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PROCESS MINING IN GOVERNANCE, RISK MANAGEMENT, COMPLIANCE (GRC), AND AUDITING: A SYSTEMATIC LITERATURE REVIEW

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ABSTRACT

Numerous studies increasingly investigate the application of process mining in governance, risk management, compliance, and auditing in response to changing business processes brought about by digital transformation. Audit on business processes is an interesting issue in the process mining literature. This study seeks to specifically map the types, areas, objectives, and frameworks of process mining application in governance, risk management, compliance, and auditing. The mapping process results in the classifications of components and sub-components. We use the systematic literature review (SLR) on the application of process mining in governance, risk management, compliance, and auditing. The SLR approach makes use of 34 papers selected based on the exclusive and inclusive terms and the mapping process related to the research questions. The data extraction results show that the financial domain dominates the research topics. Besides, we identify 6 phases as components and 32 concrete steps or activities sub-components. The SLR findings contributes to future research on the application of process mining to governance, risk management, compliance, and auditing in various research areas.

Keywords: *Process Mining, Governance, Risk Management, Compliance (GRC), Auditing, Systematic Literature Review.*

1. INTRODUCTION

Digital transformation through technological convergence including social media, mobile, analytics, cloud, and internet of things (SMACIT) brings fundamental changes to organizations [1][2]. Digital transformation represents the use of digital technology to deliver changes, including enhancing customer experience, downsizing business processes, creating new business models, and creating values [3]. Digitalization shifts organizational business processes from relatively stable and closed designs to more dynamic, open, agile, and iterative ones [4][5]. Digitalization-led changes require better governance processes, more effective risk management and compliance programs or commonly known as GRC [6].

GRC refers to organizational capabilities to achieve their objectives effectively by managing uncertainties and acting with full integrities. Effective GRC implementations through process audits will help organizations overcome various problems and anticipate many unprecedented risks [7]. Process audits are a series of activities to evaluate whether business processes are performed within certain boundaries set by managers, governments, and other stakeholders [8]. Process mining (PM) offers a novel way to put more emphasis on implementing stricter compliance tests and ensuring the reliability and validity of organizational business processes [9].

As a process-based data analytics technique, PM can be used in GRC as a form of business process audit [10]. PM offers stricter methods to evaluate and ensure the validity and reliability of information on organizational business process [11]. PM is categorized as a form of analytical methods in modern audits [12]. PM for audit within the GRC framework is a rapidly research topic along with changes in organizational business processes [13].

Several studies have investigated the use of PM for audits, and anomaly and fraud detection within the GRC framework. For example, Wil van der Aalst in 2010 introduced the Auditing 2.0 framework based on the PM method [14]. PM can serve as new audit evidence for auditors that facilitates the evaluation of internal control effectiveness, audit risk assessment, and fraud scheme identification [15]. Prior studies by Jans [11], [16]–[20] showed the use of PM for internal audit activities. Werner has also analyzed the PM implementation for financially-related audits [7], [18], [21]–[24]. The facts indicate that studies on PM in GRC and audits largely focus on the financial [25] and manufacturing domains [26]. PM in GRC and audits can be widely used in various domains, especially for process audits. The PM methods enable the evaluation of historical data in event-log according to the desired models. This advantage is important to detect deviations and find and measure their error levels.

Nevertheless, these studies have not systematically and comprehensively investigated the implementation of PM in GRC and audit. Systematic and comprehensive studies in this topic use various settings, including health [27], information system security [28], supply chain management [29], and the application of PM in manufacturing processes [26]. Like prior systematic reviews, this study is mainly motivated to define specifically research types and areas, research objectives, and particularly the frameworks or methodologies of PM application in GRC and auditing. Hence, this study aims to offer a systematic understanding, based on prior studies, that is crucial to develop comprehensive analysis of the main components of PM methodologies and frameworks in GRC and auditing.

Based on these arguments, our research questions are (1) What are the research types and areas of PM in GRC and auditing, (2) What are the research purposes of PM in GRC and auditing, and (3) What are the framework components and steps of PM in GRC and auditing. We use the systematic literature review (SLR) to answer these research questions as introduced by Petersen [30]. The SLR consists of several phases, starting from determining the scope; searching, determining, and filtering or selecting the literature; extracting data and mapping based on the research questions; and lastly analyzing the SLR results.

