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Driving and Inhibiting Factors for Implementing Audit Analytics in an Internal Audit Function

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ABSTRACT: Internal audit function (IAF) effectiveness can be improved by embracing Audit Analytics (AA). However, despite its promises, AA implementation remains limited. Although there is research on AA implementation in general, there needs to be an overview of insight into inhibiting and driving factors for internal auditing. This paper examines those driving and inhibiting factors by exploring the literature on AA implementation. The initial search revealed 98 uniquely identified papers. Further filtering and the additional search returned 42 articles, which were analyzed in detail. The analysis resulted in 12 driving and 23 inhibiting factors, grouped into internal, regulation, data, infrastructure, and audit practice categories. The literature shows that IAF encounters multiple and intertwined factors in AA implementation and needs to anticipate those factors. Moreover, AA implementation affects IAF's parts and stakeholders differently, requiring internal and external collaboration. Building on these insights, we provide recommendations for further research.

JEL Classifications: M42; M49; O32.

Keywords: audit analytics; driving factors; inhibiting factors; internal audit.

I. INTRODUCTION

Audit analytics (AA) encompasses various forms of technology-based audits, from *continuous auditing* (CA) and some of its derivations like *Multidimensional Audit Data Selection* (MADS), to the advanced use of machine learning for fraud detection (Stippich and Preber 2016; Eulerich and Kalinichenko 2018). For this paper, we define AA as *the process of identifying, gathering, validating, analyzing, and interpreting digital data using information and communication technology to further the purpose and mission of internal auditing*. This definition is adopted from Lambrechts, Lourens, Millar, and Sparks (2011, 2) and Dai, Byrnes, Liu, and Vasarhelyi (2019, 7), with a slight modification to focus on the use of digital data and information technology for internal audit purposes. The most distinct characteristic is its ability to provide proactive and ongoing assurance. In proactive assurance, internal audit function (IAF) assists an organization in anticipating future risks and opportunities, such as through predictive analytics (Huibers 2013; Stippich and Preber 2016). Ongoing assurance can be achieved through the use of CA. AA also enables IAF to expand its service coverage (such as in operational and fraud areas), test larger samples, or even complete population data (Ames et al. 2015; Barr-Pulliam, Brown-Liburd, and Sanderson 2022). AA also allows auditors to perform audits remotely (Teeter, Alles, and Vasarhelyi 2010), which improves its advantage in the post-pandemic era. In this way, AA

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can improve IAF's effectiveness and efficiency (Bumgarner and Vasarhelyi 2018; Li, Dai, Gershberg, and Vasarhelyi 2018). Table 1 summarizes the distinction between the traditional and AA approaches.

AA can be used for both internal and external audits. This paper focuses on AA in the internal audit setting for the following reasons. Compared with external audits, which mainly engage in financial audits, an *internal audit function* (IAF) covers more areas for assurance and advisory services (Li et al. 2018). There is also a regulatory boundary for external audits, which may limit the applicability of AA (Austin, Carpenter, Christ, and Nielson 2018; Appelbaum, Kogan, and Vasarhelyi 2018). Therefore, AA for IAF can be used for a broader range of activities and have likely different inhibitors and drivers.

IAF is a vital part of any modern organization as the key governance mechanism to assure the organization's adequacy of governance, risk management, and internal control (Chambers and Odar 2015; Erasmus and Coetzee 2018). Although IAF initially focused on financial reporting, it currently serves as a part of an organization's governance and compliance mechanisms (Sarens and Abdolmohammadi 2011; Mihret 2014; Vadasi, Bekiaris, and Andrikopoulos 2019). The contemporary roles of IAF imply various challenges, in which AA may assist in addressing these challenges.

Although AA provides various opportunities, its implementation in IAF is considerably low (Cardoni, Kiseleva, and De Luca 2020; Gonzalez, Sharma, and Galletta 2012; Li et al. 2018). Hence, there is a need to understand the driving and inhibiting factors for AA implementation (Eilifsen, Kinserdal, Messier, and McKee 2020; Michael and Dixon 2019). However, there is a lack of a structured overview of those factors. Insight into these factors will lay the foundation for a better understanding of AA uptake and adoption.

Although there are also reviews in this field addressing CA (as a subset of AA) or AA in general (e.g., Appelbaum et al. 2018; Eulerich and Kalinichenko 2018; Joshi and Marthandan 2020), there is no specific literature review on factors related to AA implementation for IAF. Therefore, this paper aims to fill the void in the field by exploring the literature to gain insight into the driving and inhibiting factors in AA implementation for IAF. We expect to extend the body of knowledge in the field and develop a basis for further empirical research agenda. Moreover, we shed light on the interrelation among factors and how those factors influence AA implementation in IAF.

This paper is structured as follows: the next section presents extant literature reviews, followed by the research approach, analysis results, and discussions in Sections III, IV, and V consecutively. The paper's final section provides the conclusions, limitations, and future studies.

II. LITERATURE BACKGROUND

This section elaborates on previous literature review articles related to AA. We discuss the article's focus, method, and key insights. We also identify and briefly discuss earlier literature reviews focused on CA as the subset of AA. We include the reviews on CA to obtain relevant insight from CA as a dominant type of AA.

Some earlier literature reviews by Brown, Wong, and Baldwin (2007) and Eulerich and Kalinichenko (2018) focused on research trends in the CA-related field for both IAFs and external auditors. They categorized the research based on demand for CA, theoretical/practical focus, enabling technologies for CA implementation, implementation in audit practices, and the impact of CA implementation. Referring to the classification by Paré, Trudel, Jaana, and Kitsiou (2015), these are descriptive reviews focusing on primary studies and delivering content and frequency analysis.

Appelbaum et al. (2018) performed a literature review to identify and categorize research on AA use for external auditors in the 'analytical procedure' activity. They performed a systematic review using search strings and inclusion and exclusion criteria to select the reviewed papers. The review categorized the papers based on the analytics types and the engagement phases (in which AA is used in the "analytical procedure" part). Their findings suggested more practical research on AA use, especially for the "analytical procedure" part. Moreover, they found a lack of actual use of AA in financial audit engagement by external audits. However, their review did not specifically focus on this phenomenon. Hence, our research will focus on identifying drivers and inhibitors for AA use, specifically in internal audit activities.

TABLE 1
Comparison of Traditional and AA Approach

Aspect	Traditional Audit	AA
Time	Periodic	Ongoing (real-time/near real-time)
Coverage	Limited sample	Larger sample or even population data
Focus	Past (historic)	Present (insight) and future (foresight)

The recent literature review by [Joshi and Marthandan \(2020\)](#) addressed audit data analytics. This review investigated the benefits and challenges of incorporating Big Data for audit practices in the form of audit data analytics using a narrative review approach. The essential insight from this review was that data capture, privacy issue, and poor technology solutions are the major hindrances to the use of AA by auditors. This review also suggested investigating audit data analytics types and how these types will improve audit effectiveness. More importantly, Joshi and Marthandan argued that using Big Data for audit is a transformational opportunity and challenge for auditing professionals.

In contrast, this paper will focus on AA in general, whereas other literature reviews focus on CA. This broader point of view incorporates the various possible uses of digital data for audit purposes. It also allows for discussion on the advanced techniques of data analytics in audit activities and its implication, such as the use of advanced machine learning techniques for predictive analytics or the possibility of counter analytics to be anticipated. This paper also examines the use of AA for IAF, which provides more opportunities for broader application of the approach ([Li et al. 2018](#)). Hence, this paper complements and extends the existing literature reviews by capturing a wide range of factors related to AA implementation by IAF, encompassing technical, organizational, and social aspects, to lay the ground for further and more detailed examinations of the factors to assist the actual implementation of AA.

III. RESEARCH APPROACH

Literature Review Design

This paper reviews the literature to gain insight into the driving and inhibiting factors in AA implementation (in its various forms), especially with relevance to IAF. A literature review generally consists of three main phases, i.e., planning, conducting and analyzing, and reporting ([Kitchenham and Charters 2007](#); [Morioka and de Carvalho 2016](#); [Petticrew and Roberts 2006](#); [Snyder 2019](#); [Thomé, L. Scavarda, and A. Scavarda 2016](#); [Wahono 2015](#)).

The planning phase is crucial as it defines and formulates the review research questions and protocol. It includes setting explicit criteria to select the appropriate literature and developing a methodology to analyze the resulting literature. The next phase is literature identification and selection, extraction, and analysis to answer the review question based on the predetermined review strategies ([Kitchenham and Charters 2007](#); [Rouhani, Mahrin, Nikpay, Ahmad, and Nikfard 2015](#)). This phase also identifies literature from the relevant databases, including the application of search string and metadata recording and analysis based on the developed analysis strategy and evidence synthesis. The final facet is to disseminate the result either as a part of the study (e.g., dissertation) or as an independent academic work (e.g., paper).

