
**Analytical Procedures, Risk Signals, and Auditor's Professional Judgment in
Audit Planning: An International Literature Review**

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Abstract

Analytical procedures are widely used during audit planning to identify unexpected relationships, unusual fluctuations, and other risk-relevant information, yet the literature explaining how such information is evaluated and incorporated into auditors' planning-stage professional judgment remains fragmented across research on analytical procedures and research on auditor judgment and decision making. This narrative review examines how risk signals arising from analytical procedures are evaluated, weighted, and integrated by auditors when assessing risks of material misstatement during audit planning. Using purposive and snowball sampling, the review synthesizes literature spanning the 1970s to 2026. The synthesis organizes existing research through a review-specific conceptual framework in which risk-relevant analytical results are evaluated as signals, weighted and integrated with other information, examined through diagnostic reasoning, and incorporated into evolving risk assessments through belief updating; professional skepticism operates as a cross-cutting condition affecting the quality of these processes. The review identifies three related gaps: limited theoretical integration across these cognitive mechanisms, insufficient empirical examination of the integrated process and its boundary conditions, and uncertainty regarding the transferability of existing findings across different institutional and technological audit environments. Its principal conceptual contribution is therefore not the introduction of a new standalone theory, but the organization and connection of previously separate research streams into a common planning-stage explanatory account

linking analytical procedures, risk signals, and professional judgment. This synthesis provides a basis for future empirical examination of the proposed relationships and their boundary conditions, including in developing-country audit environments.

Keywords: analytical procedures, risk signals, professional judgment, audit planning, cue utilization theory, diagnostic reasoning, belief-adjustment theory, professional skepticism

1. Introduction

Audit planning establishes the overall direction, scope, and foundation for subsequent audit work. Analytical procedures applied at this stage allow auditors to examine relationships, variations, and trends in financial and non-financial information, thereby identifying issues requiring attention. Such procedures often generate risk signals—such as unusual fluctuations or deviations from expectations (ISA 520, 2023; Messier, Glover, & Prawitt, 2021). These signals do not themselves constitute audit conclusions; rather, auditors must evaluate their significance and integrate them with other relevant information to form professional judgment at the planning stage (Libby, Artman, & Willingham, 1985; Bonner, 1999).

The institutional foundation of this topic is linked to Agency Theory (Jensen & Meckling, 1976): information asymmetry and conflicts of interest between principals (owners) and agents (management) create the need for independent audits. This institutional requirement underpins the necessity of assessing risks of material misstatement during audit planning. In this study, Agency Theory provides the background explanation for audit planning requirements, while the cognitive mechanisms of how auditors use risk signals are explained through Cue Utilization Theory, Diagnostic Reasoning, and Belief-Adjustment Theory (section 3.4).

This subject is not new: since the 1970s, extensive research has accumulated on auditor judgment and decision-making (JDM), with some studies themselves published as major literature reviews. To position this review within the existing literature, prior international reviews addressing analytical procedures, risk signals, or auditor professional judgment are first identified and compared in terms of their scope, contributions, and limitations (Section 4).

Although analytical procedures and professional judgment have each been widely studied, the mechanisms through which auditors evaluate and integrate risk signals from analytical procedures when forming planning-stage professional judgment have not yet been brought together within a single explanatory account. This review therefore addresses the following research question: How does the international auditing literature explain the process through which auditors evaluate and integrate risk signals arising from analytical procedures into professional judgment during the audit planning stage?

The review's scope is accordingly bounded to the audit planning stage: it synthesizes evidence on how analytical-procedure-generated risk signals are evaluated, weighted, and integrated into planning-stage judgments concerning the risk of material misstatement, while studies on subsequent audit responses, substantive testing, or final audit opinions fall outside its scope.

Foundational studies on general auditor judgment and decision-making that are not specific to analytical procedures are drawn upon selectively, as supporting theoretical evidence to explain the underlying cognitive mechanisms (Section 3.4), rather than as the review's core evidence base.

2. Methodology of the Literature Review

2.1. Type of Review

A systematic review synthesizes research findings based on predefined search strategies and selection criteria, and when quantitative results need to be combined statistically, meta-analysis is used. In contrast, a narrative review is more suitable for synthesizing diverse qualitative and theoretical research directions, organizing them thematically, chronologically, and according to the logic of theoretical development (Grant & Booth, 2009; Snyder, 2019).

