSAS (International Public Sector Accounting Standards) or ISSAIs (International Standards of Supreme Audit Institutions (ISSAIs)) to support their opinions (Cho et al., 2020).

The INTOSAI highlights the opportunities brought by digital technologies and expressed difficulties especially in accessing, capturing, and treating complex data generated in the process of implementing government policies (INTOSAI, 2019). Many countries are experiencing a significant gap in data availability, and the quantity of data remains a challenge, particularly in decentralized government systems at both local, regional, and subnational levels. Many auditors in this period of transition are yet to gain skills needed in a more automated audit workflow (Scholtes, 2020) and are cautious and conservative to embrace DT (Alles, 2015; Zhang et al., 2018).

The literature in public sector auditing to date, however, has focused on individual technologies use and diffusion, rather than comprehensively addressing DT. DT of public sector auditing provides promising outcomes, but like the popular saying by Doctorow "technology giveth technology taketh away." It comes with challenges that slow down the process of digitally transforming the auditing function. However, there exists very little empirical literature on how public sector audit institutions perceive and define the phenomenon of DT in their strategy and operations (Eggers & Bellman, 2015). In the next section, the DT concept will be addressed together with a framework of analysis.

3 | DIGITAL TRANSFORMATION: CONCEPTUAL DEVELOPMENT

The DT concept has been interchangeably, sometimes wrongly, associated with terms like digitization and digitalization. Digitization is the process of converting information or a process from analogical to digital (Maltaverne, 2017), which is the transformation from a physical artifact to a digital one, for example, the move from paper invoicing reconciliation to an electronic one. Digitalization is the process of using technologies to change business models. I-SCOOP (2016) defines digitalization as "the use of digital technology and data (digitized and natively digital) to create revenue/transform business processes (not simply digitizing them) and create an environment for digital business, whereby digital information is at the core." In the same vein, Unruh and Kiron (2017) define DT as "the innovation of business models and processes that exploit digital opportunities."

Digitization and digitalization emphasize technology, while DT is more concerned with strategy and overall business model. DT is a broader term, it involves the whole of organization change, not just a particular process(es) or project(s). DT is the move or act taken by an organization to keep up or adapt to a digital innovation emerging and diffusing in the external environment. DT is usually induced by innovations and the way people adopt or react to them. When the SAIs' ecosystem is affected by a technological-driven change, they may or may not respond to that by adapting and innovating to meet up new societal demands. DT is a holistic approach to change involving not only the technology but also other nontechnological aspects such as strategy, organizational culture, and leadership (Bumann & Peter, 2019, 2016).

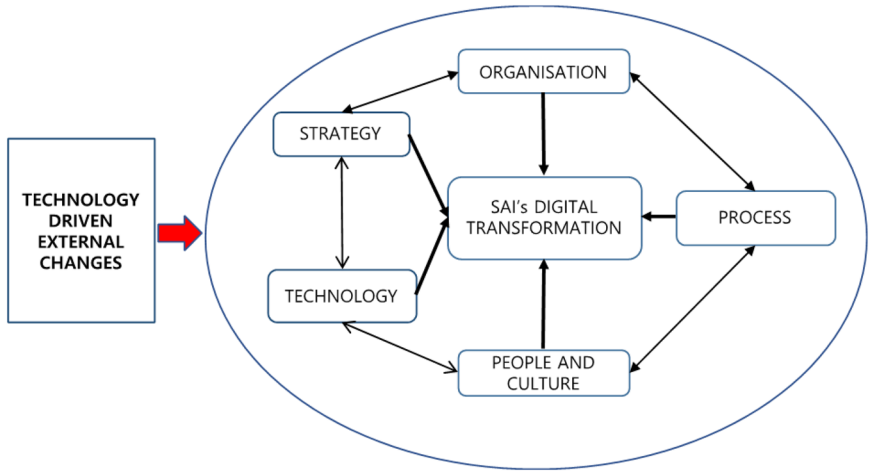

FIGURE 1 Digital transformation framework [Colour figure can be viewed at wileyonlinelibrary.com]

Drawing from the available DT literature (Bumann & Peter, 2019; Parker et al., 2016; Verhoef et al., 2021) and sociotechnical theory (Leavitt, 1965; Clark, 1972; Bostrom & Heinen, 1977; Nograšek & Vintar, 2014), we derived the following DT framework (Figure 1). Sociotechnical theory, for example, suggests that to digitally transform an organization, it must consider the different relationships between the different subsystems of an organization (Leavitt, 1965). In particular, the framework illustrates that DT requires integrated and connected moves towards a change in an organization's strategies, organization, processes, people and culture, and technology. The five factors are directly involved with DT but also bear reciprocal relations.

The first key tenet of the framework is the existence of a DT strategy. A well-structured digital strategy is considered as an important ingredient for a successful DT. There is a great debate on what digital strategy should an organization adopt; this debate can be classified into three schools of thought. The first group considers a digital strategy to be a subordinated functional-level strategy that works in line with the overall business strategy (e.g., Chan & Reich, 2007; Sabberwal & Chan, 2001; Matt et al., 2015). The second school of thought argues for a strategy that combines the IT or digital strategy and the overall organizational strategy (e.g., Bharadwaj et al., 2013). And finally, the last group considers DT to be an overarching subject matter that must be handled separately (e.g., Hess et al., 2016; Ismail et al., 2017). Despite these divergences, they all agreed on the need and importance of a strategy. Management should not only well articulate their vision and strategy but must strive to properly communicate it with the rest of the organization.

Ramilo and Bin Embi (2014) argued that DT is a disruptive process requiring new forms of organization, thus DT is a holistic approach to change where the interdependence of organizational technologies and structures is recognized (Liao & Ai Lin Teo, 2019). The organization element of the model refers to how the organizational structure is transformed, through new internal procedures, regulations, standards, and guidelines (Berghaus et al., 2017; Schlaepfer et al., 2017). Previous research argues that DT has a great impact on organizational structure (Sklyar et al., 2019). DT attainment requires organizational changes that match digital changes (Eggers & Francis Park, 2018), that is creating a less stressful DT process. Agility enabling organization structures such as lean, flat holarcratic (Verhoef et al., 2021) organizational structures are commonly applied by DT leaders. Agility aids their response to disruption from their ecosystem (Gimpel et al., 2018; Gunsberg et al., 2018). Organizations are called upon to "move away from traditional hierarchies and embrace leaner and flatter organizational structures which empower employees and allow greater agility and faster decision making" (World Economic Forum [WEF], 2016). Organizations usually create new roles such as chief digital officer (CDO) or chief information officer (CIO) to lead their organization's DT campaign (Kraus et al., 2021). The DT in the organizational dimension is closely related to the other dimensions such as culture, strategy, and technology.

