

Designing a Model for Integrating Process Mining into Financial Statement Auditing

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Citation: Andarz, E., Dastoori, M., & Moradpour, S. (2025). Designing a Model for Integrating Process Mining into Financial Statement Auditing. *Business, Marketing, and Finance Open*, 2(5), 1-12.

Received: 24 March 2025




Revised: 17 April 2025

Accepted: 04 May 2025

Published: 01 September 2025



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Abstract: The objective of the present study was to design a model for integrating process mining into the auditing of financial statements. The research employed an exploratory mixed-method approach (qualitative–quantitative). Participants in the qualitative phase included experts and specialists in financial statement auditing with experience in management and policy-making. Using purposive sampling and based on the principle of theoretical saturation, a sample size of 10 individuals was determined. Participants in the quantitative phase consisted of certified public accountants responsible for financial statement auditing in reporting companies in Tehran Province. Using stratified random sampling and Cochran’s formula, a sample size of 303 individuals was established. The data collection tools included semi-structured interviews for the qualitative phase and a researcher-made questionnaire for the quantitative phase. The qualitative data were analyzed using thematic analysis, and the quantitative data were analyzed through structural equation modeling with the use of SPSS and LISREL software. The findings indicated that 82% of the model design for integrating process mining into financial statement auditing depended on dimensions comprising four main themes: (1) individual factors, (2) environmental factors, (3) institutional factors, and (4) organizational factors; and four sub-themes: (1) adoption, (2) development of process mining in auditing, (3) implementation of process mining in auditing, and (4) performance evaluation of process mining in auditing. The results also demonstrated that the implementation of process mining enhances the reliability of audit results and, by replacing traditional manual auditing methods, strengthens the evidentiary power of audits. As a novel data mining technique, process mining equips auditors with tools to keep pace with technological advancements and challenges.

Keywords: model, process mining, auditing, financial statements.

1. Introduction

Nowadays, global corporate scandals and the bankruptcy of institutions have raised a critical question: Are current auditing techniques up-to-date and aligned with present conditions, or is the implementation of modern auditing techniques being inadequately executed? In recent years, with the increase in commercial and economic transactions, the advancement of information technology, and the accumulation of financial data, process mining techniques have become prevalent as an efficient means to utilize these data effectively [1]. In today’s economic environment, with the growing demand for reliable information, the need for competent auditors to validate the reports and information presented has become essential. Auditing is an inseparable part of the financial reporting

process, and by lending credibility to the information provided, it plays a crucial role in the informed judgment and decision-making of users [2-4].

In this regard, companies have increasingly automated their complex operations using advanced computer systems. This transformation has also affected the fields of accounting and auditing [5]. Public accountants face new challenges due to the increased automation of transaction processing, greater heterogeneity of source systems, higher complexity of business processes, and the growing volume and diversity of generated data. International and national auditing standards do not explicitly specify how data analysis techniques can or should be employed in contemporary audits [6]. Historically, Computer-Assisted Audit Tools (CAATs) have rarely been used as technological support in external audits. The overall adoption of advanced data analysis techniques such as regression or classification has been limited in the auditing profession, even though these are particularly significant in the context of big data [7].

The analytical techniques embedded in these tools usually rely on data of a financial nature. Analyses often focus on testing individual transactions in the general ledger to support journal entry tests and perform semi-automated analytical procedures for auditing specific account balances (Appelbaum, Kogan, & Vasarhelyi, 2018, p. 85). To date, the analysis and evaluation of clients' internal processes and controls in audits have primarily been a manual task involving observing staff during process and control activities, inquiring with process owners, reviewing process documentation, and manually testing samples of source documents. This study focuses on process mining as a relatively new data analysis technique [8]. This sequence of actions seeks to analyze and examine data generated from process flows over a given organizational period. The concept of process mining involves discovering, monitoring, and improving actual processes through the extraction of knowledge from event logs. The event history can be used to manage these three functionalities of process mining (Hosseini, Mosleh, & Hosseini, 2018, p. 116). Therefore, the aim of process mining is to discover, monitor, and enhance real processes by extracting knowledge from data stored in information systems [9].