This study produces several understudied areas: PM research areas in GRC and auditing, their research objectives, and, most significantly, our findings of the components and sub-components of PM frameworks. These results contribute to development of PM science in GRC and auditing by defining the components and sub-components of PM frameworks in GRC and auditing that have been adjusted to the phases of PM methods[2] [31]. Our findings also help scholars and practitioners understand the state-of-the-art of PM application in GRC and auditing. Technically, this research contributes to the implementation of PM types in the context of auditing. The implementation of PM, which is a wedge between Business Process Management (BPM) and data mining, is still rare, so the results of this study contribute significantly to the development of information systems and technology.

This paper is organized as follows; the introduction that consists of background and research motivations, literature review explaining process mining theories and GRC and auditing, research methods that consist of SLR research phases, analysis that explains SLR results and discusses the results based on research questions, and conclusions that contain research conclusions and suggestions for future studies.

2. LITERATURE REVIEW

This part discusses theories related to the research issues, namely PM, GRC, and auditing theories. Each issue is discussed separately.

2.1 Process Mining

PM is the intersection between data mining and business process management that focuses on understanding the processes and capturing more significant findings [32]. PM seeks to search, monitor, and enhance real processes (as opposed to assumed processes) by extracting knowledge from event-logs from information systems. PM consists of process discovery, conformance checking, dan performance measurement [33], as illustrated by the following Figure 1.

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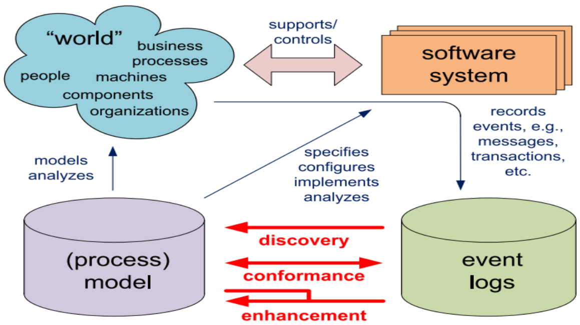

Figure 1: Process Mining Types

PM indicates differences between actual and designed processes. PM also illustrates how the processes are performed in practices and the social relationships between individuals. PM's basic idea is diagnosing processes by mining even-logs for knowledge [34].

Effective PM implementations require the Process Mining Project Methodology (PM^2) that is designed to support PM implementation projects aiming to enhance process performance or compliance with rules and regulations [31]. The PM^2 method seeks to overcome prior methods by providing frameworks encompassing most data mining techniques that function as guidance for PM initiatives [35]. This method consists of 6 (six) phases: planning, data extraction, data processing, mining & analysis, evaluation, and process improvement & support. Figure 2 below illustrates the phases of data processing, mining & analysis, and evaluation performed in several iterations [31].

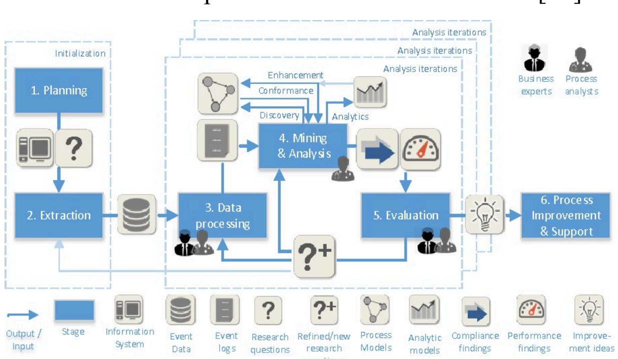

Figure 2: Process Mining Project Methodology

2.2 Governance, Risk Management, Compliance (GRC) and Auditing

GRC and auditing refer to organizational capabilities to achieve their objectives effectively by managing uncertainties and acting with full integrity. Governance is a combination of culture, policies, processes, regulations, and institutions that determines structures in which organizations are managed and directed. Risk management represents a process to identify, evaluate, and prioritize risks and make plans to minimize or eliminate the impacts of negative events. Compliance refers to actions to comply with, and exhibit compliance with, external laws and regulations and internal policies and procedures [7] [8].

GRC is closely related to audits because audits are performed to ensure the validity and reliability of information about organizations and their related processes. Specifically, audits evaluate whether organizations run their business processes within certain boundaries set by managers, governments, and other stakeholders [8].