The subject of this study (analytical procedures, risk signals, and auditor professional judgment) is based on empirical research accumulated over several decades, conducted in both experimental and real audit environments with diverse methodologies. Therefore, this article adopts a narrative literature review approach with critical synthesis. This choice is consistent with the methodological tradition widely used in audit research (Bonner, 1999; Nelson & Tan, 2005; Messier, Simon, & Smith, 2013; Appelbaum, Kogan, Vasarhelyi, & Yan, 2018).

2.2. Source Identification Process, Scope, and Criteria

Sources were identified through an extensive, iterative source-identification process conducted between September 2025–June 2026, using structured searches of Web of Science, Scopus, and Google Scholar, supplemented by citation snowballing from key works. The process was documented in a structured literature record that recorded each source's research purpose, principal findings, relevance to the broader research program, and preliminary assessment for potential use. In total, 233 candidate works were logged. Following preliminary screening, 21 records were excluded because they were duplicates or had been assessed in the screening record as not suitable for use in the broader research program, leaving a broader pool of 212 works spanning audit planning, analytical procedures, auditor judgment and decision making, risk assessment, and related audit-technology research. From this broader pool, 70 works were identified as directly relevant to the specific scope of the present review—analytical procedures, risk signals, and professional judgment in audit planning—and were retained for the review-specific evidence base.

This process drew on three main source categories and identification routes:

Academic articles published between the 1970s and 2026 in leading journals on analytical procedures, risk signals, and auditor professional judgment (The Accounting Review, Journal of Accounting Research, Auditing: A Journal of Practice & Theory, Contemporary Accounting Research, Accounting Horizons, Accounting, Organizations and Society, Journal of Accounting Literature).

Official standards and guidance from international audit standard-setting bodies (the International Auditing and Assurance Standards Board [IAASB], the Public Company Accounting Oversight Board [PCAOB], and the American Institute of Certified Public Accountants [AICPA]), including standards, implementation guidance, and inspection reports.

Relevant prior literature reviews directly related to the topic, along with their cited primary sources and additional relevant studies identified through snowball sampling.

Keywords used in the search included: “analytical procedures,” “audit risk signal,” “red flag,” “cue utilization theory,” “diagnostic reasoning in auditing,” “professional judgment in auditing,” “professional skepticism,” “audit planning,” “risk assessment procedures.”

Within this broader pool, studies meeting the review-specific inclusion criteria constituted the core evidence base. Broader auditor judgment and decision-making, professional skepticism, and foundational theoretical studies were used selectively as supporting evidence.

Inclusion criteria:

- Direct relevance to analytical procedures used during audit planning, risk signals arising from or interpreted through such procedures, or auditors’ evaluation and integration of those signals into planning-stage professional judgment and risk assessment.
- For the core evidence base, priority was given to peer-reviewed journal articles and authoritative auditing standards or guidance. Foundational theoretical and methodological works were retained separately where necessary to support conceptual development and review methodology.

Exclusion criteria:

- Works focusing primarily on other topics such as financial reporting quality or auditor independence, without direct connection to analytical procedures or professional judgment.
- Works focusing primarily on audit stages beyond planning, including substantive testing, subsequent audit responses, or final audit opinions, unless they provided supporting theoretical insight directly relevant to the interpretation or integration of planning-stage risk signals.

It should be noted that this review is not a fully protocol-based systematic search in the style of Cochrane or PRISMA. Instead, it follows purposive and snowball sampling based on key works, citation networks, and leading journals.

2.3. Analytical Framework

The collected sources were analyzed at three levels.

Chronological: The stages of research development were identified, showing how the focus of studies shifted over time.

Thematic: The studies were grouped into two major categories with similar content — (a) the use of analytical procedures, and (b) risk signals and professional judgment — and synthesized accordingly.

Theoretical: The main theoretical frameworks used in the studies (Cue Utilization Theory, Diagnostic Reasoning, and Belief-Adjustment Theory) were identified, and their interrelationships were explained.

2.4. Limitations of the Review Methodology

This review has several methodological limitations that should be considered when interpreting its findings.

First, source identification relied on purposive and snowball sampling rather than a fully protocol-based systematic search. While the underlying literature record covered a broad pool of 212 works over an extended period (September 2025–June 2026), this pool reflects a broader research program rather than an exhaustive, review-specific search, and some relevant studies may have been missed.