Literature Review Questions

Research on AA has covered many important aspects, including drivers, issues, tools, and types of AA implementation ([Eulerich and Kalinichenko 2018](#); [Joshi and Marthandan 2020](#)). Nevertheless, there is a need to unravel the driving and inhibiting factors, which represents in the following research questions:

RQ1: What are the driving factors of AA implementation in IAF?

RQ2: What are the inhibiting factors of AA implementation in IAF?

Search Strategy

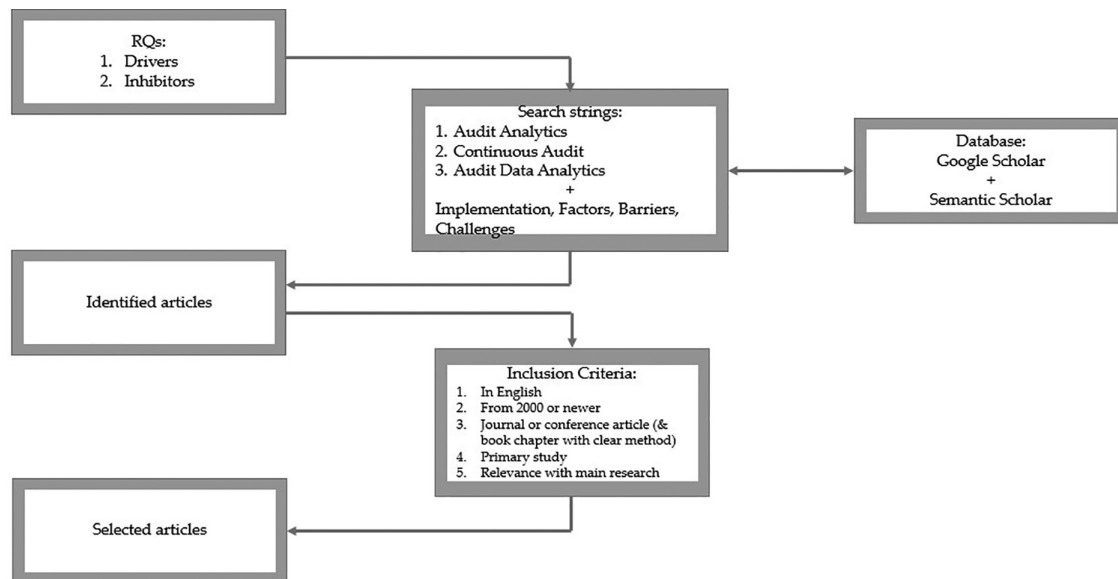
The search strategy aims to ensure relevant studies are retrieved to achieve its objectives ([Thomé et al. 2016](#)). It consists of a database as the source of papers extracted, search strings, and inclusion (and exclusion) criteria. [Figure 1](#) visualizes the search strategy.

This paper utilized the Google Scholar database to provide a wide range of research and study results on AA implementation. This approach assisted in ensuring the comprehensiveness of the search results. One might argue that Google Scholar deliverable varies in quality, which may affect the result. Nevertheless, [Tober \(2011\)](#) suggests that Google Scholar indexes most important papers across disciplines. Furthermore, this paper addresses the possible limitation through inclusion and exclusion criteria.

This paper used a search strings approach with the following keywords to extract studies from the Google Scholar database:

- (1) “Audit Analytics” is the umbrella term that encompasses all practices, including continuous audit, predictive analytics, and other technology and digital data in internal audit practices;
- (2) “Continuous Audit” is used as the initial term for the use of digital data for real-time or near real-time audit; and

FIGURE 1
Literature Search Strategy



- (3) “Audit Data Analytics” is used to emphasize the use of technology in audit practices (Barr-Pulliam et al. 2022; Krieger, Drews, and Velte 2021).

Each keyword was used on its own or combined with “implementation” to capture the study of “real-world” AA practices (e.g., has been or is being implemented). Moreover, each keyword was combined with “factors,” “barriers,” or “challenges”; to align with the research questions. These keywords resulted in 15 search strings. This approach helps to improve search results’ relevance (vom Brocke et al. 2015). In addition, we search the article from 2000 onwards to balance the coverage of the studies and their relevance with the current progress of AA. This choice considers that the AA field has been progressing significantly; hence, the driving and inhibiting factors from an older era (older than 2000) might have limited relevance to the future development of this field.

The initial list was assessed based on the following inclusion criteria:

- (1) Only papers written in English are considered;
- (2) Only including papers from journals and conferences. Book chapters were only included if they clearly stated their research method;
- (3) Focusing on primary studies to obtain factors reflecting real-world practice obtained from those studies; and
- (4) Analysis of relevance (as suggested by vom Brocke et al. 2015) to ensure the paper retrieved examine AA practices.

The article included studies of AA in the internal audit field or general audit with relevance to internal audit activity.

In addition, we calibrated the initial result through additional search using an alternative tool and method. In addition to Google Scholar, Semantic Scholar (using Research Rabbit) was used for the additional literature search. Furthermore, the string keywords search was complemented by snowballing from one of the key articles in the field (i.e., Li et al. 2018). This additional search ensured that all related works were considered.

Selecting literature is crucial as it addresses the need to balance coverage and depth of analysis from the selected papers (Morioka and de Carvalho 2016). The strategy presented in this section aimed to ensure the selection of appropriate literature, as this will affect the next steps of the review and its result.

Analysis and Synthesize Strategy

The analysis started with a descriptive analysis to provide an overview of the selected literature by providing general information, such as journals/publishers, types of publication, year of publication, or authors (Snyder 2019). It provided information about the landscape of the literature in the field.

The next step was to perform a detailed analysis to answer the research questions based on data and information extracted (from the selected studies). This phase aimed to answer the questions using the data collected. In this step, we elaborated on driving and inhibiting factors in the AA implementation, including common themes, similarities, and differences from each study. This approach resulted in a taxonomy of driving and inhibiting factors identified from various literature in AA-related research.

Furthermore, this paper extracted information based on the explicit narration as well as implicit insight provided in the articles. This paper obtained relevant notions from the articles to identify the driving and inhibiting factors. Driving factors are generally started or followed by narration on why auditors (or audit units) are encouraged, driven, or (for instance) enforced to digitalize their audit practice. In contrast, inhibiting factors are commonly preceded or followed by explaining the hurdles to using audit analytics. Further, the first step's results were grouped to develop a "factor." For instance, narrations that mention investment or funding requirements to develop and utilize analytics were grouped as investment/funding factors. The analysis results list is presented in tabular format, as shown in the following sections.

We grouped the identified factors into five categories, i.e., internal factors, regulation, technology (infrastructure and data), and audit practice. The categories were adapted from categories in the previous literature reviews (i.e., Brown et al. 2007; Eulerich and Kalinichenko 2018), with slight modifications. Internal factors refer to factors related to the organization's operation or within the scope of authority of the organization (to which IAF belongs). In comparison, regulation refers to factors that are forced by authoritative entities. Although the initial description focused on the legal aspect, this paper extended the description of regulation to include less formal types, such as standards or guidelines related to audit activities. Moreover, we split technology into two categories for more detailed analysis, i.e., infrastructure that deals with (IT) hardware and software and data that represent digital data for AA purposes. Another category is audit practice which refers to factors related to audit activities, which in the previous reviews comprised external and other factors.

The selected studies contain mainly primary studies to gain insight from the real-life practice of AA. This paper included concerns, potential issues, or prerequisites anticipated by the authors or participants of the articles being reviewed.

Selection and Analysis Process

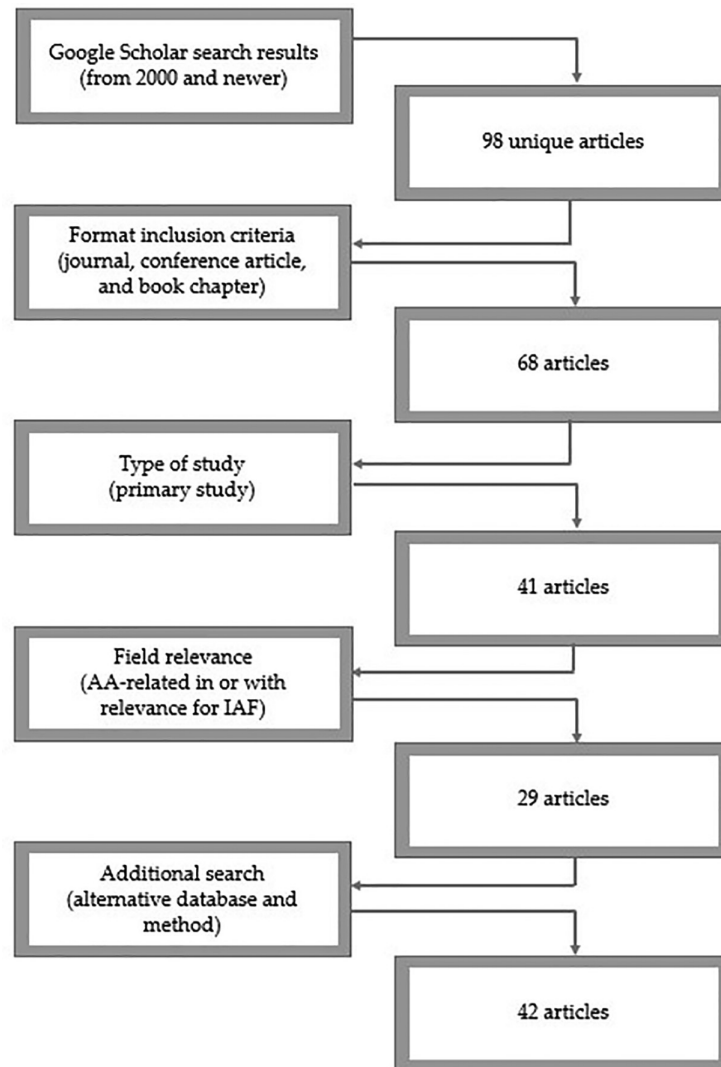
We performed our initial search from June 26 to 28, 2021. The initial search resulted in 118 articles, with some appearing more than once during the search process—further examination resulted in 98 uniquely identified articles. Moreover, we calibrated the initial search with an additional search using an AI-based tool and snowballing method (on October 18 and December 1, 2022). Figure 2 visualizes the filtering process of the identified articles.