Technologies by themselves are useless without the right competencies and skills. It is a failure for an organization to invest in technology thinking it will add value without properly considering those who are to use it (Andersson et al., 2018). People here involve both the management and new roles such as CDO and CIO (Kraus et al., 2021). Leading DT does not necessarily mean neglecting the role of people or paying less attention to organizational cultures and other nontechnology aspects of DT. DT leaders should avoid starting the change process with technology. First, they have to embed auditors with digital culture. Staff will certainly require new skills and experiences with different technologies (Andersson et al., 2018). SAI organizations should invest in empowering their employees through training programs (Cascio & Mon Teealegre, 2016; Schlaepfer et al., 2017). DT goes beyond adopting new technologies or designing new processes and services. A digital culture determines how an organization's staff understands, accepts, and advances DT. This is very important especially in the accounting and auditing profession that works with rules and standards. Without a well-managed digital culture, that is aligning DT with employees' values, it would be like forcing technology on staff, which may resist (Craig et al., 2014). DT focused only on technology at the expense of culture is limited, as digital culture is as important as technology. Cultures such as the "fail forward culture," as described by Schlaepfer et al. (2017) that create the opportunity to experiment, encourage creativity, and tryouts should be in place. In such a culture, auditors will have the opportunity to try to experiment, and if they fail, it can be considered as part of the learning process to better their art. A successful digital culture must have good digital leadership that can create a conducive environment for innovation and is not afraid to invest in risk-taking (Berghaus et al., 2017; Kane et al., 2015).

Technology is unarguably very important in DT, but its adoption should come after the right organizational culture and strategy is in place. The agility of an organization in adapting and using new technologies is very essential for DT to take place (Hess et al., 2016). SAIs should lead by example; they should be proactive to be the early adopters and leaders. SAIs should experiment with new technologies and innovations to discover potential that can help innovate their work. Today we have technologies such as the Internet of Things (IoT), blockchain, machine learning (ML) at an infancy stage in the SAI community, these are potential disruptors that SAIs should look after (Beckstrom, 2020). Ingestad (2020) posits the unprecedented scale of technological innovation. Technological changes are pervasive, persistent, and extremely rapid. SAIs should improve the effectiveness and efficiency of their processes by leveraging the power of advanced technology. Techniques such as process mining could help improve their efficiency since it is designed to discern, monitor, and improve real processes, using SAIs current organizational event logs, process mining can extract knowledge on how processes currently functions and can monitor deviations by comparing a simulated process model and the actual log (Van der Aalst, 2016). Labor-intensive processes can be automated to gain efficiency and to give auditors enough time to focus on brainstorming activities. SAIs currently face a sophisticated audience (stakeholders), who do not only expect them to react to their demands but also in predicting their needs. SAIs should adopt a customer-centric view when transforming their processes, which is looking at the needs of their stakeholders.

The five elements of the DT framework need to be considered with a holistic approach (Bumann & Peter, 2019; Parker et al., 2016), taking into consideration not only the technological aspects but mostly the other nontechnological ones and the existing interrelations.

4 | RESEARCH METHODOLOGY

To understand SAIs' perception of and how they approach DT a qualitative exploratory research approach was adopted. Exploratory research is an appropriate way of establishing the field at the early stages of an emerging topic, particularly in studying expert practices like auditing (Power & Gendron, 2015). From an ontological and epistemological standpoint, we adopted the interpretive research paradigm (Miles et al., 2013). The core purpose of an interpretive research stance is not to "discover the truth" (Rynes & Gephert, 2004) but to comprehend the meaning and concepts applied by social actors (SAIs) in their practice setting as a means to uncover the different versions of reality for each social actor. Based on this assertion, social actors (e.g., SAIs) are considered to be subjective (Guba & Lincoln, 1994). Our methodological approach is appropriate as both social actors (the researcher and the auditors) are under the

constant influence of social interactions which imparts the existing and changing reality by reflecting on their beliefs and values (Power & Gendron, 2015).

4.1 | Data collection and analysis

Given the novelty nature of this phenomenon (DT) in the SAIs' community, semistructured interviews were conducted as an instrument to collect data directly from social actors (auditors) involved in DT within the SAI community. Semistructured interviews, being flexible by nature, were considered more apt to gather insights from the SAIs' auditors (Horton et al., 2004). We adopted a purposive homogeneous sample (SAI's common function is auditing the state), choosing such a sampling method was informed by the principal aims of the research, existing knowledge and theories available on the topic, the research gap to be exploited, and the research population. The SAIs' auditors selected were experts with technical, process, and interpretive knowledge concerning the DT of public sector auditing. We were more lenient with the definition of experts since DT is still a new evolving phenomenon in the SAI community. We considered experts to include leaders of SAI at all organizational levels who are championing the DT crusade. Meuser and Nagel (2009) consider an expert to be one who is responsible for a concept, has relevant factual knowledge, accumulated or specific knowledge, information, or privileged access to information. Our expert's selection process lay less emphasis on their biographies (Mergel et al., 2019), but we were more interested in their viewpoints, their role as leaders or representatives of SAI organizations, privileges they have in accessing decision-making processes and people (Mergel et al., 2019). The experts selected are very well known for their direct involvement in digital-related transformation activities in their SAI organizations or at the international level through INTOSAI, most of them being speakers at or a host of DT-related seminars, webinars, and conferences, at their office level or internationally participating in regional organizations. We also considered their activities involving designing and setting DT strategies for their organization. Our experts selected range from heads of SAIs, heads of IT units, or SAIs who are or play the role of CIO, CDO, and heads of innovation labs, and so on. The strength of an expert interview research method relies on the number of interviews carried out and the quality of the experts who participated (Mergel et al., 2019).

We applied the chain referral approach (snowball sampling) that is asking interviewees to propose or connect us to experts who can give an insight into the phenomenon in question. We contacted 80 supreme state audit institutions but received acceptance for an interview from 15 SAIs and succeeded in interviewing 11 SAIs as shown in Table 1. The low and slow response to our interview request was mainly due to the novelty of the concept among SAI, the COVID 19 outbreak, and in some rare cases language barrier, but our research compensated for this low turnout by reviewing the secondary sources of information (see the Appendix). To decide on the minimum level of interviews to be carried out in qualitative research is a never-ending question (O'Reilly & Parker, 2013). To adequately capture the patterns and divergence across interviewees, Glaser and Strauss (1967) proposed at least 10 interviews, while Guest et al. (2006) advocated for 12 interviews as a threshold where one can obtain insight about the studied phenomenon. However, the key tenets we followed is to reach a theoretical saturation (Guest et al., 2006; O'Reilly & Parker, 2013), when no further insights were coming from new interviews. Consequently, given that from the last interviewees no additional evidence or new insights were emerging, a theoretical saturation can be claimed to be achieved.