Second, screening and selection of sources were conducted primarily by a single researcher without independent second-reviewer verification, which introduces the possibility of selection bias.

Third, the review draws primarily on major accounting and auditing outlets; studies published in other languages, interdisciplinary outlets outside the principal accounting and auditing literature, non-indexed regional journals, and unpublished working papers were not systematically searched, which may limit the scope of perspectives captured.

These limitations are characteristic of narrative review approaches and should be considered when interpreting the review's conclusions (Grant & Booth, 2009).

3. Theoretical Foundations and Key Concepts

3.1. Analytical Procedures

Analytical procedures are audit techniques that examine plausible relationships among financial and non-financial information to identify significant deviations from expectations or inconsistencies with other relevant data (ISA 520, 2023). Theoretically, this process involves forming expectations based on prior knowledge, comparing them with actual information, and detecting unexpected variances. In this review, such unexpected variances may constitute potential risk signals when they are risk-relevant and warrant further auditor evaluation.

This logic is consistent with Kinney's (1979) expectation model, Koonce's (1992) explanation–counterexplanation approach, Hirst & Koonce's (1996) empirical studies in real audit settings, and Appelbaum et al.'s (2018) Analytical Procedures Framework. These studies do not define

analytical procedures differently, but rather examine them from different perspectives: some focus on explaining auditors' cognitive processes, while others systematize the structure, use, and development of analytical procedures.

In practice, analytical procedures have evolved from traditional statistical and comparative methods to data-driven audit analytics platforms, general ledger analytic tools, and even AI-based approaches. Despite these developments, a common audit-planning function of these approaches is to identify information that may indicate audit risk (Appelbaum et al., 2018; Cao, Chychyla, & Stewart, 2015; O'Leary, Richardson, & Watson, 2025). Therefore, this study treats analytical procedures as sources of risk signals during audit planning, and their theoretical development, empirical evidence, and practical application are examined in detail in section 5.

3.2. Risk Signals

During audit planning, auditors use analytical procedures to identify information that may indicate risks of material misstatement. In the literature, such information is described using terms such as cue, anomaly, unusual fluctuation, red flag, and risk indicator, depending on scope and purpose (Libby, 1981; Lombardi, Sipior, & Dannemiller, 2023). A cue is the most general unit of information in decision-making and does not itself prove risk (Brunswik, 1952; Libby, 1981). Accordingly, cue is used in this review as the broader cognitive concept referring to information available to a decision-maker—most directly relevant to Cue Utilization Theory (Section 3.4)—whereas the terms discussed below refer more specifically to risk-relevant information in the context of analytical procedures.

Koonce (1992) explained how auditors interpret and evaluate such information, while Brazel, Jones, & Zimbelman (2009) empirically demonstrated that unusual discrepancies between financial and non-financial data can serve as signals requiring further investigation. Such anomalies and unusual fluctuations do not by themselves establish that a material misstatement exists; rather, when they are risk-relevant and warrant further evaluation, they are treated in this review as potential risk signals. Loebbecke, Eining, & Willingham (1989) identified red flags as warning indicators particularly relevant to fraud risk. Accordingly, red flag is treated as a narrower warning concept, whereas risk signal is used in this review as a broader integrative concept for risk-relevant information arising from analytical procedures. The term risk indicator is used more broadly across auditing and risk-related literature and is therefore not treated as strictly interchangeable with the review-specific concept of a risk signal.

Accordingly, this review adopts risk signal as an integrative, review-specific concept rather than as a term formally defined in auditing standards. A risk signal is defined as risk-relevant information arising from an unexpected relationship, unusual fluctuation, inconsistency, or other result identified through analytical procedures that warrants further auditor evaluation during audit planning. A risk signal does not by itself establish that a material misstatement exists; rather, it serves as an informational input that auditors evaluate, weight, and integrate with other relevant information when forming planning-stage professional judgment and assessing risks of material misstatement.

3.3. Professional Judgment

Professional judgment is the cognitive process by which auditors make reasoned decisions based on professional knowledge, experience, applicable standards, and contextual information (Bonner, 1999; Nelson & Tan, 2005). In audit decision-making research, this process is described as sequential information processing: collecting, evaluating, integrating, and forming conclusions (Libby, 1981). These approaches complement each other, collectively explaining both the cognitive and decision-making aspects of professional judgment.