The initial search results (98 articles) indicated a notifiable increase in AA-related articles since the mid-2010s, in contrast to the search result from Eulerich and Kalinichenko (2018) work, which showed relatively consistent results from 2001 to 2014. This difference might come from different search strings employed between this paper and their study. Since their study focused on CA, they used terms related to CA such as "continuous auditing," "continuous monitoring," or "continuous assurance," which are more popular terms, including in the guidelines for internal auditors (Coderre 2005; Ames et al. 2015; Lambrechts et al. 2011). Conversely, our work used the terms "audit analytics" and "audit data analytics" (besides "continuous audit") to obtain broader insights into audit practices. The term "analytics" has increased its popularity in internal audit literature since 2016 when the IIA published its working paper on data analytics (i.e., by Stippich and Preber 2016). Although less popular (especially in the early 2000s), this terminology is relevant for our search string, considering the prevalence of digital data and information technology enables more advanced techniques like predictive and prescriptive analytics as a part of AA. Moreover, this result also suggests that our work extends the discussion in the field by expanding the scope of analysis to cover not only CA but other types of analytics for audit purposes.

We excluded thirty of the initial result articles for not meeting the inclusion criteria to be published in academic research, like in the form of commentary or course material. Subsequently, 27 articles were excluded for not being a primary study. Furthermore, 12 articles were left out for their lack of relevance to this paper's objective, e.g., study on medical technology, accounting education, or programming language, resulting in 29 articles. Thirteen relevant articles were added based on additional searches using a different database (Semantic Scholar) and technique (snowballing). Finally, 42 articles were included in the final analysis. The analysis, findings, and discussions in the subsequent sections of this paper refer to the 42 articles as presented in Appendix A.

Furthermore, the authors iteratively discussed the identification, development, and narration of the factors throughout the development of this paper to minimize bias in the analysis processes and results. We also discussed other details like the categorization of the factors and the method in the reviewed papers. From the discussion, we changed the

FIGURE 2
Literature Search Process



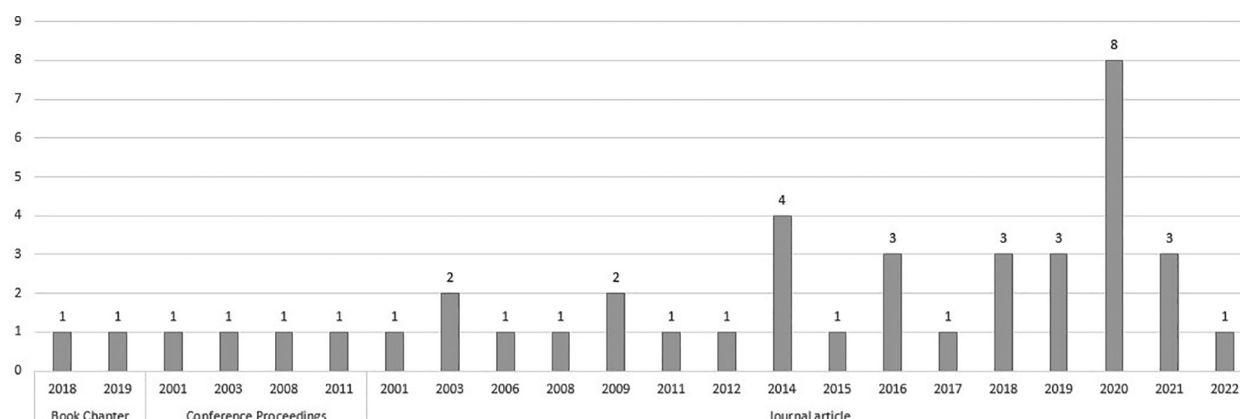
categories from using arbitrary terms to referring to the existing categories from the extant reviews. Moreover, we had to interpret the research methods of some papers which did not mention the method explicitly. For example, some papers were classified as design science research (DSR) as they followed the research steps that resemble relevance, design, and rigor cycle in DSR (e.g., [Dai et al. 2019](#); [Kearns, Barker, and Danese 2011](#); [Wang and Kogan 2020](#)). Papers mentioning the use of quantitative and qualitative analysis were classified as mixed-methods research (e.g., [Van der Nest, Smidt, and Lubbe 2018](#)).

IV. RESULTS

Descriptive Analysis

The studies gathered for the analysis cover twenty-one years of research, from 2001 to 2022. Most selected articles are from journal papers, whereas less than 15 percent originate from conference proceedings and book chapters, as visualized in [Figure 3](#). Moreover, the articles analyzed employ various research methods such as case studies, experiments,

FIGURE 3
Distribution of Articles Based on the Year and Type of Publication



design science research, and simulation. These various methods support the strength of gathered insights for analysis in this paper. However, some studies do not clearly state their research methods, and we had to interpret the text. Table 2 displays the categorization of articles based on the publication type.

One of the indicators of the quality of a study is the “cite count,” which shows how often an article is cited in other research. Nonetheless, it is also important to note that the number (of cite-count) will typically increase over time. Hence, older articles expect to have more cite-count than newer ones. In this review, articles published in 2016 and newer were cited 20.8 times on average, with the exception of the paper “Understanding usage and value of audit analytics for internal auditors: An organizational approach” by Li et al. (2018), which cited 126 times. In contrast, older articles (published in 2015 or older) were cited 110.5 times on average, with most of those cited at least 29 times (15 out of 18). Older articles have had a longer time period to be cited and likely receive a higher number of citations. According to the “cite count,” the selected articles are adequate to be included.

We also mapped the selected articles to see the relationships among them. Some key literature was included in the selection, indicated by the connections with many other selected articles as shown in Figure 4. However, some more ‘independent’ papers were also included, which we believe will enhance the insight and discussion for this paper.

Findings

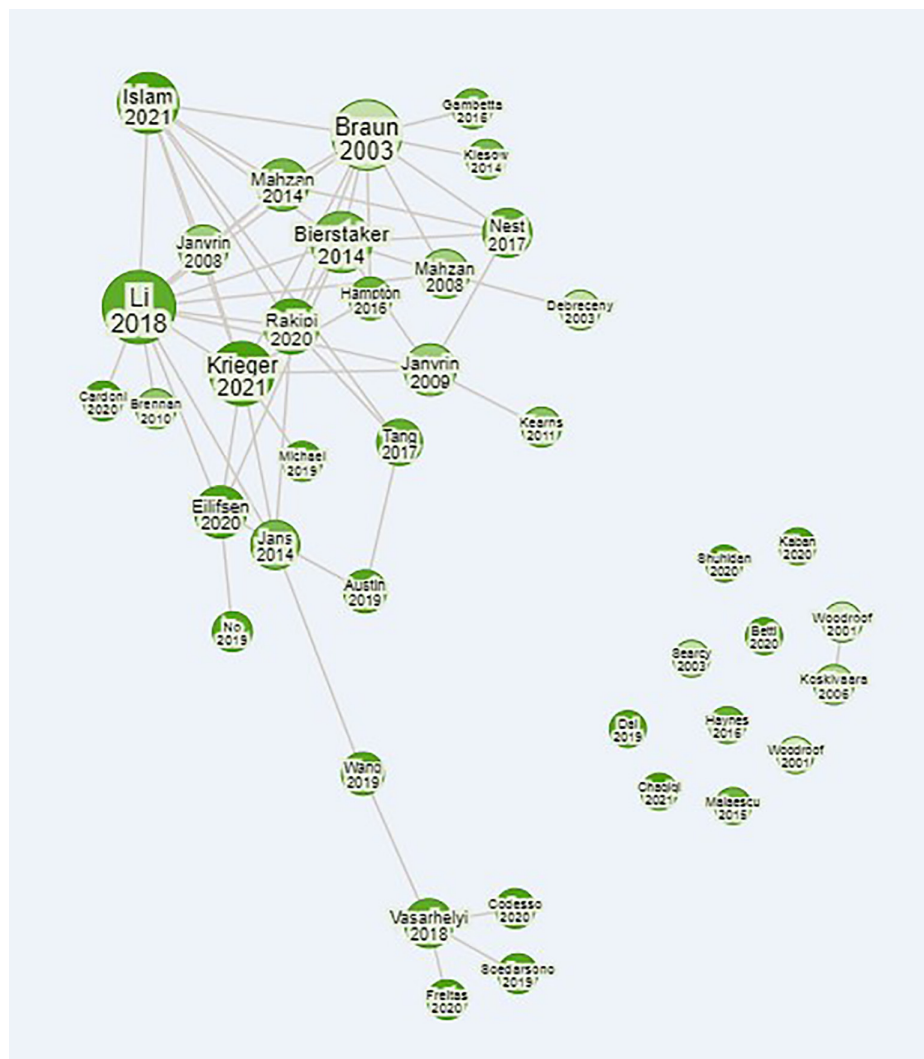
RQ1: What Are the Driving Factors of AA Implementation?