PM has been an auditors' useful tool to generate more knowledge about actual business processes that helps auditors assess risks better. Auditors do not only receive data from employees, but also metadata or data on data recorded automatically and completely [19]. PM adoption in GRC and auditing aims to: (1) enable auditors to evaluate all transaction population (2) facilitate automatic transaction entries from the systems, and (3) eliminate dependence on potentially subjective data provided by auditees [11]. Accordingly, PM implementation in GRC and auditing is an interesting research issue.

3. RESEARCH METHOD

This part discusses research methods to find, select, extract, classify, and analyze prior studies on PM in GRC and auditing according to the research questions. SLR is used to identify research areas, PM methods used, constituting components, and framework phases.

3.1 SLR Method

This study uses a systematic approach to identify, regulate, and understand the main contributions of the state-of-art related to PM in GRC and auditing. We use the SLR method as introduced by Petersen et al. [30] as illustrated in Figure 3 below.

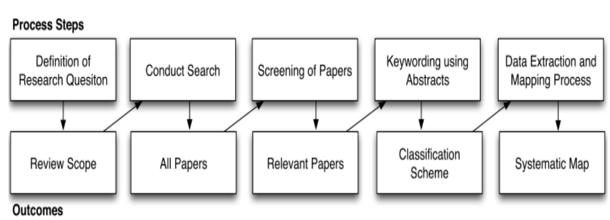

Figure 3: SLR's Process Stages and Outcomes

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Based on the above process stages, the following are SLR's stages and outcomes:

- Defining research scope: determining research questions designed to offer research scope.
- Searching: identifying papers with search strings in selected scientific databases based on publication periods.
- Screening papers: screening relevant papers by applying suitable inclusion and exclusion criteria.
- Identifying and combining based on keywords in the abstracts to have a better understanding of research topics and generate a better organized paper classification according to the research objectives.
- Extracting data and mapping: extracting, mapping, and visualizing the results to answer the research questions.

3.2 Research Questions

Based on the research objectives, we propose the following research questions (1) What are the research types and areas of PM in GRC and auditing, (2) What are the research purposes of PM in GRC and auditing, and (3) What are the framework components and steps of PM in GRC and auditing.

3.3 Search Strings

After proposing the research questions, the next stage searches for papers in scientific databases with the following keywords as search strings:

- *"Process Mining" AND "Auditing";*
- *"Process Mining" AND "Governance" OR "Risk Management" OR "Compliance";*
- *"Process Mining" AND "Governance, Risk Management, Compliance" OR "GRC".*

We use the following 8 research databases in the analysis:

- IEEE Digital Library
- Indersience
- Sciencedirect (Elsevier)
- ACM Digital Library
- Emerald
- AISNet
- Google Scholar.

3.4 Inclusion and Exclusion Criteria

Next, the most crucial stage is screening more specifically based on inclusion and exclusion criteria:

- Inclusion criteria, the selected papers must be:
  a) Electronically available and found by the search strings in all fields and periods.
  b) At least reviewed by two journal or conference reviewers.
  c) Published online from 2000 to February 2020.
  d) Snowball technique that includes some referenced papers not indexed in selected digital libraries.
- Exclusion criteria, papers that:
  a) Are not written in English.
  b) Are duplicated work.
  c) Do not focus on process mining, e.g.: mining iron, metal mining, pollution, chemistry, or environmental impacts.
  d) Refer to process mining for GRC and auditing only in introduction, or fundamentals, or part of the state-of-art.
  e) Refer to process mining only as a further research direction.
  f) Are only related to the author's biography.
  g) Not real scientific papers, such as only content guides, indexes, or marketing information.
  h) Contribute very shortly, only one or two pages.
  i) Are unavailable, removed, or retracted.

3.5 Identification and Combination

This stage identifies the most relevant papers based on keywords in papers' abstracts and contents. Besides, we also combine and classify papers based on their types.

3.6 Data Extraction and Mapping

This stage extracts data from paper contents based on the research questions and objectives. Data extraction focuses on data related to components and sub-components as illustrated by the PM^2 method's stages [31]. We use this method to identify components and sub-components better based on prior studies on PM in GRC and auditing.