According to international auditing standards, professional judgment integrates the entity's business environment, internal controls, results of analytical procedures, and other relevant information to form the basis for assessing risks of material misstatement (ISA 200, 2023; ISA 315 (Revised 2019), 2023).

In this study, planning-stage professional judgment is defined as the process of integrating risk signals from analytical procedures with other relevant information to reasonably assess risks of material misstatement. This definition applies only to the planning stage and does not include subsequent audit responses, substantive testing, or final audit opinions.

3.4. Theoretical Frameworks

To explain how risk signals identified through analytical procedures are evaluated and incorporated into planning-stage professional judgment, this review adopts a review-specific integrated conceptual framework that draws on three complementary theoretical perspectives—Cue Utilization Theory, Diagnostic Reasoning, and Belief-Adjustment Theory—rather than proposing a new standalone theory.

Within this framework, analytical procedures (Section 5) may reveal an unexpected relationship, unusual fluctuation, or inconsistency. As defined in Section 3.2, such a result may constitute a potential risk signal when it is risk-relevant and warrants further auditor evaluation; this threshold reflects a direct application of the risk-signal definition rather than a separate theoretical stage, and it precedes the cognitive processing explained by the theories below.

Cue Utilization Theory (Brunswik, 1952; Libby, 1981): Auditors evaluate the relevance and reliability of multiple information signals and integrate them into conclusions. It provides the foundation for explaining how risk signals identified through analytical procedures are weighted and combined.

Diagnostic Reasoning (Koonce, 1992): Auditors compare possible explanations for signals and select the most plausible one. In practice, cue weighting and diagnostic reasoning are interactive rather than strictly sequential: as auditors weight and integrate a risk signal against other available cues, they simultaneously develop and compare possible explanations for it, revising each in light of the other (Bedard & Biggs, 1991).

Belief-Adjustment Theory (Hogarth & Einhorn, 1992): Auditors update prior evaluations as new information is added, explaining how the sequence of information influences final assessments. As additional risk signals or evidence emerge during planning, this updating process repeats, so that planning-stage judgment develops through successive rounds of evaluation rather than a single pass. Professional skepticism (Section 6.5) is not a separate stage in this process; rather, it is a cross-cutting condition that influences the quality of evaluation, reasoning, and integration throughout.

This framework does not replace the Analytical Procedures Framework of Appelbaum et al. (2018); rather, it extends the explanatory focus beyond the analytical-procedure process itself to the cognitive mechanisms through which risk-relevant analytical results are evaluated, reasoned about, and integrated as auditors form planning-stage professional judgment for assessing risks of material misstatement.

4. Prior International Literature Reviews on This Topic

To position the present review within the existing literature, the search strategy described in Section 2.2 identified relevant prior international reviews addressing analytical procedures, risk signals, and auditor professional judgment, either separately or in combination. The most directly relevant reviews were then compared in terms of their review method, scope, contributions, and limitations, as summarized in Table 1.