We identified 12 driving factors for AA implementation identified in the articles, as presented in Table 3. There are three dominant factors stand-up among others with more than ten times emergence in the selected articles, i.e., digital

TABLE 2
Distribution of Articles Based on the Type of Publication

Type of Publication	Count	Lit IDs	Examples
Book chapter	2	2, 18	- Continuous auditing: Theory and application, Emerald Publishing Limited. 2018 - Rutgers studies in accounting analytics: Audit analytics in the financial industry. Emerald Publishing Limited. 2019
Conference	4	3, 17, 19, 41	- 36th Annual Hawaii International Conference on System Sciences, 2003 - Proceedings of the 11th European Conference on e-Government. 2011
Journal article	36	1, 4–16, 20–40, 42	- <i>International Journal of Accounting Information Systems</i> - <i>Journal of Information Systems</i> - <i>Journal of Emerging Technologies in Accounting</i>

FIGURE 4
Mapping of the Reviewed Articles



(The full-color version is available online.)

data (ID 6, appears in 22 articles), limitation of traditional audit practices (ID 3, 20 articles), and the stakeholder's expectation (ID 4, 12 articles). Another driving factor often emerged is computing power (ID 5), which appears in 10 articles.

These often-mentioned driving factors indicate that IAF faces “pressures” both from internal factors within its control and external factors outside its authority, as suggested by, for example, [Hampton and Stratopoulos \(2016\)](#). On the one hand, IAF may have limited influence regarding data-related factors like the growth of digital data resulting from business process digitalization (IDs 6 and 10). Hence, IAF is *enforced* to improve its service delivery to keep up with the digitalization of its client. On the other hand, internal factors, such as the possibilities enabled by more advanced technologies (IDs 1 and 2), allow IAF to respond to those external pressures.

Some driving factors emerge only a few times from the articles, like optimization of IAF's resources (ID 2), regulatory (ID 7), business complexity (ID 9), and the trend in Big Data Analytics (BDA or DA) (ID 10). However, the trend of BDA use by organizations and the publication by IIA on the use of DA for internal audit may further drive the use of AA by IAF in the future despite their less emergence in the literature. This suggestion has been strengthened by the rise

TABLE 3
Identified Driving Factors from the Selected Literature

ID	Category	Driving Factor	Description	Count	References (Lit ID) ^a
1	Internal	Investment in IT	Organization's financial and nonfinancial spending in its effort to improve its IT system.	6	1, 13, 21, 27, 35, 37
2	Internal	Optimization of IAF's resources	Utilization of IAF's financial and nonfinancial resource allocation, including in its effort to enable data-driven audit practices, e.g., provision of AA tools, and relevant training for auditors.	(5) ^b 4	1, 7, 21, 38, ^b 42
3	Audit Practice	Limitation in current/traditional audit practices	Limitation of traditional audit practices OR the possibility offered by AA to handle current challenges and meet current expectations, e.g., difficulty in handling a large amount of data, difficulty in delivering more timely assurance.	20	2, 3, 4, 6, 9, 10, 12, 15, 17, 22, 23, 27, 28, 30, 31, 34, 35, 36, 38, 41, 42
4	Internal	Stakeholder's expectation	Demand from various stakeholders of IAF (e.g., board, management/client, and regulator) for IAF to deliver better services (in terms of quality or timeliness).	12	2, 6, 7, 14, 15, 16, 17, 20, 25, 26, 29, 32
5	Technology-Infrastructure	Computing power	Increased data processing capabilities supported by current (information) technology.	10	3, 8, 10, 12, 13, 15, 17, 18, 21, 31
6	Technology-Data	Digital data	(Large) amount and stream of data provided by the digitalization of business processes or from other sources (e.g., social media) relevant to analysis and testing pertinent to audit practices.	22	3, 4, 5, 6, 7, 8, 10, 11, 13, 17, 19, 20, 21, 23, 27, 29, 30, 33, 34, 35, 39, 41
7	Regulation	Regulatory/mandatory	Requirement by regulation (either pertaining to IAF, selected country/region, or industry-specific) implies the need for the IAF to utilize AA.	(5) ^b 3	8, 12, ^b 25, ^b 32, 36
8	Internal	Stakeholder's support	Support from stakeholders of IAF (e.g., board, management/client, or regulator) to assist IAF in delivering better services, such as in the form of data provision, or joint analytics projects.	1	9
9	Audit Practice	Business complexity	Increased interrelation of business process and activities (enabled by IT), forcing IAF to improve its practices to fulfill its mission.	8	18, 24, 29, 30, 35, 39, 41, 42
10	Technology-Data	(Big) Data analytics trend	Growing trend to involve and utilize (Big) Data Analytics in business processes, including the use of analytics by IAF in audit practices.	9	25, 26, 31, 33, 34, 37, 40, 41, 42
11	Internal	Data and IT-related knowledge in IAF	General knowledge within the IAF's personnel of key information technology risks and controls and available technology-based audit techniques to perform the assigned work.	1	32

(continued on next page)

TABLE 3 (continued)

ID	Category	Driving Factor	Description	Count	References (Lit ID) ^a
12	Internal	Knowledgeability of CAE	The CAE's (IAF's leader) critical thinking, business savviness, and awareness on the potentials and risks regarding information technology for IAF's purpose.	1	32

^a Refer to Literature ID in [Appendix A](#).

^b The articles refer to circumstances pertinent to external auditors with relevance for IAF.

of AA-related publications since 2016. In addition, internal awareness (IDs 11 and 12) also started to emerge as one of the possible drivers of AA use in IAF activities.

Moreover, although many articles mention stakeholders' expectation for better services by IAF (which directly or indirectly drives IAF to utilize AA), only one article mentions stakeholders' support as a possible driving factor (Codesso, de Freitas, Wang, Carvalho, and da Silva Filho 2020). This finding is alarming and might need to be considered in AA implementation since it will require support from stakeholders, like in most technology diffusion processes (Krieger et al. 2021; Austin et al. 2018). This issue will be further elaborated on in the following subsection and subsequent sections.

A higher factor occurrence does not imply a more significant factor's magnitude. In the context of this review, the appearance of driving factors informs about the drivers anticipated by authors of the studies regarding AA implementation. Therefore, further empirical studies might be needed to assess these driving factors' significance.

RQ2: What Are the Inhibiting Factors of AA Implementation?

One of the most intriguing facets of AA is that despite its lauded benefit, the implementation of this approach is relatively slower than anticipated (Cardoni et al. 2020; Eulerich and Kalinichenko 2018; Krieger et al. 2021; Li et al. 2018; Wang and Cuthbertson 2015). This contradiction indicates challenges to AA implementation in audit practices.

In total, 23 inhibiting factors were identified and classified into five categories, as listed in Table 4. Four inhibiting factors have the most occurrences. The auditor's competence issue (ID 4) is found to be the most frequent and mentioned in 25 articles, followed by high investment requirement (ID 1) and dynamics in the audit process (ID 3), with the appearance in 18 studies, respectively. Another challenging issue is the data access issue (ID 12). Although the internal factor (i.e., limitation in auditor competence) is the most concerning inhibitor, the subsequent three inhibitors represent external factors that are not necessarily within the authority of IAF (or the Chief Audit Executive (CAE),¹ in this matter) to solve. Therefore, this implies the importance of stakeholders' support, which, unfortunately, is the less apparent driving factor in AA implementation (see Table 3).

Conversely, some inhibitors get less attention, like independence impairment (ID 19), counter analytics (ID 20), or the need for aid (specifically consulting services from external consultants) to assist IAFs in developing AA (ID 22). However, these inhibiting factors' lack of appearance does not imply they are less critical or require less attention. This notion, at most, indicates that these are less observed in AA discussions. However, the discussion of each challenge's magnitude is beyond this paper's scope.