To complement the empirics, we performed a document analysis. Documents provide data on the context within which the social actor operates (Mills et al., 2006). Document analysis assists the researcher in uncovering meaning, developing understanding, and discovering relevant insights about the phenomenon under study (Merriam, 2001). A document can also play an ex ante role in helping the researcher design the research questions, derive a research problem, and even direct how interviews may be conducted since it can be referenced or can contextualize the data collected during interviews. We applied document analysis as a complementary research method to triangulate research findings (Bowen, 2009). Applying a document analysis to this research will go a long way to help it obtain evidence triangulation—that is corroborative findings can be envisaged through the different methods of data collection and analysis employed in this research. We reviewed over 300 publications relating to DT; we excluded those published by

TABLE 1 Summary of interviewees

No.	ID	Date of interview	Role	Duration of interviews (minutes)	Region	Medium
1	001A1	March 22, 2020	Head of IT	41:22	Middle East	Skype
2	001C2	March 21, 2020	Auditor general	38:24	Asia	Phone
3	001F3	March 11, 2020	Auditor general	35:51	Europe	Skype
4	001K4	April 4, 2020	Auditor general	43:44	Africa	Skype
5	001N5	March 30, 2020	Manager datahub	26:32	Europe	Phone
6	001S6	March 27, 2020	IT audit manager	71:24	Europe	Skype
7	001U7	March 18, 2020	Deputy head of IT department	45:18	Asia	Skype
8	001D1	December 17, 2020	Director – data analytics	69.05	Europe	Zoom
9	001B1	December 15, 2020	Chief data scientist	45:17	Europe	Zoom
10	001T2	January 9, 2021	Chief data scientist	39:45	Europe	Zoom
11	001N2	January 21, 2021	Senior data scientist	75:32	Europe	Zoom

non-SAIs such as publications from hired experts who are not supreme state auditors. This reduced the sample to 102 documents.

Videos as a source of evidence have been used for some time now in social science research (see Goldman, 2007; Erickson, 2011). Jewitt (2012) argued that video can support exploratory research allowing the capture of things that may pass unnoticed, it allows researchers to revisit past moments, and reawaken the experiences of researchers and/or participants. The videos were collected from SAI websites, social media channels like Twitter, Facebook, and YouTube. We were careful to focus on DT-related videos. We downloaded and transcribed 12 video presentations, adding up to 102 documents initially collected, our total sample increased to 114 publications spanning from 2015 to 2020.

5 | DIGITAL TRANSFORMATION: THE SAI'S PERSPECTIVE

The advent of new technologies in the public sector poses questions such as what is the future for public sector auditing in this world of big data, data analytics, artificial intelligence, the IoT, ML, and the digital revolution? Some see these innovations as a threat, while others see them as an opportunity. Unlike in the private sector, where the digital revolution in auditing was highly motivated by the auditees who demanded more from auditors as their business information systems went automated, SAIs are called upon to lead and recommend DT to their auditees. The limitations of actual practices, the auditors interviewed, and extracts of experts from the documents argued for the need to move forward in adopting new technologies:

> How do we engage the entire community in understanding and using big data? Auditors must be involved in this movement! We must experiment! We may fail, but we have to try!.

Vaz-Silva, W. (SAI Brazil's Secretary of Information Technologies for External Control) (2018)

At the helm of INTOSAI, there is this unanimous acknowledgment of the potential impacts these technologies will have in public sector auditing and through seminars, workshops, and conferences, calls have been made to awaken SAIs to be better prepared to adapt to this new public sector auditing environment. The XXIII (INCOSAI, 2019) was dedicated to discussing how SAIs on a government or domestic level could relate to the public sector auditing developments and technological evolutions to remain relevant while addressing the needs of different stakeholders and adding value by offering independent external oversight on the achievement of nationally accepted goals including those linked to the sustainable development goals. The conference was able to paint a picture of the fundamental changes in public auditing and policy globally that have created a new environment and expectations for and from SAI (INCOSAI, 2019). These changes have echoed the need for new approaches in the public sector auditing and urged SAIs to rethink their role in the governmental accountability process (INCOSAI, 2019). SAIs may be different about their capacities, constitution, and mandates but they all have some homogeneous challenges such as coping with the complexities of government's policies to achieve both national and internationally agreed goals (e.g., SDGs-Sustainable Development Goals), also data revolution and digitization has brought great changes to SAIs work. Even the INTOSAI Supervisory Committee on Emerging Issues and SAI leaders have acknowledged the potential impacts of science and technological trends on governments and SAIs in the future as echoed below:

> […] Technology is driving change in society, and different professions are rediscovering roles and aligning themselves with the technological *direction of the future. The auditing* profession cannot be immune to these effects.

Al-Amimi (2020), President, State Audit Institution of the United Arab Emirates

The continuous generation and accumulation of data and technological advancements serve both as challenges and opportunities to ameliorate public audit quality:

> The digital age gives SAIs ample opportunities to modernize and ample opportunities to fail, but we should not be afraid.

Dr. Ellen van Schoten, Netherlands Court of Audit

Driven by these changes in the audit ecosystem, SAIs have started to experiment with the potential applications of DT in auditing. An ECA audit team applied visual data analysis techniques to help fish out undervalued textile and shoe products from China (ECA Journal, 2020). In 2015, the Audit Account Chamber of the Russian Federation developed an information analysis system (IAS) to conduct remote audits. With the backing of the 2013 federal law that gave them the right to directly access auditee information systems, they were able to assess more than 130 information systems in more than 30 states agencies. In 2017 alone, the IAS helped the auditors in detecting 650 procedural violations (10% of all the violations identified that year) and concealments in the public procurement process. The SAI of Peru invested roughly 2.7 million USD in executing the CCM (concurrent control model). Using this model, they were able to help the state prevent loss worth 26.5 million USD relating to the 2017 "EL Niño" phenomenon construction and reconstruction work.

As the above examples show, DT in SAIs' work is diffusing with a great interest in the potential applications. The next section portrays the findings concerning the factors involved in the DT of SAIs, as guided by the framework of analysis (Figure 1).

TABLE 2 Example of proactive strategic initiatives by SAIs

SAI	Name of innovation lab/incubator
Federal Court of Accounts – Brazil (TCU)	coLAB-I
ECA	ECALab
Office of the Auditor General (OAG) of Norway	Innovation Lab
US Government Accountability Office	Innovation Lab
SAI Belgium	DataLab
Netherlands Court of Audit	Innovation Lab

5.1 | Strategy

The strategic approach that SAIs adopted towards the changing environment can be broadly classified into proactive and reactive change. Pathak (2010) argues that "proactive change is a change that is initiated by an organization because it is desirable to do so. Reactive change is change initiated in an organization because it is made necessary by outside forces."

SAIs showed a proactive approach by creating in-house digital or technology incubators (innovation labs) to help fish and experiment potential (disruptive) innovations. Digital factories (innovation labs) require a cross-functional approach that is bringing together people from different specialties and departments with one goal to develop new value propositions or unique products. Some SAIs are already experimenting with that. The ECA in its 2018–2020 strategy aims to exploit technology to bring innovation in its audit, which is greasing the wheels for auditing and better presentation of audit findings in its reports. In particular, ECA has created the ECALab, an interdisciplinary innovation laboratory with the main focus on DT of ECA's auditing function using technological advancements (ECA, 2020), constantly testing new audit and organizational procedures refining and iterating them before finally integrating them into the broader organization.

In a bid to improve audit quality and make the audit work more efficient and easier in this digital era, some SAIs are taking a proactive strategic stance. Initiatives such as the creation of innovation labs (incubators) are an example. In this incubator environment, digital culture is becoming the new normal especially among SAIs from technologically advanced nations (e.g., SAI Belgium, Norway, GAO, Russia, United Kingdom, South Korea, ECA).