Table 1. Selected Prior International Literature Reviews Relevant to This Topic

Author (Year)	Review Method / Context	Scope	Main Contribution	Distinctive Features Compared to This Review
Bonner (1999)	Narrative synthesis of accounting JDM research	General review of judgment and decision-making (JDM) research in accounting	Synthesized research on professional judgment and decision-making, systematizing how knowledge, experience, task characteristics, and environmental factors affect decision quality.	Addressed audit decision-making broadly but did not connect risk signals from analytical procedures to planning-stage judgment.
Nelson & Tan (2005)	Narrative review organized by task, person, and interpersonal-interaction factors	Review of audit professional judgment and decision-making research	Summarized an integrated framework explaining auditor decision-making through the interaction of task characteristics, individual traits, and environmental factors.	Covered general audit decision-making but did not specifically examine the cognitive mechanisms of risk signals from analytical procedures.
Nelson (2009)	Narrative review proposing a theoretical model of professional skepticism	Review of theories and models of professional skepticism	Developed a theoretical model explaining how professional skepticism affects the quality of audit judgment.	Focused on skepticism, without addressing how risk signals are generated or used.
Hammersley (2011)	Narrative review proposing a model of fraud-related planning judgments	Review of auditor judgment in planning fraud risk assessments	Systematized cognitive factors influencing fraud risk evaluation and planning-stage decision-making.	Focused only on fraud risk, not on general audit risk signals.
Messier, Simon, & Smith (2013)	Narrative synthesis of two decades of behavioral analytical-procedures research	20-year review of behavioral research on analytical procedures	Synthesized empirical studies on analytical procedures, systematizing findings on expectation formation, comparison, and explanation processes.	Concentrated on analytical procedures and behavioral research, without specifically isolating planning-stage risk signals.
Appelbaum, Kogan, Vasarhelyi, & Yan (2018)	Systematic literature survey synthesizing 301 studies	Comprehensive review of analytical procedures and audit analytics in external auditing	Synthesized 301 studies, developed the Analytical Procedures Framework, and identified trends and gaps in audit analytics.	Focused on analytic methods and technological development, without unifying risk signals from analytical procedures with professional judgment mechanisms.
Barr-Pulliam, Calvin, Eulerich, & Maghakyan (2024)	Narrative review of the literature conducted in response to IAASB Exposure Draft ED-500	Review of recent research on audit evidence, technology, and professional judgment	Synthesized recent studies on audit evidence and technology, systematizing how technological change affects evidence evaluation and auditor judgment.	Focused on audit evidence and technology, without specifically addressing risk signals from analytical procedures in planning.

Source: Compiled by the author based on the reviewed literature

Taken together, the prior reviews summarized in Table 1 do not establish that no prior research has connected analytical procedures and auditor judgment. Rather, they show that existing reviews have primarily organized the literature around broader judgment and decision-making, professional skepticism, fraud-risk assessment, analytical procedures, or technology and audit evidence. This comparison provides the basis for the present review's narrower contribution: explaining how risk-relevant results arising from analytical procedures can be traced through cognitive evaluation and integration into planning-stage professional judgment. The following sections therefore examine research on analytical procedures (Section 5) and on risk signals and professional judgment (Section 6) in greater detail.

5. Use of Analytical Procedures in Audit Planning

5.1. Foundational Studies (1970s–1980s)

The earliest studies on analytical procedures focused not so much on the methods themselves, but on how auditors, working with limited information, could form expectations, detect unusual fluctuations, and identify issues requiring attention at an early stage. In other words, these studies aimed to establish—both theoretically and empirically—that analytical procedures serve as tools supporting risk assessment during audit planning.

One of the first studies in this area, Kinney (1979), examined how auditors could form expectations using limited information within preliminary analytical procedures, showing that the effectiveness of such procedures depends heavily on the quality of the expectations developed by auditors. Later, Hylas & Ashton (1982) demonstrated that analytical evaluation contributes meaningfully to detecting errors in financial statements. Hirst & Koonce (1996), through field studies, found that auditors widely use analytical procedures in practice, and that the processes of expectation formation and explanation of variances determine their effectiveness. Subsequently, Eimers (2002) empirically confirmed, based on actual audit documentation, that the efficiency of analytical procedures is closely linked to the quality of expectation formation, auditors' knowledge of the client, and risk assessment.

5.2. The Standardization Era

The use of analytical procedures shifted from theoretical research to formal requirements in auditing standards, making them an official component of audit planning (AICPA, 1988; ISA 520, 2023). This development established analytical procedures not merely as efficient audit techniques but as essential procedures for risk assessment.

The standardized role of analytical procedures became increasingly important as data analytics expanded the range and complexity of information available for audit analysis (Appelbaum, Kogan, & Vasarhelyi, 2017).

5.3. Technology and Data-Driven Analytics

Research from the past decade increasingly examines the extension of analytical procedures toward full-population analytics, continuous auditing, and AI-driven risk assessment. This growing body of literature reflects not only technological change but a broader theoretical and practical inquiry into the quality and scope of information available for audit planning.