V. DISCUSSION

This section discusses the insight generated from this paper's findings presented in the previous segment. The section consists of further elaboration on the results of the literature review related to the answer to the research questions.

Relationships among Factors

Although presented individually, factors intertwine and might simultaneously influence AA implementation. For instance, IAF experiences the growth of digital data in the organization, which exacerbates complexities in performing IAF tasks while at the same time facing the limitations of its current practices (e.g., Dai et al. 2019; de Freitas, Codesso, and Augusto 2020). This finding exemplifies the notion that IAF faces multiple factors and needs to anticipate many pressures. Therefore, the AA field will benefit from research examining these intertwined driving and inhibiting factors, which expect to answer the most critical factors that require IAF's attention. Moreover, building from that, research to examine generalized principles in response to the priority of the driving factors and to tackle challenges is also a promising endeavor.

Moreover, some contrasting findings between AA implementation's driving and inhibiting factors are worth further discussion. For instance, on the one hand, high IT investment is one of the driving factors for AA implementation (Austin et al. 2018; Haynes and Li 2016; Brennan and Teeter 2010; Michael and Dixon 2019), whereas on the other hand, IAF faces inadequacy of auditor's competence as one of the significant hurdles to utilizing AA (e.g., Cardoni et al. 2020; Michael and Dixon 2019; No, Lee, Huang, and Li 2019). In this regard, there should be possibilities to direct some of the investment to improve human capital for IT, business, and include internal auditor personnel.

Another example is that stakeholders expect IAF to provide ongoing assurance or use a larger sample (e.g., Chaqiqi and Nugroho 2021; Koskivaara 2006; Rakipi, De Santis, and D'Onza 2021), whereas conversely, data access to respond

¹ CAE might come in various terms. Nevertheless, in this regard, CAE refers to the head of IAF.

TABLE 4
Identified Inhibiting Factors from the Selected Literature

ID	Category	Inhibiting Factor	Description	Count	References (Lit ID) ^a
1	Internal	Investment/funding requirement	AA implementation in assurance activities requires financial commitment (including cost-benefit consideration), such as for tools/infrastructure, training, including outsourcing AA for an engagement.	18	1, 5, 7, 8, 9, 10, 13, 16, 18, 19, 20, 22, 24, 25, 30, 33, 34, 38
2	Regulation	Inadequate (internal) audit standard/guidance	Lack of (internal) audit standard and its derivation, including guidelines or procedures; which inform how (internal) audit perform/conduct the use of AA in an assurance engagement, including the impairment in independence and objectivity and how to mitigate it.	(5) ^b 3	1, ^b 5, ^b 25, ^b 29, 42
3	Audit Practice	Dynamics in audit process	Problems due to unclear interaction mechanism and dynamics in interaction between the auditor, client, and other stakeholders in an assurance engagement (or other activities related to it), including the use of AA.	18	1, 5, 7, 8, 10, 11, 13, 17, 18, 19, 20, 24, 25, 29, 30, 32, 35, 36
4	Internal	Limited auditor's competence	The limitation of (internal) auditor's ability to perform the necessary task (e.g., obtain business understanding in IT-based environment, scripting, statistical knowledge) to use AA in an engagement.	25	1, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 22, 24, 26, 29, 33, 34, 36, 39, 40, 41, 42
5	Internal	Inadequate number of auditors (for AA implementation)	Inadequate numbers of IAF's personnel with skill and knowledge to perform AA-related tasks in an engagement.	4	8, 17, 29, 32
6	Audit Practice	Limited AA use-case	Limited audit analytics use case to be developed and performed in an assurance engagement, which includes the objectives, analysis techniques, and data requirement.	5	5, 9, 16, 25, 32
7	Internal	Conflict in stakeholder's interest	Problems due to varieties among the related parties' (such as the board, management or audit client, or IT division) perception, preferences, support, and interest (which within their respective authorities) on the use of AA by IAF in an engagement.	4	1, 8, 17, 36
8	Audit Practice	Potential bias	Risk of bias in the AA results resulting in skepticism from the auditors, clients, or other IAF's stakeholders (e.g., model bias due to limited training data for predictive analytics, or conclusion derived from incomplete data).	2	3, 5
9	Internal	Cultural readiness	Limited organization's and IAF's (including its personnel) awareness of the importance and benefit of AA (in delivering IAF's mission) and commitment to do the necessary process to adopt AA.	7	1, 17, 18, 21, 29, 35, 41
10	Technology-Infrastructure	Limited infrastructure capability	Limited ability of an organization's IT infrastructure and system to enable AA in assurance engagements, such as to facilitate: data exchange and sharing process, or analysis and computational task to a large amount of data.	6	11, 12, 21, 22, 29, 31

(continued on next page)

TABLE 4 (continued)

ID	Category	Inhibiting Factor	Description	Count	References (Lit ID) ^a
11	Technology-Data	Data unavailability 1—Capture	Unavailability of data in the digital form required for AA within an organization's data ecosystem (including database or data warehouse) which is captured by the organization's business application.	3	1, 10, 18
12	Technology-Data	Data unavailability 2—Access	Unavailability (including authorization, approval, and provision in any means) of digital data for the auditor to collect, evaluate, and analyze in the context of AA.	14	1, 3, 5, 7, 10, 11, 13, 17, 18, 19, 20, 24, 28, 29
13	Technology-Data	Data security	Concern regarding data confidentiality, ^c i.e., ensuring data is accessible only to those with proper authorization; this concern might affect data exchange among business/data owners and including IAF.	3	13, 15, 30
14	Technology-Data	Data inaccuracy	Data does not represent the object (such as an event, transaction, or item details) in an error-free (or within the acceptable level of error) manner.	7	1, 2, 5, 7, 24, 28, 39
15	Technology-Data	Data incompleteness	Data is not completely representing the object (such as an event, transaction, or item details) or that some objects are unrepresented in the data.	2	24, 28
16	Technology-Data	Varieties of data format	Different types of data format and platforms with its own specific characteristics which will affect how to process (collect/extract, evaluate, cleanse, and analyze) the data, including in this regard for AA implementation.	6	1, 4, 17, 22, 29, 41
17	Technology-Data	Huge data volume	The huge size of data which will affect how to store, exchange/transmit, and process the data, including in this regard for AA implementation.	2	2, 5
18	Technology-Infrastructure	Unavailability or limited AA tools	Unavailability or limitation of software (IT application, including the required software) capable of performing AA-related tasks, including data extraction, cleansing, evaluation, and analysis.	3	15, 17, 26
19	Regulation	Independence impairment	Possibility of AA-related tasks in assurance or consulting engagement affecting IAF's (or individual auditor's) independence and objectivity.	2	1, 32
20	Audit Practice	Counter analytics	Possibility of limitation in analytics result (especially for fraud detection) if the perpetrator understands how analytics work.	1	1
21	Internal	Organization and business complexity	Problems due to complex organizational structure and business process (including IT system complexity and variations) influencing the effort required to implement AA in an engagement.	6	10, 13, 17, 21, 30, 38

(continued on next page)

TABLE 4 (continued)

ID	Category	Inhibiting Factor	Description	Count	References (Lit ID) ^a
22	Internal	Limited aid in development process	Development of innovation requires practical aids, such as in the form of the implementation framework, an example from a success story, or consulting services. Although not mandatory, these aids assist in innovation diffusion, such as in AA implementation by IAF.	3	9, 39, 42
23	Audit Practice	Audit team dynamics	Challenge due to the dynamics in the interaction among auditors within audit team in an audit practice (or other related activities, including the use of AA), such as task assignment or sharing, or internal communication.	2	13, 28

^a Refer to Literature ID in [Appendix A](#).

^b The articles refer to circumstances pertinent to external auditors with relevance for IAF.

^c In most references, data security often refers to confidentiality, integrity, and availability (known as CIA triad). Nevertheless, in the context of this paper, security particularly refers to confidentiality as integrity and availability are discussed as separate issues. Moreover, confidentiality includes privacy issue.

to the expectation is still becoming one of the issues (e.g., [Chaqiqi and Nugroho 2021](#)). The increasing concern for privacy and confidentiality might be one of the possible culprits for this problem. In this regard, concern with the security of their data limits the data access for parties outside their business units. Therefore, addressing security issues *might* also benefit addressing data access problems. This circumstance might be applied to other challenges, i.e., addressing one challenge might assist in solving another. However, this premise is beyond the scope of this paper and requires deeper investigation.

New and Possible Future Issues on AA Implementation

Some earlier literature reviews intentionally discussed factors related to CA ([Brown et al. 2007](#); [Eulerich and Kalinichenko 2018](#)), whereas others focused on other aspects of AA ([Appelbaum et al. 2018](#); [Joshi and Marthandan 2020](#)). These reviews provided insight into driving and inhibiting factors relevant to this research. Some factors were mentioned in those reviews, like the limitation of the traditional approach/opportunity of AA or stakeholders' demand, which drive IAF to implement AA (or CA), and the limited skills and high cost/investment which inhibit AA (or CA) implementation. Nevertheless, our review found some additional crucial factors, like the importance of CAE's awareness to drive AA implementation in IAF; or the possibility of IAF's independence impairment, unclear use-case, and counter analytics as inhibitors.