Process mining algorithms analyze data from computer systems to provide insights into business processes within an organization. This potential can assist auditors in overcoming significant limitations and inefficiencies in modern auditing, particularly in assessing the design and operational effectiveness of internal controls [10, 11]. Traditional audit procedures, when business transactions are primarily processed by computers rather than humans and when control procedures are embedded and automated within software systems, provide limited reliable information. Manually inspecting a sufficiently large sample of transactions in industries that process millions or billions of transactions daily, such as retail or telecommunications, becomes inefficient or even infeasible [7].

Several important studies in this area are reported next. First, the study by Rostamloo et al. (2022) titled "Exploring the Implementation of Process Mining in Financial Statement Auditing" revealed that process mining enables the automated analysis of business processes. The findings demonstrated the feasibility of incorporating process mining into financial statement auditing in accordance with contemporary auditing standards and generally accepted auditing practices. The implementation of process mining enhances the reliability of audit results and strengthens audit evidence by replacing manual audit methods [12].

Another study by Oursaji and Ghamian (2021), titled "A Review of Process Mining in Financial Statement Auditing," showed that process mining provides an opportunity to improve the audit of financial statements and overcome the limitations of conventional audit procedures in the face of increasingly automated or semi-automated

financial transactions. The findings reaffirmed that implementing process mining increases the reliability of audit outcomes and improves the strength of audit evidence by replacing manual auditing approaches [13].

Additionally, a study by Mostafaei Dolatabad et al. (2019), titled "Evaluating Process Mining in Discovering Semi-Automated Process Models in the Banking Industry (A Case Study on the Bank Guarantee Issuance Process)," found that manually recorded data can impact the results of process mining. Consequently, in the validation phase, a new validation metric called expert-driven validation criterion was introduced alongside the traditional conformance measurement, and the discovered process model showed a match rate of 87.2%. The findings suggested that fuzzy mining algorithms can also be used effectively in semi-automated process environments [14].

Furthermore, a study by Koh et al. (2021), titled "The Effects of Financial Statement Disaggregation on Audit Pricing," indicated that higher audit fees result from auditors' assessments of elevated risks associated with commercial litigation between clients and auditors. Although financial statement disaggregation may enhance the quality of financial information, it can also impose costs on firms in terms of increased audit fees and a higher likelihood of litigation [15].

Chiu and Jans (2019), in their study "Process Mining Event Logs: A Case Study on Evaluating the Effectiveness of Internal Controls," demonstrated that process mining can assist auditors in identifying audit-relevant issues such as nonstandard transaction types, weekend activities, and personnel involved in multiple violations. Process mining enables auditors to detect potential risks, inefficient controls, and ineffective processes [16].

The core focus and objective of process mining are to uncover how various organizational or business processes are actually carried out. Process identification and analysis are central to modern business solutions such as activity-based management, business process reengineering, and business intelligence. Since business processes in practice are highly complex and often interact with other processes simultaneously or with delays, they usually do not align with the expectations of process designers. The main goal of process mining is to extract knowledge from event logs recorded by information systems. Until recently, the data in these logs were rarely used for analyzing core processes. Process mining aims to improve this by providing techniques and tools to discover and identify processes, controls, data, and organizational or social structures. Since all information systems are equipped with event logs, process mining has become a dynamic and vibrant research field.

A primary concern for advocates of process mining in auditing is that if auditors are to seriously consider adopting this method, they must be explicitly convinced that process mining is a novel auditing approach—not merely a new statistical analysis method. This study, taking into account the requirements outlined in the International Standards on Auditing (ISA) and using transparent examples from a field study, discusses how process mining can be integrated into different phases of the audit to support the auditor. Accordingly, the main research question of the present study is: How can process mining be integrated into financial statement auditing as a novel data analysis technique, and what model can be proposed for this purpose?

2. Methodology

This research is applied in nature and employs a mixed-methods exploratory design (qualitative and quantitative). Participants in the qualitative phase included all experts and specialists in financial statement auditing with experience in management and policy-making. The qualitative sample size was determined to be 10 individuals based on the principle of theoretical saturation. In the qualitative approach, purposive sampling was used to select participants with rich information. Initially, a key expert was consulted for interviews with 10

specialists in financial statement auditing, and after the interview, they were asked to refer other knowledgeable individuals, through which additional experts were identified.