4. RESULTS AND DISCUSSIONS

This section discusses the results of the SLR based on the research questions and objectives. The focus of analysis and discussion is on PM components and sub-components in GRC and auditing based on PM^2 theory [31]. As a form of SLR, the findings will be described in the form of types of research (review or research paper); research area or domain (financial, manufacturing, healthcare, information systems, etc.); and

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components/sub-components as well as the stages of the PM method on GRC and auditing.

4.1 Paper Selection Results

Based on the stages and paper selection process, a total of 34 papers were found to be the most relevant to the search strings and selection criteria as shown in Table I. In stage 1, 1,459 papers were found from 8 scientific article databases. This search used the search strings as described above. In the second stage there were 50 selected papers and in the third stage there were 34. Based on the SLR method proposed by Petersen [30], these 34 papers were then systematically extracted to answer research questions.

Table 1: Paper Selection

No	Database	SLR		
		Stage 1	*Stage 2*	*Stage 3*
1	Emerald	48	1	1
2	AISnet	57	3	2
3	IEEE	176	8	8
4	Sciencedirect	203	10	9
5	Inderscience	13	3	-
6	ACM Digital Library	48	3	1
7	Springer Link	572	7	5
8	Google Scholar	342	15	8
	Sum	**1.459**	**50**	**34**

The data extraction came up with 26 papers discussing the framework and stages of using PM. While the remaining 8 papers do not discuss the framework and stages. Next was the identification of components and sub-components in accordance with the stages in the PM^2 method. This method was chosen because this method was a refinement of the existing PM implementation methods [31]. This identification and mapping process was carried out to determine what components and sub-components were relevant in the context of PM implementation on GRC and auditing.

4.2 Types of Research and Publication

The results of research data extraction showed that there were 22 studies published in the form of journal articles and 12 others at conferences. Furthermore, from the type of research, there were 5 review articles and the remaining 29 were empirical research articles with various approaches, models, datasets and especially the PM framework on GRC and auditing.

Based on the available data, it could be seen that there has been an increase in the number of research on GRC and auditing, especially since Wil van der Aalst launched a scientific article with the title Auditing 2.0: Using Process Mining to Support Tomorrow's Auditor in 2010 [14]. Subsequently in 2011, Wil van der Aalst introduced a conceptual model for online auditing [36]. These two studies have greatly influenced PM research on GRC and subsequent auditing [37].

Research in this domain then continues to grow to this day. Based on the data in Figure 4, for 2020 only 1 article were identified, due to the SLR time limit until February 2020.

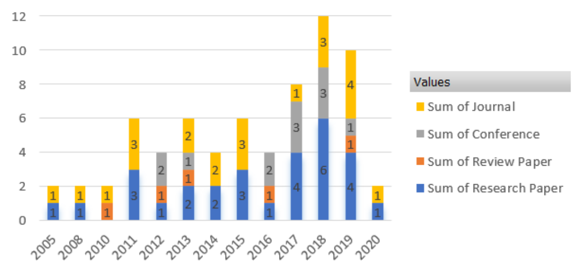

Figure 4: Number and Types of Research and Publication

4.3 Most Prolific Author

Table 2 shows the most prolific authors based on the 34 selected papers. Due to space limitations, this section only presents the 14 most productive researchers with at least 2 papers published. The total number of researchers from the 34 selected papers are 64 people. Mieke Jans is the most prolific researcher in PM research on GRC and auditing. The terminology used by Jans at the beginning of his PM research was Business Process Mining [38]. The next most productive researcher is Michael Werner whose research focus is on financial audits using PM. One of the fundamental findings that also became the basis for determining PM components and sub-components in GRC and auditing is Multilevel Process Mining for Financial Audits [22].

Table 2: Most Prolific Author

No	Name	# Papers
1	Jans, Mieke	6
2	Werner, Michael	5
3	Wisudiawan, Gede Agung Ary	4
4	van der Aalst, Wil M.P.	3
5	Kurniati, Angelina Prima	3
6	van Der Werf, Jan Martijn	3
7	Gehrke, Nick	3
8	Alles, Michael	2
9	Herdiani, Anisa	2
10	Nüttgens, Markus	2
11	Verdonk, Marc	2
12	Vanhoof, Koen	2
13	Vasarhelyi, Miklos	2

No	Name	# Papers
14	van Hee, Kees M.	2

4.4 Domains dan Objectives of Research

The research domain refers to the area or field of PM application in GRC and auditing. For ease of grouping, the application domain refers to the area of application of PM as described by Garcia et al [13]. The determination of the research domain is in line with one of the research questions, because apart from finance, the application of PM to GRC and auditing has also begun to be widely used in other domains. This increase is due to the digitization process in various sectors [33] requiring audits, especially process audits to ensure performance and conformance [37].