Some factors only emerge in a few articles, and some even in only one (article). It might be because those factors arose just recently due to the recent advancement of AA in audit practices. Therefore, these factors are fruitful for further studies. For instance, the emergence of predictive and prescriptive analytics ([Stippich and Preber 2016](#); [Austin et al. 2018](#)) enables IAF to provide foresight, i.e., predict the future rather than merely evaluate the past, to direct management's decision. Using these techniques might obscure the barrier between assurance and consulting services, impairing auditors' independence ([Austin et al. 2018](#); [Betti and Sarens 2021](#)). These techniques also generate challenges for IAF to develop relevant AA use-case specifically relevant for audit purposes ([Krieger et al. 2021](#); [Codesso, de Freitas, Wang, de Carvalho, and da Silva Filho 2020](#); [Malaescu and Sutton 2015](#); [Islam and Stafford 2022](#)) instead of emulating business units' analytics. Another intriguing issue is the possibility of counter-analytics ([Austin et al. 2018](#)), which requires IAF to mitigate this risk in advance in developing its AA capabilities.

Moreover, the number of studies on AI outside a specific field, like healthcare, that considers organizational factors are relatively limited ([Cubric 2020](#)). Therefore, we encourage empirical research to explore AA approaches or techniques (e.g., as exemplified in the study by [No et al. 2019](#); [Yoon, Liu, Chiu, and Vasarhelyi 2021](#)), and the use of advanced AI techniques for predictive analytics for audit purposes. Such approaches should consider organizational and regulatory factors and newly emerged challenges like implication on IAF's independence or the possibility of counter-analytics. This type of research may use insight from similar research in a different field, such as the use of BDA for crime prevention (e.g., as exemplified by [Chauhan and Aluvalu 2016](#); [Craja, Kim, and Lessmann 2020](#)).

Another less-concerned driving factor that emerges from the literature is the regulatory requirement. This phenomenon aligns with the inhibiting factors, in which regulatory-related issues in the IAF context appear only in one literature source ([Chaqiqi and Nugroho 2021](#)). Although there are publications from IIA regarding this matter ([Ames et al. 2015](#); [Coderre 2005](#); [Lambrechts et al. 2011](#)), its use is more as a suggestion rather than a binding standard. These findings imply that regulatory requirements in the IAF environment might be less rigid than in the external audit setting, especially in financial audits ([Li et al. 2018](#)). For instance, the lack of clear standards renders external audit firms uncertain whether AA provides acceptable evidence for financial audits ([Austin et al. 2018](#); [Eilifsen et al. 2020](#); [Krieger et al. 2021](#)), whereas this issue might not necessarily apply to IAF's context. This rather loose regulatory context offers the opportunity for the IAF to explore the possibility of AA for the IAF. In addition, research to propose a regulatory framework will also benefit AA's academic and practical realms.

Those factors' lack of appearance does not imply that they are less critical or require less attention. The assessment of each challenge's magnitude is beyond this paper's scope. Therefore, in addition to research on the prioritization of inhibiting factors, as mentioned earlier, we suggest an empirical examination of the effect of the factors on AA implementation and empirical research to explore AA approaches or techniques for further research.

Technological factors such as information technology/infrastructure and data, facilitate the advancement of AA. Nevertheless, our findings suggest that the newly emerged issues are also related to other categories of factors (regulation and audit practices). This notion implies that the regulation and the audit practice aspects need to catch up with the rapid advancement of technology. Practitioners and academics may have to anticipate that these categories of factors will have to adapt quickly as technological factors keep progressing rapidly.

Different Perspectives among Different Actors

One of the key motivations for this paper is that the implementation of AA is lower than anticipated despite its promised benefits. One of the possible explanations, which has been discussed elaborately in the previous sections, is that factors are hindering IAF from utilizing AA and realizing its benefits. However, the traditional approach's possible hidden advantages may also inhibit AA implementation.

In the previous sections, we discussed the drivers and inhibitors for AA implementation by IAF. This concern might build from agency theory, in which IAF serves as the intermediary to resolve conflicting interests between principals and agents (Adams 1994; Rakipi et al. 2021). Nevertheless, an alternative lens exists to view this relationship, i.e., through *multiple-agency theory* or *stakeholders theory*. These theories imply that an organization (i.e., the IAF) might face multiple collective action problems due to (competing) interests of various stakeholders under joint service delivery (Spiller 1990; Spiller and Urbiztondo 1994; Voorn, Genugten, and Thiel 2019). In this case, although it is true that IAF serves the highest rank in the organizations, IAF also serves other parties in the organization as its clients through assurance and consulting services. In addition, IAF may indirectly serve external parties of the organization, e.g., regulators, through mandatory assurance. The influences from various actors from the inside and outside of the organization indicate the need to incorporate those actors' views in IAF's activities, including AA use.

The alternative lens above shows the reason for the seemingly opposite stances of IAF's stakeholders. In this regard, there might be competing interests among different stakeholders. For instance, although the board expects accurate and timely audit results which can be delivered using the AA approach, the business process owner's primary concern might be to exercise their authority on data security (Haynes and Li 2016; Koskivaara 2006) or the system's performance to serve the business process (Kearns et al. 2011; Debreceeny, Gray, Tham, Goh, and Tang 2003). In addition, there might be different perspectives on the significance of the issues between different levels of actors. For instance, executives might see strategic opportunities or challenges as essential for AA implementation. Conversely, employees on the operational level might be more concerned about data accuracy or infrastructure capability.

Less than half of the 12 identified driving factors emerge from the IAF, whereas three out of the top four inhibiting factors are external. The significance of external driving and inhibiting factors indicates the need for IAF to respond carefully and anticipate its environment concerning AA implementation. Therefore, the implementation of AA will not only address IAF's needs but also acknowledge the stakeholders' concerns. Furthermore, considering the possibility of a different impact on a different part of the IAF, we suggest that empirical research identifies the perceived impact of the challenges on each part of the IAF as an organization.

The examples and discussions above reveal the different perceptions of *the benefits* of the traditional approach, not only from the organization's perspective but also from the audit client's perspective. Using agency theory, some of these examples are the primary reason IAF is needed, i.e., to bridge the conflicting interest between the board as the principal and the business process owner as the agent. Conversely, in multiple-agency theory, these examples inform IAF to consider other stakeholders' concerns. In this regard, IAF's actions often require cooperation and assistance from those other stakeholders and, ultimately, aim to benefit those stakeholders as well.

Finally, from the findings related to driving and inhibiting factors of AA implementation, we can infer that the AA implementation and the realization of its benefits go beyond the scope of the authority of IAF (i.e., CAE, the auditors, and the relevant divisions in IAF). External stakeholders need to be taken into account when investigating the AA implementation. In this regard, we are also aware that an organization's decision-making is not always a rational process and follows information logic (e.g., as exemplified by van der Voort, Klievink, Arnaboldi, and Meijer (2019) in a public organization setting). Therefore, there is an urgency for collaboration with related parties (Haynes and Li 2016; de Freitas et al. 2020) to tackle those challenges.

VI. CONCLUSIONS, LIMITATIONS, AND FUTURE RESEARCH

Conclusions

Internal auditing is struggling with the implementation of AA, as they are confronted with many diverse stakeholders and various functions for which it can be used. This paper has identified 12 driving and 23 inhibiting factors for AA implementation. IAF encounters many intertwined factors in the AA implementation effort. Some factors originate from the internal audit function and its environment, and some are beyond the scope of the IAF's authority. Our analysis also suggests that AA implementation affects IAF's stakeholders and parts differently. It can be seen from differing concerns between the governing body and audit client or between IAF's executive and operational layers. Hence, stakeholder management approaches are recommended to move forward in implementing AA. The implementation of AA

should involve various parts of IAF and incorporate different considerations from different stakeholders. For implementing AA in IAF, an internal stakeholder approach alone is not sufficient, and external stakeholders should be involved.

Some factors are found frequently, like skills and infrastructures; however, some factors are overlooked by past studies, such as the importance of chief audit executive active support, the possibility of independence impairment, and counter analytics. This insight informs the promising avenues to investigate these factors and its implication for future AA implementation. This notion suggests that a broader range of factors should be considered to effectively implement AA in IAF.

Limitations

The search strategy and the literature source may limit the number of returned relevant articles. In particular, the use of Google Scholar and Semantic Scholar as database sources serve a breadth of coverage while, at the same time, it may suffer from the lack of more targeted literature. There are possible alternative search methods and more targeted databases for performing a literature review. Therefore, we hope future reviews using different methods and literature sources will enrich the discussion in AA-related studies and reaffirm or expand the findings from this paper.