> […..] Innovation labs, also often referred to as accelerators, hubs, or incubators, are units or teams that employ creativity and flexibility aimed at inventing ideas, products, processes, and services to help solve problems, create work efficiencies, and address emerging trends. They can function in a variety of ways—operating as a completely separate unit from the organization or functioning as an internal team staffed with existing employees.(INTOSAI, 2020, p.21)

For example, in 2019, the office of the Auditor General of Norway established an innovation lab to help respond to emerging science and technological trends affecting the audit community (Beckstrom, 2020). ECA created the ECALab made up of experts from different fields (IT, audits, and language services) to explore innovations, technologies, and methods. Currently, they are working on the possibility of using association mining in performance auditing. Table 2 shows some of does capacity building of SAI's proactive change initiatives through the creation of incubators of ideas or innovation labs.

In other SAIs, a more reactive strategic response was initiated. This strategy response was mainly driven by the offerings of technological revolution and big data. These are reactions by leveraging the power of technological tools. Below is an example of reactive changes:

> [….] In 2014, SAI-China set up the Department of Electronic Data Audit, which collects, verifies, and processes electronic data related to audit, aiming for the holistic analysis and use of such data. Since 2015, SAI-China has started Phase III of the Golden Audit Project, which focuses on big data. At present, SAI-China is trying to promote the digitized audit approach featuring "general analysis, spotting suspicious items, decentralized verification, and systemic research," and exploring the comprehensive analysis and utilization of data from multiple levels, regions, systems, sectors, and businesses. (001C2).

Some SAIs also pointed their rapid transformation using new technologies was induced by the pandemic which restricted them to carry out their business as normal; as a result, they sort to virtual and remote auditing practices such as automating and connecting data query systems with their auditees, using video conferencing to carry out interviews, etc. (reactive change)

> The COVID-19 Pandemic has forced SAIs to adopt in a short space of time a new way of interacting with each other in the workplace; to relook the concept of the physical workspace; to consider how SAIs need to respond to these very changes that are occurring in the public sector; and, to re-examine the changes that would be required to how work is executed on a daily basis. SAIs must be ready to respond to the change brought on by the new normal. This means greater use of information technology and data analytics to enable the application of real-time audit techniques. (CAROSAI, 2020, p.5)

> COVID-19 is affecting us all. The way we live, work and socialize has changed dramatically. The National Audit Office is no different, our staff is working from home and we will also have an important role to play in reporting on the government's response to COVID-19. (Gallagher, 2020, p.5)

The SAIs interviewed are adopting real-time and continuous auditing models to meet up with the challenges, this implies a transformation of both how they operate and how they audit. NAO Finland applied agile and took a reactive approach to meet up with its changing environment (that is transformation on how the central government manages its finances).

> …NAO Finland extensively reformed financial audits over the past year …The reform, which responds to changes in managing central government finances, aims to use new digital technologies more extensively. NAO Finland is excellently positioned to leverage data analytics to improve financial audits given its longstanding use within the organization coupled with an extremely high level of digitalization in the financial administration of Finland's central government. (NAOF, 2021, p.13)

Conclusively, despite being futuristic and having an innovative culture, SAIs do acknowledge their DT goals to some extent can be hindered by their auditee (government level or transformation or degree of interest in DT).

5.2 | Organization

SAIs are updating their organizational structure with the creation of special innovation or foresight departs in charge of leading DT and innovation-related activities. Today's most innovative SAIs start the DT by creating a foresight organ. Such an organ usually does not focus on technology alone but starts by asking the right questions then seeks what technological tool can answer such a question "a kind of reverse engineering process," most of the incubators or innovation Labs were born by foresight organs. For example, ECA started by creating the digital steering committee which led to

the creation of ECALab ("a place where auditors and data scientist can find each other and where ideas for technology and innovation can be nurtured and put into practice," ECA, 2020)

> Digital technologies are transforming the world at an unprecedented speed. With the creation of its Digital Steering Committee (DSC), the ECA identified an urgent need to undertake a digital transformation in the way we audit. The aim of this transformation is to use the potential of technology to deliver our audits more easily, quickly, accurately, and extensively than ever before and provide more useful information for the accountability process. (ECA Journal, 2020)

GAO through the Science, Technology Assessment, and Analytics unit (a foresight organ), and established their innovation lab. Innovation labs as an organizational construct are also called "digital factories," a place where auditors of all departments do collaborate and share ideas, and with the aid of agility and design thinking, new products and services are developed.

> ….the ECALab, an in-house centre for research and innovation. This space for sharing ideas, exploring, testing, and implementing technologies in the audit process is part of the ECA's digital transformation initiative. The ECALab is comprised of data science enthusiasts and expert auditors who cooperate on finding tailored solutions to audit tasks and audit-related projects.

This in itself creates, to a certain extent a leaner and flatter organizational structure, which empowers employees (auditors) and allows "greater agility and faster decision making" (WEF, 2016; Nadkarni & Prugl, 2021). Conclusively, the organization dimension of DT overlaps with the other dimension, for example, SAIs adopting an agile culture.

Presently even at the level of INTOSAI, there exist no specific standard guiding the DT of audits. What is present are INTOSAI guides on applying specific individual technologies. For example, the IDI's (INTOSAI Development Initiative)) SDGs audit model ISAM (pilot version March 2020), dedicated an appendix titled "Using data analytics for an audit of the implementation of SDGs." Generally, SAI at the national level does have some sought of in-house guidelines on how to integrate technological tools and techniques into the auditing process. Capacity-building seminars and workshops to discuss standard operating procedures for using these technologies have been the norm. Regional and international SAI do share best practices especially using the INTOSAI as a platform. SAI China, as an example, has proposed a draft "Guidance on Conducting Audit Activities with Data Analytics," but it has still to be approved.

SAIs using their independence and the freedom to design how they audit, create in-house procedures, and guidelines on how to integrate technology into their auditing workflow where necessary. Most SAIs are adopting their governments' public administration guidelines on DT. This is so common among EU SAIs, whose main source of technology and big data analytics guidelines are generated from different EU DT initiatives such as the "DIGITALEUROPE," supranational agreements such as the Tallin eGovernment Declaration' (2017), and other Eurostat guidelines on big data. Nevertheless, we had one interviewee who stressed the difficulty in setting a universal or a panacea-like standard to regulate DT in auditing:

> (…) We don't use regulations because that's difficult since we use many different techniques. Sometimes they're somehow experimental, so I think writing a regulation brings about a new technology. We use "R" in our office, so when we write an R script we describe every step that was taken with the data, in that way we ensure that the replicability of the work becomes a scientific formula. We always tell our auditors to document everything in the R script and preferably they should take a clearance procedure with the department that was audited by handing them their R script for them to see what data was used. (001N5)

5.3 | Technology

Interviewees generally agreed that DT will increase audit efficiency and effectiveness. Data analytics augments analysis capacity, allowing for population-wide testing and profiling, smarter nonstatistical sampling, as well as the use of automated and repeatable analytical processes. Envisaged as a useful tool in audit planning, data analytics will also focus on risk-based areas of interest and anomaly identification, resulting in more meaningful analysis and objective sampling (INCOSAI, 2019). However, just a handful of auditors are equipped with data analytical skills and versed in data mining (Scholtes, 2020). Given the fact that a majority of data in the public sector is unstructured, without using other techniques, it will not be possible to make sense of big unstructured data, currently, and data mining tools are commonly applied in mining structured data such as spreadsheets in rows and columns formats.