In the quantitative phase, the statistical population consisted of all certified public accountants responsible for financial statement auditing in reporting companies located in Tehran Province. Using stratified random sampling based on region and Cochran's formula, a sample size of 303 individuals was determined. Data collection was conducted through library research. The data collection instrument in the qualitative phase was semi-structured interviews, and in the quantitative phase, a researcher-developed questionnaire was used. The questionnaire consisted of 26 items across four dimensions: environmental factors, individual factors, institutional factors, and organizational factors.

The validity of the questionnaire was assessed using two methods: (1) face validity and (2) content validity. Reliability was confirmed using Cronbach's alpha for each dimension, calculated as 0.87, 0.70, 0.72, and 0.79, respectively. For data analysis, thematic analysis was used in the qualitative phase, and structural equation modeling was applied in the quantitative phase using SPSS and LISREL software.

3. Findings and Results

The analysis of the research findings can be utilized in various ways to support the needs of the research audience and facilitate the achievement of the study's objectives. In the present study, the first step involved an extensive review of the literature, examination of documentation, and comparative studies to define the model for integrating process mining into financial statement auditing from the perspective of experts in the field.

Table 1. Titles of Dimensions in the Model for Integrating Process Mining into Financial Statement Auditing

Environmental Factors	Individual Factors	Institutional Factors	Organizational Factors
Policies related to intellectual property	Employees' personal motivations	Organizational culture	Costs associated with process mining in auditing
Environmental and regional infrastructure	Demographic characteristics	Department	Dysfunctional organizational structure
Availability of investors in the area of process mining in auditing	Psychological characteristics	Incentives (revenue-sharing between research teams and the organization, promotion and recognition systems)	Devaluation of non-applied research
Organizational environment, density of companies in a region and their selection	Work experiences	Regulations for the protection of products and modern technologies and intellectual property rights	Prolonged bureaucratic processes
Availability of skilled and specialized human resources	Individual's social network	Organizational mission	Organizational resources (allocated revenues and budgets for process mining in auditing, technical support, physical infrastructure, communication networks)
Government-related factors		Organizational objectives	
Availability of incubators		Previous activities and contracts of the organization	
Availability of supportive laws		Organizational policies	

1. Recruitment

In the process of employee communication to achieve optimal outcomes, attention must be paid to each function of process mining in auditing. One of the most important of these functions is recruitment. Occupational

psychology research has demonstrated that certain personality types are more suitable for specific jobs. For example, in client-facing roles, traits such as behavioral extroversion, high emotional intelligence, and persuasive ability contribute to more effective communication between employees and clients, thereby aiding the organization in achieving its goals.

Moreover, individuals in high-contact positions who engage in interactive relationships with clients must possess particular interpersonal and behavioral skills. Skills such as constructive negotiation, conflict management, and stress management, alongside organizational knowledge, enable individuals to communicate more effectively. Additionally, the recruitment process itself should undergo modifications. Human resource planning, the development of job-specific competencies, and the creation of individual assessment mechanisms based on personality traits and skills can support the admission of more qualified personnel into the organization.

Table 2. Extracted Open Codes Related to the Recruitment Process in Process Mining for Auditing

Final Codes	Extracted Codes	Extracted Codes
Extroversion	Confidentiality	General behavior
Task behavior	Organizational citizenship behavior	Integrity
Job description	Suitable personality	High communication skills
High emotional intelligence	Responsibility	Patience
Warmth	Individual networking	Problem management
Creativity	Experience	Capabilities, indicators, and knowledge related to employee needs
Strong verbal communication	Learning ability	Gender (male and female)
Warm and engaging personality type	Quick to connect	Genetic traits
Negotiation ability	Numerical abilities	Attractive personal appearance
Ethics, commitment, and expertise	Expertise and motivation	Necessary potential
Service-oriented mindset	Service-oriented culture	Communication abilities
Verbal communication	Body language (behavioral and visual)	Stress management
Personality type	Eye contact and interaction	Homogeneous workforce
Extroversion	Ethical mindset	Beliefs
Personality and morality	Professional expertise	Sharp and cheerful
Competency alignment	Competency model	Memory and attention to detail
Professional recruitment process	Strong public relations	Hiring more efficient personnel
Enhanced communication and interpersonal skills	Higher stress tolerance	Verbal skills
Persuasion ability	Tolerance and flexibility	Conventional education and certification
Knowledge, skills, and abilities	Job-person fit	Personality type
Defined recruitment method	Organizational showcase	Negotiation and professional principles
Technical knowledge	High-level cultural and individual skills	Human capital recruitment
Stronger social relationships	Social intelligence	Behavioral control
Integrity	Stronger social relationships	High emotional intelligence
Responsibility	Learning ability	Persuasion ability
Higher stress tolerance	Verbal skills	Service orientation
Individual networking	Technical knowledge	Negotiation and professional principles
Enhanced interpersonal and communication skills	Standard education	Employee capabilities
Stress management	Body language	Human capital recruitment
Defined recruitment methods	Job-person fit	Professional recruitment process
Competency-based hiring	Creating an organizational competency model	