Most PM research domains on GRC and auditing are in the financial area. This is in line with several previous SLR studies [13][39]. One of the research domains that has also begun to apply PM on GRC and auditing is the manufacturing domain. This is related to how to ensure governance and risks in the production process. The following in Figure 5 is the domain of PM research on GRC and auditing.

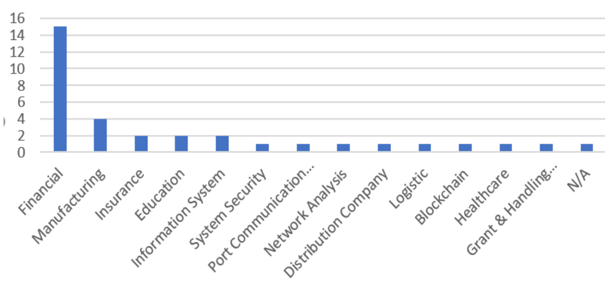

Figure 5: PM Research Domain on GRC and Auditing

4.5 PM Components on GRC and Auditing

Method components and sub-components were the result of mapping of 26 frameworks from various PM research on GRC and auditing to PM^2 methods, as shown in Figure 2 above. PM^2 was designed to support the implementation of PM which aimed to improve process performance (*performance*) and measure compliance with rules and procedures (*conformance*). It covers a wide range of mining processes and other analytical techniques and is suitable for both structured and unstructured process analysis.

Each stage in PM^2 is defined as a component, while concrete steps as well as activities are defined as sub-components. This sub-component came from the 26 papers that empirically use the stages and frameworks in PM in GRC and auditing. PM^2 has 6 stages which are then called components, namely (1) Planning, (2) Extraction (3) Data Processing, (4) Mining & Analysis, (5) Evaluation, and (6) Process Improvement & Support.

The purpose of the Planning phase was to prepare the PM project. For this reason, the identified sub-components include the aspects of business process selection related to the selected process which can be answered using event-logs and so on. The purpose of the Extraction stage was to extract the event-log and process model. To that end, the identified sub-components include the extraction process, the number and form of datasets, business process modeling, and so on. The purpose of the Data Processing stage was to process the event-log in such a way that it was optimal for the analysis stage. To that end, the identified sub-components include the data import/export functions, automatic data processing, data processing capabilities, and so on. The purpose of the Mining & Analysis stage was to answer PM's objectives on GRC and auditing and get a complete picture of process performance and compliance. For this reason, the identified sub-components include the process discovery, conformance checking, process analysis & enhancement, and so on. The purpose of the Evaluation phase was to link the findings of the analysis with ideas for improvement that achieve the project objectives. To that end, the identified sub-components included the evaluation, verification, and validation of the diagnosis and so on. The objective of the Process Improvement & Support stage was to use the PM results on the GRC and auditing obtained to modify the actual process execution. The input from this stage was the idea of improvement from the evaluation stage. The output of this stage was the process modification and improvement.

To that end, the identified sub-components include facilitation of business process improvement and so on. In full, Table 3 is comprised of the 6 components and 32 sub-components identified from the selected paper.

Table 3: Mapping of Components and Sub-Components

No	Components	Sub-Components	Reference
1	**Planning**	Business processes and event-logs identified as a whole	[34] [40] [14] [36] [38] [17] [41] [21] [42] [7] [19] [20] [43] [22] [10] [44] [23] [45] [24] [46] [47] [48] [49] [50]
		Integration of information systems as the source of business	[40] [14] [36] [38] [17] [41] [21] [19] [43] [22] [45] [51] [46] [47] [52] [11] [53]