Future Research

The results of this paper suggest numerous opportunities for further research. First, we suggest empirical studies to evaluate the impact of the factors on AA implementation. Moreover, considering that the driving and inhibiting factors affect various actors in the IAF differently, it will be beneficial to perform exploratory case studies incorporating different points of view from different actors in an AA-related study. Empirical research in this area can focus on showing the interrelation among factors, such as which drivers or inhibitors should be prioritized.

Another fruitful study is to assess each AA type's appropriateness depending on the context. It includes research to evaluate the effectiveness of CA or predictive analytics in deterring fraud and the suitable regulatory framework which incorporates the risk and measure to address the newly arisen issue from AA implementation by IAF, such as independence impairment or counter-analytics. In addition, research to design AA practice will be helpful to address the limited relevant AA use-case for audit purposes as one of the inhibiting factors. Finally, considering the rapid advancement of analytics in the field of auditing, we encourage future review of AA-related studies using different methods and databases for article sources to enrich the discussion and keep up with the field's progress. Future reviews can employ different analysis techniques to enhance the field, for instance, using textual analysis, as suggested by Singh and Singla (2021).

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APPENDIX A

The List of Selected Articles

Lit ID	Citation	Method	Driving Factor(s)	Inhibiting Factor(s)	Cite Count ^a
1	Austin et al. (2018)	Semistructured interview with accounting profession (in client, including supporting like risk, IT, IAF), regulators, and internal and external auditors, using socio-technical systems theory in innovation theory (S-T)	1. High investment in technology (investment in IT) 2. High investment in data analytics (in audit unit) (optimization of IAF's resources)	1. Auditor's competence (obtaining skillset) 2. High investment required 3. Data capture (availability, including client's willingness to share data), accuracy, (format/standard) consistency 4. Complex interaction between financial reporting process (audit objectives) and data analytics (audit process) involving client, auditors, and regulators 5. Conflict and tension between stakeholders (in financial reporting and audit process), different preferences of data analytics regulation between management and auditors 6. Tension between client and auditor about the need to share auditor's data analytics detail or auditor use of client DA (relate to independence and regulation preferences above) 7. Lack of clear regulation (guidance) of DA in financial reporting environment 8. Independence (potentially compromised, due to predictive will blur separation between consulting and assurance, impeding independence) 9. Limitation in fully addressing fraud, if the perpetrator understands how analytics works 10. Changing culture (toward more digital data-driven) in IAF	27
2	Dai et al. (2019)	Design science research	1. Limitation of traditional audit model in handling large amount of data 2. Demand for more (internal) audit effectiveness and efficiency in handling (high-dimensionality) data	1. Data volume (for supervised learning, since unsupervised considered scalable) 2. Data cleanliness (for unsupervised learning)	9

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Lit ID	Citation	Method	Driving Factor(s)	Inhibiting Factor(s)	Cite Count ^a
3	Cleary (2011)	Descriptive cases study	1. Necessity to make a better decision 2. Advancement of computational power 3. Vast amount of data	1. Full access to population of data 2. Possibility of bias from data sample (training for supervised modelling)	29
4	Gambetta, García-Benau, and Zorio-Grima (2016)	Case study (with support from literature review)	1. Address banking business risk (i.e., loan loss provision/LLP) 2. Digitalization of business process (i.e., the use of ERP)	Unstandardized data (type, format) from client	22
5	Krieger et al. (2021)	Grounded theory, through qualitative interview	Digitalization of business process (technology adoption)	1. (The need for) acceptance on standard or lack of regulation 2. Auditor competence (or skills in using ADA) 3. Budget issue (cost restrictions) 4. Connection between audit domain and technology (ideation of innovation issue) 5. (The need to) access client's transactional data 6. Identify (useful or correct) use case (especially for ML and DL) 7. Data quality (especially for PM and ML) 8. Data volume (for training and testing and build robust model (especially for DL)	32
6	Li et al. (2018)	SEM	1. Higher demand/expectation for IAF 2. More frequent access to business 3. More flexibility to explore DA for audit	Requires more skills on auditor (e.g., statistical techniques and the use of data mining tools)	126
7	Rakipi et al. (2021)	Quantitative method (regression model)	1. Trend of Big Data in organization 2. Alignment with organizational activities (management, audit committee) 3. Alignment with (internal) auditor's soft skills and technical skills 4. Digitalization of business process	1. Independence issue, i.e., IAFs reporting line which can impair adoption of DA by IAF 2. Data access (auditing purpose by IAFs) 3. Lack of financial support (can prevent investment in DA techniques) 4. Auditor's competence (technical skill) 5. Low data quality	19
8	Tang, Norman, and Vendirzyk (2017)	Case study	1. Vast amount of data (generated from business)	1. Adequacy (quantity and skill) of personnel	46

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Lit ID	Citation	Method	Driving Factor(s)	Inhibiting Factor(s)	Cite Count ^a
9	Codesso et al. (2020)	Case study	2. Technology improvement, enabling organization to harness the data 3. Obligatory by standard (for IAF) 1. (The need to) improve audit performance (in this case, especially in tax compliance process) 2. The complexity of business process (i. e., tax administration) 3. Business process digitalization (e.g., the use of RFID, GPS, ERP) 4. Management support (administrative office's willingness)	2. Funding limitation (to address personnel issue 3. (Stakeholder's) expectation gap (of the use of DA by IAF) 1. The (perceived high implementation) cost of AA 2. Limited consultant to aid AA implementation 3. New method (internal auditor's decision on work to focus on) 4. Auditor's competence (technical skills to extract and analyze data)	3
10	de Freitas et al. (2020)	Case study	1. Large amount of data 2. Improve of technology 3. Reduce risk of fraud in payroll process (as one of the important process in large organization) 4. Time lag for audit result	1. Auditor skills (lack of IT background, scripting) 2. Limited training availability 3. Organization's lack of IT development (the use of IT in its business process) 4. High investment for IT and infrastructure 5. Large and complex organization 6. Data access for audit purpose 7. Communication protocol between auditor and client	5
11	Debreceeny et al. (2003)	Simulation (design science, using example data)	Digitalization (computer-to-computer) business process	1. (Auditor competence) learning time to understand business process and its correspondence data structure and to understanding in SQL language 2. System performance (EAM will interfere with business system operation) 3. Approval from business process owner	81
12	Kearns et al. (2011)	Simulation (design science, using example data)	1. Audit ineffectiveness in uncovering fraud 2. (Information) technology improvement 3. Regulatory (SOX) Utilization of ERP with CA capabilities	1. Technical barriers (lack of EAMs) 2. Auditor's competence 3. Impediment on performance of business process system when using EAM	10
13	Haynes and Li (2016)	(Cross-sectional) case study	Utilization of ERP with CA capabilities	1. (Challenges in proper implementation of ERP) cost/investment	16

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Lit ID	Citation	Method	Driving Factor(s)	Inhibiting Factor(s)	Cite Count ^a
14	Kaban (2020)	Simulation (case study, using example data)	(Information) technology improvement (Demand for) concurrent audit due to IT improvement in business (High) workload and demand on auditor's performance	(Challenges in proper implementation of ERP) (information) security (Challenges in the utilization of CA in ERP) conflict in audit team (e.g., conflicting ego between 2 coders) - Different system in client (cross-platform issues) - Full data access for audit (test 100% transaction data) - Auditor (and client's employee) competence (to utilize ERP and realize its benefit, including CA) Auditor competence (i.e., in fraud detection, but also in defining scenario for CA in fraud)	5
15	Koskivaara (2006)	Simulation (case study, using example data)	Increased demand of timely and ongoing assurance on risk management and control	- Auditor's competence (IT and statistic) - Audit software analytical tools - Ensuring data security	29
16	Malaescu and Sutton (2015)	Experiment		- Limited knowledge (among IAFs) on how to effectively implement CA - Feasible and economic (of scale) of CA's use case (what continuous audit technologies are available and how to effectively implement and leverage them)	66
17	Searcy, Woodroof, and Behn (2003)	Exploratory survey	- Rapid advancement of (information) technology, and especially: (Network) technology and (open) database architecture - The need for more frequent reporting (amid high-profile scandal (e.g., Enron)) (Requirement) for more efficient method to allow the scarce resources to be cost-effective and value-maximizing	- Real-time (financial) data access for auditor - Client-side's limited/lack of (number) of personnel (man-hours) (i.e., to provide data/support to enable CA by IAF) - Auditor's competence (skills in IT and risk and control related to it) - Control documentation (including IS documentation) - Manual and labor-intensive process (in client)	67