2. Development

In the realm of training, several general categories of knowledge and skills can be identified. All employees in an organization should have a comprehensive understanding of other personnel categories. This knowledge contributes to appropriate job performance. Furthermore, familiarity with the organization's identity, values, procedures, and unique services ensures accurate service delivery to staff. While some communication skills are embedded in personality traits, the power of training, repetition, and reinforcement cannot be overlooked. Therefore, training in communication skills, marketing principles, and effective interaction strategies with employees should be included in the organization's training program.

In the domain of organizational provisions, planning for employee career advancement is both one of the most significant employee demands and one of the most motivating aspects of a job. Thus, it should be prioritized and framed within an employee-centered approach.

Table 3. Extracted Open Codes Related to Development Processes in Process Mining for Auditing

Final Codes	Extracted Codes	Extracted Codes
Employee interaction methods	Required capabilities for employee interaction	Accurate understanding of employee needs
Specialized management	Consumer culture and behavior	Employee changes
Responding to employee complaints	Communication with individuals	Communication with employees
Organizational performance awareness	Competitor activities awareness	Sensitivity to changes
Problem identification	IT	Management for managers
Marketing	Succession planning	Employee beliefs and attitudes
Career path and appointments	Official contracts	Work commitment
Persuasive style	Appropriate presentation to individuals	Training position perception in employees
Employee engagement	Clear career advancement path	Managerial behavior
Effective communication skills	Sales techniques	Handling complaints
Induction training	Career path and job rotation	Appointments
Technical knowledge	Human knowledge	English proficiency
Negotiation techniques	Organizational behavior management	Proper speech training
Correct language use	Respect for cultural considerations	Extroversion
Employee-centered approach	Communication	Consumer behavior
Needs identification	Creating employee needs	Sales and negotiation techniques
Job analysis	Intelligent market understanding	Market and competitor awareness
Communication facilitation	Procedure and policy training	Support systems
Empathy and proper communication	Product knowledge	Job security
Learning environment	Belief in employee-centered approach	Meeting employee needs
Career progression	Eye contact respect	Listening to employees
Behavioral clarity	Speaking skills	Citizenship characteristics
Organizational culture and expectations	Organizational awareness	Onboarding training
Continuous training calendar	Employee training needs assessment	Organizational vision and orientation
Organizational values	Employee psychology	Stress and anxiety control
Organizational strategy familiarity	Organizational training, guarantees, and L/Cs	Target market characteristics
New product launches	Ethnicity-related topics	Healthy and proper social interaction
Identifying employee enthusiasm	Accurate understanding of employee needs	Consumer culture and behavior
Responding to employee complaints	Employee psychology	Creating employee enthusiasm
Market and competitor awareness	Procedure and policy training	Product knowledge
Organizational training	Onboarding training	Organizational culture and expectations
Organizational values	Marketing	Creating employee needs
Communication with employees	Persuasive style	Effective communication skills
Emotional intelligence	Correct language use	Stress and anxiety control
Sales and negotiation techniques	Extroversion	Specific contractual model
Appointments	Managerial behavior	Career path and job rotation

Employee training needs assessment Job security

3. Compensation

Almost all interviewees believed that incentives and rewards are effective in promoting the development of process mining in auditing. Establishing a link between motivational aspects of personnel compensation and training-oriented principles in the organization can enhance such behaviors and gradually cultivate a training-oriented culture. Designing an appropriate compensation model requires a strong emphasis on performance evaluation parameters. The more tangible and directly linked these parameters are to strategic concepts and employee rights, the more impactful they become. However, the experiences of a large group of organizational industry experts indicate that alternative forms of compensation (instead of monetary rewards) are more effective in fostering a service-oriented culture. This includes recognizing individuals and showing respect. Research shows that employees tend to replicate the behavior they receive from their managers in their interactions with others in the organization.