No	Components	Sub-Components	Reference
		processes and event logs	
		Determination of business processes to be audited and analyzed	[14] [36] [38] [17] [41] [21] [19] [42] [20] [43] [22] [54] [10] [23] [44] [55] [51] [24] [46] [49] [47] [56] [48] [50] [57] [58] [59] [53]
		Audit and monitoring of business processes on information systems	[34] [40] [14] [36] [38] [17] [41] [21] [19] [42] [20] [43] [22] [44] [23] [24] [45] [52] [59] [53]
2	Extraction	Extraction of event-logs from selected business processes	[34] [40] [14] [36] [38] [17] [41] [21] [42] [19] [43] [22] [54] [44] [45] [24] [47] [46] [49] [48] [56] [57] [58] [59] [53]
		Amount of data (dataset) from event-log	[36] [17] [7] [21] [20] [43] [45] [24] [51] [47] [49] [48] [56] [58] [52] [59] [11] [53]
		The extracted data reflecting the actual transactions and event-logs	[34] [14] [36] [41] [21] [42] [19] [7] [43] [22] [54] [44] [24] [45] [47] [49] [46] [58] [59] [11] [53]
		Extracting information from event logs and for business process modeling	[34] [14] [38] [17] [36] [41] [42] [21] [19] [43] [22] [23] [44] [45] [24] [55] [47] [48] [49] [58] [52] [11] [53]
3	Data Processing	Functions of data import and export	[34] [38] [17] [41] [36] [21] [42] [43] [22] [54] [23] [45] [24] [51] [47] [49] [48] [56] [50] [57] [58] [52] [59] [53]
		Functions of real-time processing	[14] [36] [41] [21] [19] [42] [20] [43] [22] [24] [47] [49] [56] [50] [57] [58] [52] [11] [59] [53]
		Processing time and number of processes performed	[34] [40] [17] [41] [21] [7] [19] [20] [43] [22] [10] [45] [24] [55] [46] [47] [49] [48] [56] [50] [58] [11] [52] [53]
		Data accuracy and completeness (data integrity)	[40] [14] [36] [17] [21] [42] [20] [43] [54] [10] [23] [24] [46] [47] [49] [48] [56] [50] [58] [52] [59] [11] [53]
		Ability to filter event-log	[34] [40] [14] [38] [17] [36] [41] [21] [19] [42] [20] [43] [22] [54] [23] [24] [45] [51] [55] [47] [46] [49] [48] [56] [50] [58] [52] [59] [11] [53]
		Pre-processing of event-log	[40] [17] [41] [19] [42] [20] [43] [22] [54] [10] [23] [24] [45] [55] [47] [49] [58] [52] [59] [53]
		Ability to process large data sets (data population)	[40] [14] [36] [17] [42] [19] [43] [22] [10] [23] [45] [55] [24] [47] [49] [48] [56] [50] [57] [58] [53]
		Enrichment and aggregation of event-log to be processed	[40] [14] [38] [36] [21][41] [19] [42] [20] [43] [22] [54] [10] [23] [24] [45] [49] [47] [48] [56] [50] [52] [53]
		Process stream model	[40] [36] [42] [19] [20] [22] [54] [23] [24] [55] [51] [47] [49] [48] [11]
4	Mining & Analysis	Automation of business process analysis and audit methods	[14] [41] [21] [19] [7] [47] [56] [52] [59] [11] [53]
		Process discovery)	[34] [40] [14] [38] [17] [36] [41] [21] [19] [20] [43] [42] [22] [54] [10] [23] [45] [24] [51] [55] [47] [48] [57] [58] [52] [59] [11] [53]
		Conformance checking technique to detect non-conformance	[34] [40] [14] [38] [17] [36] [41] [21] [19] [42] [20] [43] [10] [45] [24] [55] [46] [47] [49] [48] [58] [52] [59] [11] [53]
		Extension of the process model using information from the actual process	[34] [40] [14] [38] [17] [36] [41] [21] [19] [20] [43] [42] [22] [54] [10] [23] [45] [24] [51] [55] [47] [48] [57] [58] [52] [59] [11] [53]
		Adoption of algorithms in process mining	[34] [40] [14] [38] [17] [36] [41] [21] [19] [42] [20] [43] [22] [54] [10] [44] [23] [24] [45] [55] [49] [47] [48] [52] [59] [11] [53]
		Delta analysis to check the deviation between the designed business model and the actual	[14] [36] [41] [19] [42] [20] [43] [10] [45] [24] [51] [47] [49] [58] [52] [59] [53]
		Interview techniques,	[44] [48]