Hu Zejun, Auditor General, National Audit Office of the People's Republic of China (CNAO) argues that

> big data auditing is a brand new embodiment of audit work that facilitates the evolution from audit sampling to the population; audit parts to the whole; and micro to macro and provides new methods to improve audit quality and efficiency.

Technological advancement exposure among SAI is linked to the level of their countries' E-government level. Most SAIs due to lack of resources and motivations from their governments are reluctant to be proactive in venturing and fishing out potentials of emerging technologies, one interviewee said: "We always look at the cost and benefit of a particular technology before implementing or applying it in a particular audit" (001A1).

Therefore, the findings show that the level of E-government affects the degree to which some SAI apply technology to their audits and thus affects the way they approach DT. This is true as we could attest that low-income level nations are still very behind and are practising traditional auditing with less motivation to transform their practices (venturing into the offers of emerging technologies) along with their highly sophisticated E-government counterparts. Interviewee 001N5 states: "we can't audit using these emerging technologies when our governments themselves are still using old school methods."

Most of the interviewees acknowledged the capabilities of emerging technologies to improve or eliminate the current traditional auditing methods. Some point at specific technologies that could drastically transform public auditing, but they stuck to the point that it cannot replace the auditors, one interviewee (001N2) after acknowledging the disruptive nature of the blockchain, believes it cannot replace auditors' role of assurance if they change:

> The point of auditing is not to have auditors doing the same profession until the end of the world, the point is we want to have guarantees of transactions and have certified information (…) in the coming years' auditors would not be doing what they are doing now because blockchain technologies will do that, but they will now shift their focus to emphasizing things like organizational culture and more strategic information and analysis (…) in my opinion be it blockchain or any other revolutionary technique and technology (AI, ML, NLP, RPA) they will cause the traditional auditing method to become obsolete thus auditing will change to start doing what machines cannot do. (001F3)

The majority of interviewees do acknowledge the pace has picked up and they are now at a stage where they risk becoming obsolete and irrelevant if they do not keep pace with the technological transformation, ignoring it only at their liability. Interviewee 001B1 posits:

> All of the above technologies (NLP, Big data analytics, Blockchain, in-house, and smart contracts, Machine learning, Natural language processing Process mining, RPA) are very promising and have high potential in improving audit practices. We can look at these technologies with two lenses. In the short

> term, we believe big data analytics and robotic process automation will be the technologies to watch out for. We would even venture to say that auditors will soon be required to use data analytics almost universally. Robotic process automation will be the next frontier. In the long term, as a future-looking auditor, I will keep close track of blockchain, smart contracts, machine learning, and Artificial Intelligence. It is worth mentioning that, though these technologies are not expected to take over the role of an auditor, they will act as enablers for more innovative and smart ways of practising auditing. Interpretation of results and presenting information to decision-makers will remain a task of an auditor.

SAIs, especially from technologically advanced nations, are heavily investing and acquiring the latest and most sophisticated equipment and tools capable of handling the complexities of big data. Most of our respondents attest to have renovated and augmented their IT tools:

> Our auditors are using different software, for example, we have ALC, Microsoft Power BI, strata, Macro Bond, NVivo for text analysis of interviews. We have a bunch of other smaller software packages which have been developed and designed by our staff. We have a data analyst team in charge of coding. (001F3)

More effort towards building a remote auditing environment is the next step SAIs are taking, some are already enjoying a cloud environment and are working remotely.

> Currently, SAI Belgium is investing in high-performance, centralized computers, and developing a Structured Query Language (SQL) warehouse to store recurrent financial data flows from the administration. Cloud-based solutions are also being investigated, and the organization's Data Protection Officer has established a data protection policy.
>
> Koen Van der Bracht, Supreme Audit Institution of Belgium

In terms of the application of technology in audits, most SAI find it more flexible to use technology in financial audits than in performance audits, this is partly due to the nature of data involved. Financial audits largely use structured data (spread sheets or tabulated data), while performance audits use any data type (i.e., both structured and unstructured data link plain text from social media, etc.). Although much of the analytics applied in audits has been in the area of financial audits, there are also cases where technology has been leveraged in performance audits. The UK NAO central analysis teams whose goal is to investigate value for money by applying specialist analysis techniques to government data to generate new insights' (NAO, 2021). As the empirics and key cases show, in the future public sector auditor will increase focus on value-for-money audits and employ more creative and intelligent work extending "beyond the boundaries of transactional audit and account certification."

5.4 | People and culture

The conservative nature of the auditing profession has been a major challenge to the adoption of disruptive technologies in public sector auditing. SAI China pointed out the aspect of resistance to change (traditional auditors being too conservative):

> Compared to the difficulties of learning new technologies, I think it is more difficult to change people's inherent thinking patterns and build a new big data auditing culture. At present, the SAI China is trying to promote the digitized audit approach featuring "general analysis, spotting suspicious items,

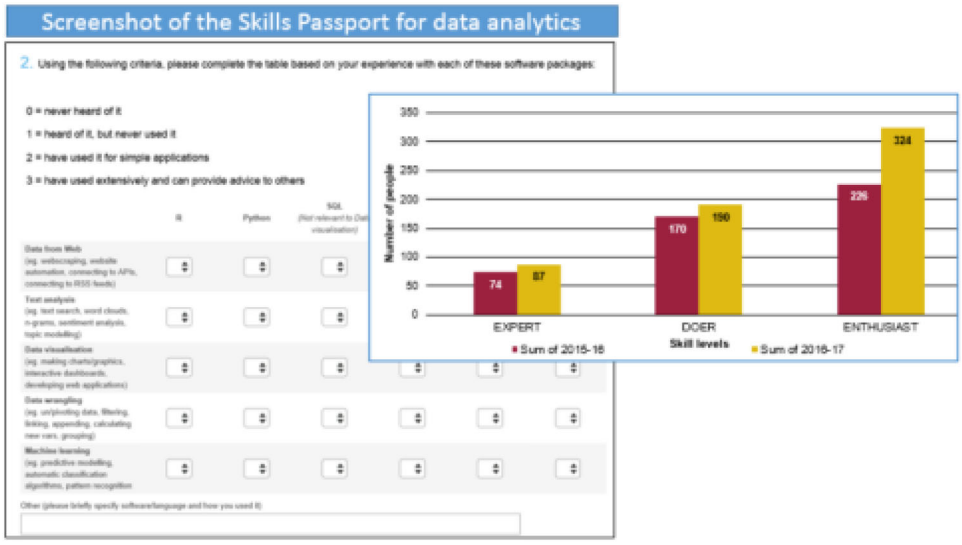

FIGURE 2 NAO skills passport for data analytics [Colour figure can be viewed at wileyonlinelibrary.com]

decentralized verification, and systemic research," and exploring the comprehensive analysis and utilization of data from multiple levels, regions, systems, sectors, and businesses. We prove the effectiveness of big data audits through practical results and promote changes in people's inherent thinking.