Table 4. Extracted Open Codes for Compensation Processes in Process Mining for Auditing

Final Codes	Extracted Codes	Extracted Codes
Individual's sense of position	Creating pride in individuals	Behavior reinforcement
Time for individual recognition	Influenced by employee satisfaction criteria	Assurance of accurate service delivery
Teamwork	Competency models for jobs	Competency-based and resource-based
Rewards instead of salary	Performance-based pay	Performance evaluation
Linking compensation to behavior	Employee satisfaction	Cost reduction
Process improvement	Satisfaction and loyalty of employees	Increased employee attraction
Goal fulfillment	Non-monetary compensation	Individual status promotion
Clear benefits	Performance change and pay improvement	Perspective of colleagues, managers, and employees
Social behavior and skill level	Receptiveness of individuals	Motivation to serve
Quality of individual performance from employee view	Good communication with employees	Motivational section
Directly behavior-related	Tangible	Compliance with health and motivational conditions
Creating pride in individuals	Time for individual recognition	Individual status promotion
Performance evaluation	Process improvement	Influenced by employee satisfaction criteria
Assurance of proper service delivery	Social skills and behavior level	Performance quality from employee view
Satisfaction and loyalty	Receptiveness of individuals	Tangibility
Performance-based pay	Direct behavioral link	Behavior reinforcement
Non-monetary compensation	Rewards instead of salary	

4. Performance Evaluation in Process Mining for Auditing

Performance management is the most central function in most models of process mining in auditing. It is defined as a set of actions and information aimed at optimizing the use of resources and facilities to achieve objectives efficiently, effectively, and economically. One of the most important phases of performance management in process mining for auditing is performance evaluation. Interviewees also acknowledged the significance of this function and emphasized that, with a well-structured, realistic, and actionable performance evaluation system, many other functions of process mining in auditing can be organized effectively.

Table 5. Extracted Open Codes for Performance Evaluation in Process Mining for Auditing

Final Codes	Extracted Codes	Extracted Codes
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Employee satisfaction survey	Satisfaction criteria	Accurate delivery, recognition, and definition of specific products
Quantitative and qualitative evaluation	Employee satisfaction survey	Individual performance measurement
Operational and financial parameters	Market research	Employee evaluation
Employee behavior	Evaluation of proper communication	Meeting employee needs
Identifying employee needs	Financial objectives	Speed, accuracy, and security
Profitability indicators	Aligned with employee expectations	Process compliance
Employee satisfaction and service quality	Quality of employee communication	Disciplinary system
Organizational core values	Branch profitability	Proper responsiveness to employees
Maintaining dignity and respect	Appropriate employee behavior	Employee-centeredness
Trustworthiness	Ability to solve complex issues	Performance outcomes such as branch profitability
Perception of employee satisfaction	Peace of mind and willingness	Employee satisfaction survey
Comparison with global benchmarks	Effective communication	Service delivery method
Response speed and behavior	Technical competence and employee follow-up	Precision and level of employee dissatisfaction
Teamwork spirit	Per capita resources	Quantitative indicators
Presented expectations	Initial value offerings	Responsibility
Market research	Branch profitability	Global benchmark comparison
Peace of mind and willingness	Per capita resources	Employee retention
Teamwork spirit	Effective communication	Respect and dignity
Disciplinary system	Speed, accuracy, and security	Quantitative indicators
Employee behavior	Individual performance measurement	Employee evaluation

Main Research Question: How can process mining be integrated into financial statement auditing as a new data analysis technique, and what model can be proposed?

In response to this question, based on the qualitative and quantitative findings of the study — derived from open interviews with experts (using thematic analysis in the qualitative phase), followed by the distribution of closed questionnaires to the statistical population (quantitative phase), and analysis using structural equation modeling — the identified dimensions were analyzed in a structural model. In the proposed model, the paths between variables represent the effectiveness of the identified factors.