No	Components	Sub-Components	Reference
		participatory analysis and questionnaires for process mining analysis involving IT, business process & audit experts	
5	Evaluation	Strict PM artifact testing with real data testing	[41] [36] [38][21] [19] [42] [7] [20] [43] [54] [10] [23] [45] [24] [51] [46] [47] [49] [48] [58] [59] [53]
		Evaluation of relevance and reliability	[34] [40] [14] [38] [17] [21] [42] [20] [43] [22] [23] [24] [51] [46] [47] [48] [58] [52] [59] [53]
		Process attribute ranking	[17] [19] [43] [10] [44] [24] [51] [55] [48] [53]
		Verification and validation	[34] [38] [36] [21] [19][42] [20] [44] [24] [45] [55] [47] [49] [48] [11] [53]
		Artificial diagnosis and evaluation	[17] [20] [22] [10] [24] [49] [48] [56] [52] [11] [59]
6	Process Improvement & Support	Facilitation and improvement of compliance management activities	[34] [40] [14] [17] [38] [36] [41] [21] [19] [42] [20] [43] [54] [10] [44] [23] [24] [51] [47] [49] [57] [52] [59] [11] [53]
		Process improvement and support through implementing innovation	[34] [14] [38] [36] [41] [19] [42] [43] [22] [10] [44] [23] [24] [45] [24] [51] [46] [47] [49] [48] [58] [52] [59] [53]
		Use and implementation of PM to support operations	[17] [19] [42] [20] [54] [10] [44] [23] [24] [51] [47] [49] [48] [57] [11] [52] [59]

4.6 Implication and Future Research

This is the main finding of the research questions that have been described previously. The results of this identification are particularly useful for mapping the components and sub-components that make up the PM method in GRC and auditing. The implication of this research is that PM on GRC and auditing which has been equipped with these components and sub-components can be researched continuously, especially to measure performance and suitability in the context of changing business processes. In addition, research opportunities to develop special algorithms that match the character of GRC, and auditing are also opened to be carried out. One of the research opportunities that can be continued is GRC and auditing on an ongoing basis as an answer to the challenges of a dynamic, iterative, and sustainable digital era.

This research opportunity is focused on automation algorithms based on the PM method which is implemented in the GRC and auditing processes. This automation is to ensure that audits and monitoring are carried out on an ongoing basis. This is important, because in the digital era most business processes run automatically and continuously. Based on the results of this SLR, it was also found that research on the automation of the audit process and continuous monitoring had never been carried out.

5. CONCLUSIONS

Based on the results of the SLR stage, all research questions have been answered. 34 selected papers have described the types and areas or domains of PM research on GRC and auditing. Most of the papers are empirical studies that comprehensively discuss PM design and methodology. Furthermore, the most productive authors were identified as well as research objectives using PM in GRC and auditing. Most PM objectives offer multiple perspectives that are important for GRC analysis and auditing. Some of them are control flow, which is used to analyze the order of execution of activities and the time perspective, which focuses on the duration and frequency of occurrence of events.

The stages and frameworks in each of these papers have been mapped and classified based on the PM^2 method. These are then referred to as components and sub-components. This study resulted in 6 components and 32 sub-components forming the PM method on GRC and auditing. This has never been studied before and becomes and becomes the main contribution in this research. These findings are expected to contribute to the development of PM knowledge on GRC and auditing through the availability of mapping components and sub-components of the PM framework on GRC and auditing that has been adjusted to the stages of the PM^2 method [31].

The results of this study have succeeded in mapping the components and sub-components of PM on GRC and auditing. This mapping has never been done before because PM on GRC and auditing research using the SLR approach is also still rarely done. Components are stages, while sub-components are activities. The existing literature has not specifically addressed this matter. The main result of this research is to structure the various stages in the PM method so that components and sub-components can be categorized.

These results are very important in PM research, which is currently growing, along with the development of information technology, especially process science. The ubiquitous automation encourages research based on the PM method to identify processes as well as the measurement of performance and conformity based on processes. The results of this study can be used as a basis for the development and implementation of PM, especially in the context of GRC and auditing.

The main limitations of this study are the lack of access to several leading journals and there are several papers that do not specifically describe the PM stages of GRC and auditing. In-depth identification and grouping or classification are, therefore, suggested to be conducted. This requires extra time and effort to adapt to the clustering in the PM^2 method.

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