At the international level, the INTOSAI and different regional SAI have been carrying out DT leadership activities such as organizing capacity-building seminars and conferences on how to leverage digital technologies in auditing. For example, the 24th UN/INTOSAI Symposium theme was "Digitalization, open data, and data mining: relevance and implications for SAIs' audit work and for enhancing their contributions to the follow-up and review of the SDGs." In more general terms, capacity-building collaborations have been and or are being organized with multidisciplinary courses and training sessions:

> We have held regular training to universalize Data Analytics skills among our auditors. Recently, we launched the SAI Academy and one of our key focus areas for capacity building is Data Analytics. In my view, there is going to be gradual progress towards Artificial Intelligence but right now we think that Data Analytics is the first step towards that goal. (001U7).

SAI organizations are exhausting all possible means by which their staff can get training, apart from in-house training, experts are usually hired to train SAI through workshops and seminars, some organizations pay for courses at universities and on online platforms. They even go as far as providing intrinsic and extrinsic motivations pushing SAIs to embrace and enjoy learning new skills. NAO UK has implemented a "Skills passport" (see Figure 2) auditors fill in this form which has checkboxes indicating to what extent an auditor is familiar with a particular technology or analytical method. Since this was instituted, NAO has experienced an increase in the number of technology experts (NAO, 2019). The interviewee raised a point concerning the diversity of audit teams:

> (…) so there is a problem of skills, you can't just hire a programmer and put in front of the computer to perform auditing, likewise, you can't just give a performance auditor a computer to just start programming let's say with python or write a script or syntax, although there is this expectation that an auditor should have both skills …it's tricky, but what we have done is we have programmers who help

> performance auditors with data skills and performance auditors do the same to pass on their auditing skills. (001S6)

Another interviewee highlighted that capacity building activities are being diffused enabling SAIs to venture into any technological transformation in their audit:

> Concerning Capacity Building in the area of Data analytics, The office has trained All Auditors in the use of at least one analytical tool (…) We have invested heavily in ICT infrastructure (…) Invested in robust security infrastructure. We are also creating awareness to staff. (001k7)

Most SAIs have created an experimental environment thus adopting the "fail forward culture" or "fail to learn culture" of DT (Schlaepfer et al., 2017; ECA, 2020), this alone motivates SAIs to think out of the box and bring out their inner talents. Overall, adopting these new technologies and methods has increased the demand for new skills sets especially in the area of data sciences and IT-related fields. This has gone a long way to increase the diversity of audit organizations. It is not a strange thing today to see people from different fields in an audit team. Most of the SAI organizations operating innovation labs especially ECA and GAO had the most diverse teams; this can be seen in their job adverts who they are recruiting. Some of these new skills are not required for the sake of performing actual audits but to work as researchers in their innovation labs, ECALab with its text analytics projects employed linguists and data scientists as part of its research team. It emerges clearly, how technology, without an adequate set of skills, competencies, and culture will do little to improve auditing practices:

> Even in the technology-driven audit process human beings would be the most critical factor on account of skill sets required, changes in cultural beliefs and behaviour patterns, and last but not least the reorganization itself. The organizational structure may have to be redefined to facilitate audits from anywhere. This may require a change in roles and responsibilities and redefining the job profiles. (Gupta, 2020)

5.5 | Process transformation

The technology dimension of DT has been the focal area of most SAIs when approaching DT. However, most interviewees consider DT as process automation using technology to gain effectiveness and efficiency in audit outcomes. SAIs are striving to automate their audits to meet up with changes occurring in their ecosystem, as a response to the transformation going on in their environment:

> The world of auditing cannot remain untouched by the digital transformation taking place in the audit universe. The technological transformation of the audit universe, on the one hand, may bring in greater accountability and transparency and on the other automating repetitive tasks could free up valuable audit time facilitating a more investigative analysis.

> (2) As a means to perform, efficient and quality audit: By harnessing the latest technological developments in the audit processes, auditors can provide greater assurance to the stakeholders as the examination may move from select samples to the analysis of the whole population. (Meenakshi Gupta, SAI INDIA 2020.

We had mixed findings concerning full automation of public sector auditing processes, some SAI believe it is possible others say it is not. Those arguing against full automation backed their argument using the nature of auditing being a human or behavioral field, difficult to be standardized.

> I think and believe that it is not possible, this is not a physical science, auditing is human sciences our machines will not find it easy to learn from such human behaviour generated data, I just know it's a dream that will not practically occur, don't get me wrong we can automate some part of the audit process, our machines are not smart yet to learn by themselves, such a system won't solve any of my tasks as a performance auditor. All the software behaviour must be fed by us. (Interviewee 001S6)

> New technology is only a tool to identify new problems, but it can't completely replace humans. Technologies can also bring out errors, it can find an inconsistency, but it can't tell us the reasons why it occurred. The interpretation and judgment of audit findings must be made by auditors. (Interviewee 001C2).

The majority of those who believe in the full automation of the audit process, their argument was mainly linked to how auditees are already operating in a full automation environment. However, they think it is not something that will happen to their processes anytime shortly.

> We believe that full automation of the audit judgment process is possible, though still somewhat in the distant future, will not be universal in application. For example, in cases where data is unstructured or we come across data that we haven't seen before, it will be too risky to rely on the judgment of machines. We believe that the auditing profession is still at quite a distance from completely relying on automated judgment. But our target is to reach a stage where we leave most of the data analytics work to machines and let the auditors do more quality work of forming machine-assisted audit judgments, at least for the near future. (Interviewee 001U7).

The school of thought advocating that technology can never replace the auditor argues that even though these technologies are powerful enough to automatically indicate risk or fraud, from that point auditors will take such insides to carry out further investigation to ascertain the actual conditions, causes, and effects of that a more qualitative investigation which machines might be limited, as such, the human and professional skepticism aspect of audits is very difficult for machines to mimic.

> Importantly, AI does not replace professional judgments of experienced auditors in detecting potentially fraudulent activities. While AI can sift through large volumes of data with tremendous accuracy, human intelligence is still an essential element for determining context-specific, proportionate, and nuanced actions stemming from algorithmic outputs. This symbiotic relationship means AI will assist Supreme Audit Institution (SAI) work and will change how that work is carried out—requiring different skills to harness AI's capacity to drive effectiveness and efficiency. (Ariga et al., 2020, p.42)

The Covid-19 pandemic triggered the automation of certain processes, especially data collection, sharing, and analyses. Most strived to upgrade their connectivity to their auditee database to directly query for data, using data online query software they could directly get data from auditee systems, summarize, and do exploratory analysis. For example SAI Hungary (SAO):

> … SAO Hungary uses data for its core auditing and analysis tasks, and digitalization and automation continue to play major roles in requesting and classifying data…The SAO has greatly enhanced digitalization, particularly in requesting data, by transitioning to full-electronic contact with auditees and accessing data using an internet-based request system. This transition has led to more effective and efficient information flow that also markedly increases objectivity and equal treatment. (INTOSAI, 2021, p.12)

Conclusively, they all agreed to have automated some parts of their work, especially those labor-intensive processes.