Table 6. Confirmatory Factor Analysis Results for the Four Dimensions (Environmental, Individual, Institutional, Organizational) in the Model for Integrating Process Mining into Financial Statement Auditing

Dimension	Question	Factor Loading	T-Statistic	Result
Environmental Factors	Q1	0.91	12.31	Confirmed
	Q2	0.92	11.66	Confirmed
	Q3	0.89	10.94	Confirmed
	Q4	0.86	10.36	Confirmed
	Q5	0.86	10.36	Confirmed
	Q6	0.89	11.04	Confirmed
	Q7	0.84	9.98	Confirmed
	Q8	0.91	11.34	Confirmed
Individual Factors	Q1	0.88	10.68	Confirmed
	Q2	0.89	11.03	Confirmed
	Q3	0.86	10.30	Confirmed
	Q4	0.83	9.72	Confirmed
	Q5	0.89	10.83	Confirmed
Institutional Factors	Q1	0.87	10.46	Confirmed

Organizational Factors	Q2	0.86	10.40	Confirmed
	Q3	0.88	10.67	Confirmed
	Q4	0.88	10.64	Confirmed
	Q5	0.88	10.72	Confirmed
	Q6	0.88	10.73	Confirmed
	Q7	0.83	9.84	Confirmed
	Q8	0.87	10.58	Confirmed
	Q1	0.91	11.31	Confirmed
	Q2	0.90	11.52	Confirmed
	Q3	0.90	11.03	Confirmed
	Q4	0.86	10.29	Confirmed
	Q5	0.84	9.99	Confirmed