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Lit ID	Citation	Method	Driving Factor(s)	Inhibiting Factor(s)	Cite Count ^a
18	Vasarhelyi and Halper (2018)	(Descriptive) case study	1. Improvement of (information) technology 2. Increased complexity from online (database) system	6. Rigidity in audit process (e.g., getting (audit) form filled rather than getting (the audit) done) 7. Poor integration of (client's) different system (related to no. 5 above) 8. Audit tools (to enable CA/AA) 9. Client buy-in for (internal) auditor to use CA/AA (related to no. 1, 2, 4, and 7 above) 1. Major intrusion in organization's IT when CA system is deployed (i.e., the CA system directly target business process system) 2. Availability of the data (whether or not the data are captured and available for CPAS, e.g., data for audit extracted from user report) 3. Auditor's experience in determining alarm (type 1 to 4) 4. Resistance from auditor (given the difficulties in developing such system and realize its benefit) 5. Startup cost to initiate CPAS (including the level of detailed business and system knowledge from auditor)	24
19	Woodroof and Searey (2001a)	Simulation (case study using example data)	1. Applicability of instant information due the improvement of (information) technology and internet 2. Economic feasibility (to produce such instant information)	1. Cost-benefit consideration (viability on certain business process which requires continuous information vital for decision making AND user acceptance on the potential benefit) 2. Data provision from client for audit (CA) purpose	38
20	Woodroof and Searey (2001b)	Simulation (case study using example data)	1. Applicability of instant information due the improvement of (information) technology and internet 2. Demand for more timely assurance (rather than periodic)	1. Cost-benefit consideration (viability on certain business process which requires continuous information vital for decision making AND user acceptance on the potential benefit) 2. Data provision from client for audit (CA) purpose	125

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Lit ID	Citation	Method	Driving Factor(s)	Inhibiting Factor(s)	Cite Count ^a
21	Brennan and Teeter (2010)	Case study	1. Possibility for CCM (from ERP) 2. Digitalization of business process enabled by IT (e.g., adoption of ERP)	1. Infrastructure capabilities (i.e., Monitoring platform that can handle CCM and other analytics) 2. Audit priority (which test to be performed or whether CA is priority?) 3. Reliability of GenCon (functioning basic control, as it may affect the result of CCM)	4
22	Cardoni et al. (2020)	Case study	Low effectiveness of IAF in fraud detection (using its traditional tools, e.g., <i>ex ante</i> periodic audit)	1. Huge investment (significant resources needed) 2. Auditor's competence (personnel with extensive knowledge) 3. Reliable IT (system design and maintenance) 4. Variety of data (heterogeneous data to analyze)	3
23	Shuhidan, Haslan, Mohd-Nassir, Hamidi, and Mohd-Sanusi (2020)	Design science using Web Development Life Cycle (WDLC)	Vast amount of data, impractical to effectively and efficiently perform traditional audit	—	1
24	Soedarsono, Mulyani, Tugiman, and Suhardi (2019)	SEM	Industry 4.0 and its impact on complex risk environment	1. (Inadequate management support related to) funding (or budget availability) 2. (Inadequate management support related to) regulations relevant to business process (financial report) and the pertinent CA-CM (including partnership, and data provision for CA-CM) 3. System capacity (to provide large volume, accurate, and high-quality data) 4. Auditor competence (lack of preparedness in light of applying business and IT risk in audit) 5. High-quality data (accurate, completeness, error free) 6. Data access (timeliness, access authorization) (actually part of quality, but specified further for emphasis)	10

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Lit ID	Citation	Method	Driving Factor(s)	Inhibiting Factor(s)	Cite Count ^a
25	Eilifsen et al. (2020)	Semistructured interview with heads of professional practices in audit firms, using institutional theory perspective	1. Growing trend of the use of Big Data (auditors, CFOs, standard-setters, and academics recognize this phenomenon) 2. Regulation/standard by professional bodies (maybe irrelevant as it talks about external, but perhaps relevant to AAIFI) 3. (Related to 1) pressure from stakeholders (global push)	1. Lack of regulatory guidance or clear position from regulator (for AA utilization in audit) 2. High investment 3. Not incorporated in IAF (audit firm) methodology, left to the team leader to decide the use 4. Concrete example of benefit of AA (practitioner find AA use proven) 5. (Relate to 2 and 4) how to turn AA output to acceptable audit evidence in a cost-efficient way	43
26	Hampton and Stratopoulos (2016)	SEM	1. Growing trend (hype) of the use of analytics and Big Data 2. Client's expectation	1. Auditor's competence 2. Availability of AA tools	10
27	Michael and Dixon (2019)	Quantitative	1. Business digitalization 2. High investment in IT (and BD) 3. The need for assurance on unstructured info/data	—	13
28	No et al. (2019)	Design science research	1. Sampling risk from using sample in audit 2. Population testing using DA 3. Potential large numbers of outliers, impractical to test all of it	1. Time constraint (the test takes longer time than anticipated/budgeted) 2. Poor quality of data 3. Data (access) unavailable	39
29	Chaqiqi and Nugroho (2021)	Qualitative	1. Anticipate disruptive risk for IAF (due to industry 4.0) 2. Digitalization of business process 3. Demand for overall (GRC) assurance effectiveness	1. Presented as the issue need to be addressed) 1. Coordination within the IAF 2. Infrastructure and technology capacity 3. Sufficient personnel 4. Auditor's competence 5. Data access (for audit purpose) 6. (Inadequacy of) DA policy (or AA strategy within the IAF) 7. Cultural readiness, including the sense of urgency 8. Data complexity	0
30	Kiesow, Zarvic, and Thomas (2014)	Design science research	1. Digitalization of business process (e.g., financial reporting process)	1. The increased dependence on IT division and management in audit	18

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APPENDIX A (continued)

Lit ID	Citation	Method	Driving Factor(s)	Inhibiting Factor(s)	Cite Count ^a
31	Wang and Kogan (2020)	Design science research	2. The increased complexity due to the adoption of Big Data in business environment 3. The opportunity provided by AA	activities 2. High-cost related to the need to re-organize the (business and audit) process 3. Security concerns due to new regulation related to digitalization The risk of disruption in the organization's information processing capacity to support AA	5
32	Islam and Stafford (2022)	Quantitative (using contingency theory)	1. The growing trend of leveraging Big Data, including for audit purposes 2. The efficiency provided by AA 3. The improvement of processing capacity 1. The increased demand from client pressuring IAF to use AA 2. IAFs in a heavily regulated industry more likely to adopt AA 3. Data-specific knowledge in the IAF drives for more use of AA 4. Awareness of CAE to utilize AA	1. Change in audit process derived from the use of AA 2. The lack trained personnel to use AA 3. Difficulty to identify "the right question to ask" and how AA will help to answer that question 4. Hesitation due to the possible independence/objectivity impairment	2
33	Van der Nest, Smidt, and Lubbe (2018)	Mixed-method	1. The increased volume of audit evidence in electronic format 2. The predicted trend of (digital) data-based audit activity	1. The required skills of auditors to utilize AA in audit activity 2. Significant cost to implement AA	10
34	Betti and Sarens (2021)	Qualitative	1. Highly digitalized and the use of analytics in business process 2. The exponential grow of digital data 3. The increased effectiveness and efficiency offered by AA	1. The high cost for hardware and develop skills 2. The limited digital skills among auditors	29
35	Bierstaker, Janvrin, and Lowe (2014)	UTAUT	1. Improve audit effectiveness and efficiency 2. Complexity in client's business processes, involving IT 3. Investment to catch up with client's IT	1. Perceived low importance of the use of CAAT 2. Require client's cooperation to implement	166
36	Braun and Davis (2003)	Mixed-methods	1. Improve audit effectiveness and efficiency 2. Requirement to speed up the audit processes	1. The need for specialized technical expertise 2. Possible disruption to the client's operation 3. Client's concern on their operation	305
37	Jans, Alles, and Vasarhelyi (2014)	Design science research	1. Investment in IT ERP systems 2. Business digitalization		184

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Lit ID	Citation	Method	Driving Factor(s)	Inhibiting Factor(s)	Cite Count ^a
38	Janvrin, Bierstaker, and Lowe (2008)	Quantitative (ANCOVA)	1. To utilize the already made (IT) investment 2. To reduce time spent and improve audit judgement	1. Require significant IT investment 2. Complexity of systems and controls	279
39	Janvrin, Bierstaker, and Lowe (2009)	Quantitative (LogReg)	1. Digitalization in client's business and audit practices 2. The increased complexity in client's business due to IT advancement	1. Limited in auditors' IT-related knowledge 2. Lack of support to initiate AA use 3. Concern for data integrity	172
40	Kim, Mannino, and Nieschwietz (2009)	Quantitative (SEM)	Growing trend of audit digitalization (using GAS)	Difficulty to use GAS's advanced features	210
41	Mahzan and Lymer (2008)	UTAUT	1. The importance of digital technology adoption in audit practices 2. The increased complexity of business processes due to IT advancement 3. Ensure (audit) effectiveness and efficiency	1. Limited knowledge for typical auditors 2. Different data format 3. Hesitant to alter the audit processes	64
42	Mahzan and Lymer (2014)	UTAUT	1. The importance of digital technology adoption in audit practices 2. The increased complexity of business processes due to IT advancement 3. Optimize investment and aim to improve cost savings	1. Importance of knowledge and skills, and support to initiate AA use 2. Lack of standard/regulatory guidance	142

^a Per December 1, 2022, based on Google Scholar.