6 | DISCUSSION AND CONCLUSION

Technological innovation has changed and is changing the way public sector auditing is performed (Bonsón & Bednárová, 2019; Schmitz & Leoni, 2019). Digitalization of processes is bringing about an unprecedented change in the way many public services are performed, and how information is produced, shared, and used. Public sector audit, and SAI, in particular, is and will be inevitably affected (Hay, 2019). However, to date, the academic literature paid little attention. This study was designed to explore the SAIs' level of perception of the DT phenomenon. Using the DT framework (Figure 1) as a lens for this exploratory study, we were able to see what is currently going on to integrate digital technologies and techniques into the auditing process. After collecting, analyzing, and exploring data (semistructured interviews, professional and academic publications), we summarize our findings based on the following themes:

1. SAI understanding of the concept of DT in public sector auditing;
2. Regulations and capacity building to guide the integration of new technologies into the auditing process;
3. Challenges and opportunities.

In terms of SAI understanding of DT, our analysis shows that most SAIs define DT based on their experiences and exposure (country's level of technological advancement) to certain potentials of technological transformation (innovations). Just a handful of them has defined digital or technological transformation strategy using the holistic change management concept. This group painted a more futurist view and had a common character trait of being proactive when it comes to the DT of auditing. SAIs with initiatives such as ECALab, DataLab, or innovation labs, in general, were found to be more proactive in their understanding of the DT of auditing. The innovation labs represented a means through which the DT strategy could be transformed into auditing practices in financial, performance, and/or compliance audit.

Besides, we reckon that there are no generally accepted standards regulating the integration of disruptive technologies into the auditing process. Despite the need expressed by some of SAI's stakeholders, some of our interviewees think the reality is far-fetched. Auditing by nature is a profession that operates strictly following certain standards and principles in making audit judgments (Appelbaum et al., 2017) and the slow introduction of DT-related auditing standards will slow down the process of transformation. However, to foster the integration of technologies into the public sector auditing process, the INTOSAI has established three working groups concerning DT, namely Working Group on IT Audit, and Working Group on Big Data, Working Group on the Impact of Science and Technology on Auditing. Looking at these emerging technologies, it is clear they have the potential of disrupting the auditing profession. For example, let us recall the basic principle of auditing which says the backbone of every audit judgment is audit evidence (ISSAI 3000/106). Audit evidence is mainly based on the ability to collect, analyze, and interpret data. New technologies can foster this process by extending the breadth of available data sources such as social media networks, videos, and audio (Moffit & Vasarhelyi, 2013; Vasarhelyi et al., 2015; Yoon et al., 2015; Brown-Liburd & Vasarhelyi, 2015). New technologies enable auditors to obtain evidence through methods and sources that were not previously

available. For example, using technologies for animal and plant species inventory in a rain forest reserve, or to measure carbon emission, land consumption. As agreed by our respondents, disruptive technologies and techniques will transform auditing methods. Auditing activities relating to public policy coherence or performances requires an approach where corroborative evidence(s) can be collected, real-time auditing, or continuous auditing can be practised. Digital technologies make it possible for auditors to audit the whole population rather than a sample and this reduces the risk of making a type one or type error in issuing audit opinions due to wrong sampling. This has the potential to move public sector auditing from a compliance approach to a more emancipatory role, supporting the societal, environmental, and economic changes called by the SDGs (Bebbington & Unerman, 2020; Funkhouser, 2011; Rika & Jacobs, 2019).

Despite the great benefits of digitizing auditing, auditors will and still face a lot of challenges and opportunities, especially when it comes to new skill requirements, audit evidence gathering (big data complexities), new auditing procedures just to name a few. However, auditors will face yet another change in identity in changing the potentiality of their role (Justesen & Skaerbaek, 2010). DT requires new skill sets from auditors, these skills are even at par with the audit technical skills, today's auditors are likened to data scientists with auditing skills. Today SAIs across the globe are carrying out capacity-building activities (e.g., IDI e-learning platform, ECA academy) to beef up their auditor's digital skills to meet up with the challenges brought by the digital revolution. As we described, technology innovation shall go hand to hand with a change in culture and people, meaning a shift in the identity of auditors.

At times, the auditee's IT environment is not advanced or up to date to permit the application of data analytics. Data structure and formats sometimes need to be treated and cleaned before being considered as audit evidence. This involves huge costs, which alone causes auditors to abandon certain data due to the high treatment cost involved that surpasses the benefits of using such data. Besides, the cost of running automated systems is very high. Proactive activities towards innovation such as data or innovation labs are very expensive to run especially for SAIs from less developed countries who are usually underfunded. In terms of structure, SAIs are rearranging their organizational settings to incorporate new hardware and software to accommodate disruptive technologies. For example, the creation of innovation labs, hiring new data scientists, creating and working in a cloud environment are some of the efforts made to accommodate disruptions. However, looking at the level of reliance on data analytics (automation) in making audit judgments (trusting the black-box), the majority of the SAIs interviewed considered data analytic to be a complementary tool in auditing, some confirmed to have in certain situations relied fully on the result of data analytic in making certain audit judgments, especially in cases where without digitization such audits could not have been possible.

Conclusively, we argue that DT can be observed and analyzed by looking at the five elements of the proposed framework (i.e., strategy, process, organization, people and culture, and technology). Our case showed that the majority of SAIs tend to give priority to the technological and process dimensions of DT. Other aspects of DT such as organizational culture, DT leadership, people, and strategy are given less attention. What most SAIs are currently doing is process automation, the corroborative evidence shows that there is still a lack of cultural change which serves as a barrier to innovation. SAIs simply introduce technology into their old systems and audit tradition, we believe this approach may risk SAIs not keeping pace with the change and disruption happening in their external environment. We concur that SAIs should take a holistic approach to DT, developing long- and short-term audit DT strategies (ECA, 2020). They should not be late adopters (Roger,) but act as leaders of DT; in this way, they will be able to create impact and remain the relevant voice when it comes to public accountability and transparency proactiveness should be new culture among SAIs this will help them design their future, not being proactive leads to the acceptance of a future designed by others.

The contribution of this paper is twofold. First, it provides one of the first portraits of SAIs' perceptions of the actual and future opportunities as well as challenges DT can bring about in public sector auditing. In so doing, we gave a response to calls in the literature to an empirical analysis of this trend (Bonsón & Bednárová, 2019; Johnsen, 2019). Second, we provide a conceptual framework of analysis, as a heuristic device, to observe and understand the factors involved in the DT of public sector auditing. The analysis supported the idea that to comprehend the DT phenomenon it does not suffice to look at a single factor, as DT has several intertwined factors that need to be considered.