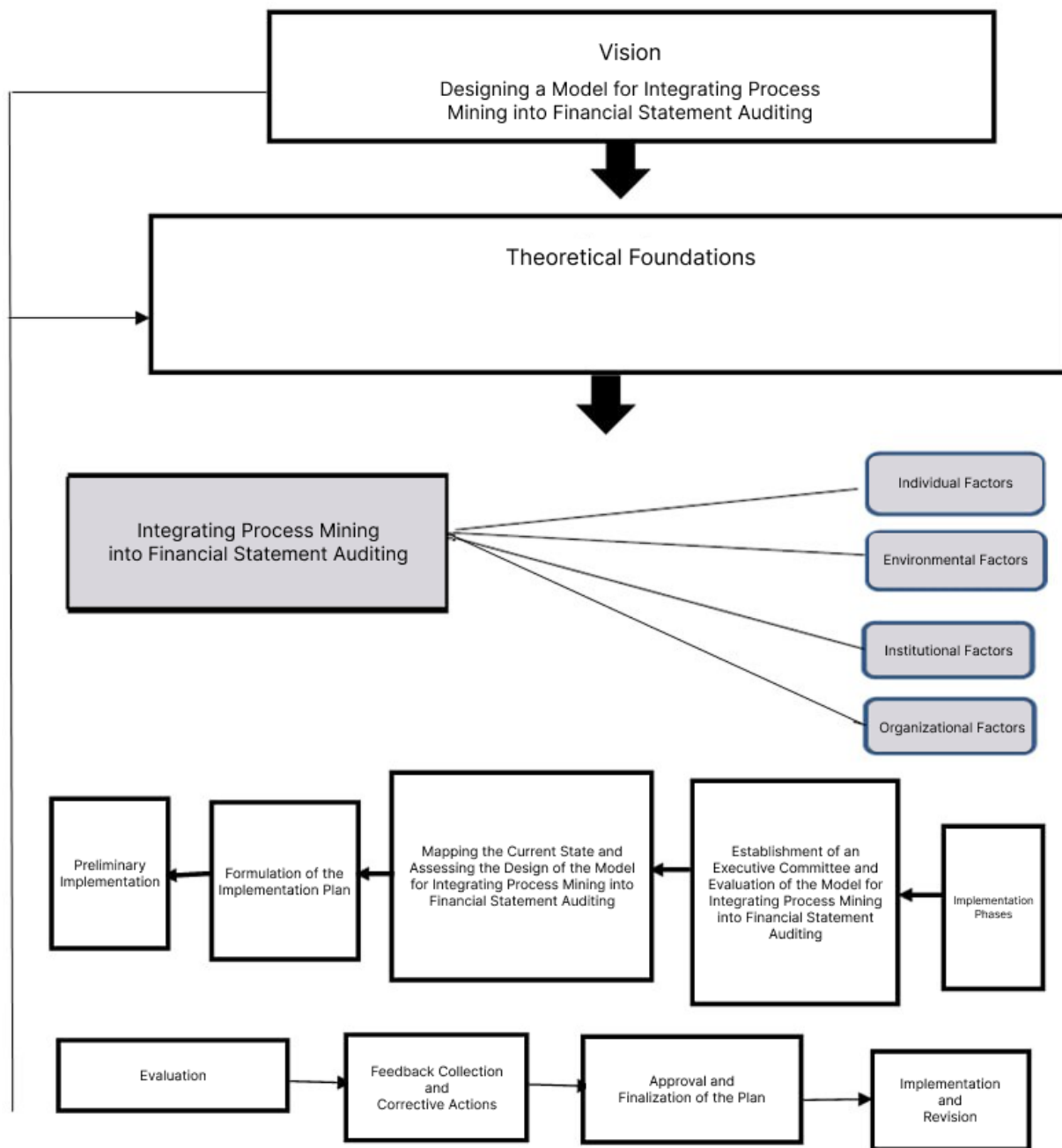


Figure 1. Final Model of the Study

4. Discussion and Conclusion

The examination of the model design for integrating process mining into financial statement auditing in the present study indicates that the variable "management excellence" encompasses four main themes: (1) environmental factors, (2) individual factors, (3) institutional factors, and (4) organizational factors, along with four sub-themes: (1) recruitment, (2) development, (3) compensation, and (4) performance evaluation. The findings of this study align with those of previous research [8, 12-15].

In explaining these results, it can be stated that financial statement auditing is a highly complex and specialized process. Digitalization and the automation of transaction processing have introduced new challenges for auditors. Emerging data analysis techniques offer opportunities to enhance the audit of financial statements and overcome the limitations of traditional auditing procedures, particularly when handling the increasing volume of financial transactions that are processed automatically or semi-automatically by computer systems. This study has discussed process mining as a novel data analysis technique that is gaining greater attention in auditing practices. Process mining enables the automated analysis of business processes. By examining relevant auditing standards and combining them with the results of a field study, this research explores how process mining can be integrated into modern auditing. The study confirms the feasibility of incorporating process mining into financial statement auditing in accordance with contemporary auditing standards and generally accepted auditing practices. The implementation of process mining increases the reliability of audit outcomes and enhances audit evidence by replacing manual audit methods. As a new data mining technique, process mining provides auditors with tools to keep pace with technological advancements and challenges.

It appears that the mined process covers a wide range of transactions within the audited company, particularly those related to the purchase of products from local third parties. However, the reconciliation of many accounts shows that clearing accounts for others, as well as trade payables for non-local suppliers and manually labeled accounts, are covered to a much lesser extent—or not at all. Beyond providing information on the completeness and accuracy of analyzed transactions, such reconciliation helps the auditor identify unusual or unexpected relationships. Additionally, the auditor, through process mining analysis of different transaction categories combined with the aforementioned financial reconciliation, obtains quantitative insights into the degree of automation in transaction processing. The information derived from financial matching tells the auditor the extent to which transactions associated with a specific financial account have actually been recorded through semi-automated or fully automated processes.

The information obtained enables the auditor to quantitatively evaluate identified exceptions, pinpoint significant deficiencies, assess control risk, and determine the impact on the nature, timing, and extent of subsequent audit procedures. For example, price discrepancies between ordered and invoiced goods may result from missed or realized early payment discounts, depending on the accounting methods chosen by the audited entity. However, it remains unclear whether the related control failed or was valid in specific instances but overlooked. When the auditor detects control deviations, the analysis results can be used to guide more substantive audit procedures.

Based on the above findings, the following practical recommendations are presented:

- By utilizing the components and dimensions of the model for integrating process mining into financial statement auditing, and considering the systemic relationships of organizations both internally and with external entities, self-efficacy in the field of process mining in financial auditing can be broadly expanded.

- Through the application of process mining in financial auditing, mechanisms of job performance and conscientiousness among employees can be enhanced to improve overall performance.
- By reinforcing process mining in financial auditing, the foundation for the emergence of respectful behavior and civic virtue in employees' professional performance can be improved in terms of self-efficacy.

Authors' Contributions

Authors equally contributed to this article.

Ethical Considerations

All procedures performed in this study were under the ethical standards.

Acknowledgments

Authors thank all participants who participate in this study.

Conflict of Interest

The authors report no conflict of interest.

Funding/Financial Support

According to the authors, this article has no financial support.

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