6.1 | Limitations and future research

The present exploratory study is limited in that our qualitative sample of SAIs interviewed was mostly from advanced nations; we had difficulties in collecting evidence from less developed countries to see their level of understanding and practice of digital revolution in auditing. Coupled with the fact that we interviewed only a handful of SAI's, we cannot generalize the findings. Our work serves as a pioneering work into this area; therefore, subsequent research is needed. In particular, we call for a comparative research approach looking at specificities of SAIs in particular national approaches to DT, considering the characteristics of SAIs as well as the whole audit ecosystem. More research will be needed in looking at specific items of DT and their impact on public sector auditing, auditors, and auditees. In addition, future research may fruitfully look at the changing role, function, and identity of auditors in SAIs as technological innovations advances.

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DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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APPENDIX A: INSTANCES WHERE SAI'S LEVERAGED TECHNOLOGY

Organization	Year	Document title (SAIs applying technology to auditing)	Data type/scope	Goal	Technologies used	Type of analysis	Outcome	Software
ECA	2019	Big Data Pilot for Performance Audits on EU Agencies	Over 200 000 news articles were gathered in cooperation with JRC43 European agencies Audit time frame from January 2018 to July 2019 (1-.5 years) 5488 distinct sources from all around the world 169 distinct ISO countries 66 distinct languages	What impact could agencies have on the media? (audit question on "external scrutiny" and "accountability") ○ Total and average news per agency ○ News duplicates ○ News outliers and event detection through text mining ○ Geographical distribution of news sources per agency	Text mining	Network analysis Summary statistics	Our analysis revealed that, typically, events related to public safety and public health generate significant news duplicates and news outliers	Python, Tableau, IBM Watson
NOA-Estonia	2018	Audit "Publicity efforts of local authorities in municipal newspapers" (2018)	NAO analyzed the media coverage of candidates participating in 2017. Total of 191 electronically available municipally funded newspapers local elections across municipal newspapers published from January to October 2017	The goal was to make sure that newspapers financed by local governments have not been used towards personal political interests; covert election campaigns; other party-political image campaigns.	Text mining	Analysis using the keywords and combinations of keywords incl: sequence, placement, size, visualizations used, overall "emotion" of the article, connection with elections, author of the article	The search returned 24,500 results/mentions of keywords (in total 6000 articles), sentiment analysis (out of the four news channels whose articles were analyzed, two TV channels tend to have positive sentiments towards particular candidates, while the other two were neutral in their news coverage of candidates)	Outsourced to a Balti Meedia-monitooringu Grupp OÜ. Excel for data presentation

(Continues)

Organization	Year	Document title (SAIs applying technology to auditing)	Data type/scope	Goal	Technologies used	Type of analysis	Outcome	Software
NOA-Estonia	2019	Audit "Effectiveness of probation supervision" (2019)	How? – Data from eight public sector databases 1. Prisoners and probationers register → probationers' personal data 2. Criminal Records Database → criminal record 2 years after probation 3. E-dossier system → criminal record 2 years after probation 4. Enforcement procedure register → debts, claims by bailiffs 5. Social services and benefits register → social services and benefits 6. Income tax register → income and the regularity of income 7. Unemployment and labor market services register → unemployment status and services provided by Unemployment Fund 8. Population register → deaths and moving abroad	What and Why? • Community sanctions such as probation are considered to be more efficient than imprisonment. • Efficiency of the probation system is measured by the rate of recidivism. Audit question was focusing on possible ways to improve the effect of probation or lower the recidivism.Offenders on probation are affected by: • the service offered by probation system: e.g., professionalism of the probation officers, readiness of the care system (material and skill related); • many other factors - such as addictions, employment, residence characteristics, other kind of services, debts, etc.	Text mining	Regression analysis and experiments of using random forest and decision tree	Probation related • The length of the probation officer's responsibility period (+) • Change of probation officers (–) • Social and rehabilitation programs (+) • Person related • Addiction problems (drugs and alcohol) (–) • Unemployment (–) • – Living conditions and cohabitation (+/–)	texta.ee

(Continues)

Organization	Year	Document title (SAIs applying technology to auditing)	Data type/scope	Goal	Technologies used	Type of analysis	Outcome	Software
ECA	2018	Identifying and visualizing tonality/emotion and geographical information in the text of ECA Special Reports using IBM Watson and Tableau	ECA special reports	Identifying and visualizing tonality/emotion and geographical information in the text of ECA Special Reports	Text mining, data visualization	Sentimental analysis (tonality and emotions)	Based on Geo-coverage based on report content (2010–2016). Chamber III seems to cover the whole world, while Chamber II is more focused on Europe and our partners, the USA, Turkey, and Russia, with respect to tonality and emotion in ECA special reports Watson identified "sadness" because we are missing things (there are deficiencies and problems), Watson identified "Disgust" as a relevant emotion, because of wastewater-related word,Joy" because followups acknowledge the results achieved words	IBM Watson, Tableau, Python
ECA	2018	EU Customs and VAT audits	SR 19/2017 SR 24/2015	Goal: NOT find all errors - assess control systems • "Are the import procedures robust?" "Are we tackling VAT fraud?	Data Visualization data Mining		Cover the whole world!	

APPENDIX B: INTERVIEW PROTOCOL (GUIDE)

Semistructured Interview Protocol (Guide)

Title: Digital Transformation and the Public Sector Auditing: The SAI's Perspective

1. **General Questions**
2. In your standing role and as an institution that champions high standards and practices for public sector auditing, what does Digital transformation mean for public sector auditing?

Follow-up questions.

(1)

a. What induces you to transform or what influences your digital transformation
b. How and when is your change process initiated In your view, what are the most promising technologies in auditing practice? And why? As an example:
c. Big data analytics
d. Blockchain and smart contracts
e. Machine learning
f. Natural language processing
g. Process mining RPA
h. What have been your experiences so far with the above technologies? What potentials do they have in public auditing?
i. Are there ongoing efforts to propose or draft regulations integrating these technologies into the auditing process?
j. Has the advent of digital transformation increased or decreased your ability to carry out effective auditing? And why?
k. What are the capacity building activities ongoing to help auditors who lack (don't have) data analytical skills, master data analytics (AI) techniques, and tools?
l. How has the digital transformation affected your (let's talk about each of them as follows)
m. IT systems
n. organizational structure?
o. Overall strategy
p. Your Audit teams' composition
q. Culture

What changes do you foresee?

1. What are the difficulties you face in implementing technological transformation and what are you doing to overcome these challenges.
2. Do you rely on data analytics, or other technologies, in making audit judgments? If yes to what extent
3. Do you believe full automation of the audit judgment process will help improve audit quality? You can explain with an illustration or example(s)
4. Given the current public sector Audit ecosystem characterized by big data (structured and unstructured data) and digital technologies, are there guidelines at your institutional level defining what information should be considered as audit evidence?
5. How are you working with different stakeholders (government, International Organizations) on big data analytics and other revolutionary technologies like AI, blockchain, etc.?