5.3.1. Data-Driven Analytics

Studies on data-driven analytics suggest that the informational environment and potential scope of analytical procedures have expanded. Trompeter & Wright (2010), drawing on interviews with 36 audit practitioners, and Earley (2015), in a practice-oriented discussion, both point to a trend of supplementing traditional sampling methods with data-driven analytics. Vasarhelyi, Kogan, & Tuttle (2015) explained this shift theoretically, while Cao, Chychyla, & Stewart (2015) conceptually argued that big data analytics can enhance early detection of high-risk accounts and transactions. Subsequent studies examined the opportunities, challenges, and use of analytic platforms in greater depth, indicating that analytical procedures are increasingly supplemented by full-population analytics in the audit environments studied (Appelbaum, Kogan, & Vasarhelyi, 2017; Eilifsen et al., 2020; Sanoran & Ruangprapun, 2023; O’Leary, Richardson, & Watson, 2025). In particular, Appelbaum, Kogan, Vasarhelyi, & Yan (2018) synthesized 301 studies to develop the Analytical Procedures Framework, systematizing analytical procedures as a sequential process of expectation formation, comparison, and explanation of variances. Their work provides a comprehensive synthesis of this literature. Collectively, this literature suggests that data analytics can broaden the information available for analytical procedures; however, the strength of this conclusion varies with the nature of the evidence. Conceptual and practice-oriented discussions primarily identify potential capabilities, empirical and exploratory studies provide evidence of actual use in the engagements examined, and Appelbaum et al.’s (2018) synthesis aggregates evidence across 301 primary studies without itself constituting new primary evidence of adoption. Taken together, the literature supports an expansion in analytical capability more clearly than it establishes uniform adoption across audit practice.

5.3.2. Continuous Auditing

Research on continuous auditing extended data-driven analytics to real-time risk assessment. Chan & Vasarhelyi (2011) explained that continuous auditing increases the ability to detect risks earlier. Eulerich, Georgi, & Schmidt (2020) empirically demonstrated that continuous audit information supports risk-based audit planning and enables continuous updating of risk assessments during planning.

These findings suggest that, in the audit environments examined, continuous-auditing approaches can accelerate information processing and support more frequently updated risk assessment. They do not, however, establish that such practices are uniformly implemented across audit settings.

5.3.3. Predictive Analytics and Artificial Intelligence

Recent studies have focused on predictive analytics based on machine learning and artificial intelligence. Alotaibi (2023), Onwubuariri et al. (2024), and Ogbonna et al. (2025) report that predictive analytics can improve efficiency in identifying risks during audit planning and enhance the ranking of high-risk accounts and transactions, while also noting that questions remain about how auditors validate these results and integrate them into professional judgment. At the practical level, Kokina et al. (2025) discuss both the opportunities associated with AI in auditing and continuing implementation challenges, including issues related to interpretability and auditor responsibility. The PCAOB (2023, 2024) provides regulatory guidance consistent with this view, stressing that analytic tools are intended to support—not replace—auditors’ professional judgment.

Critical Synthesis

Synthesizing the above studies shows that the development of analytical procedures has progressed along three main directions: traditional analytics, standardized risk assessment, and data-driven technological analytics. However, these studies have primarily focused on the capabilities of analytic tools and the effectiveness of information processing, while relatively little attention has been given to how risk signals generated by analytics are actually used in auditors’ professional judgment during the planning stage.

These findings need not be read as conflicting: Cao, Chychyla, & Stewart (2015) and Vasarhelyi, Kogan, & Tuttle (2015) address the informational capability of big data analytics for identifying risks earlier and across a broader scope, while PCAOB (2024) addresses a related but distinct question—the allocation of responsibility for evaluating and acting on that information—and Kokina et al. (2025) highlight interpretability and implementation challenges that may affect how that information is used in practice. Read together, these sources suggest that advanced analytical technologies may expand the information available to auditors while leaving the evaluation and interpretation of that information dependent on professional judgment. However, the literature does not establish that these effects or patterns of adoption are uniform across firms, engagements, or technological environments.

5.4. Limitations and Criticism

Recent studies have highlighted several limitations in the use of analytics-based procedures. The “black-box” nature and limited explainability of advanced analytic models create difficulties in using analytic results as audit evidence (Kokina et al., 2025). Moreover, the reliability of analytics depends directly on data quality and governance (Alles & Gray, 2016). Differences in platforms, analytic logic, and documentation methods across audit firms further show that a unified methodology has not yet been fully established (Appelbaum et al., 2017; Hezam et al., 2023).

Taken together, these studies show that the volume and variety of information generated by analytical procedures have expanded, but most evaluate audit quality in terms of tool

performance (e.g., detection accuracy) rather than the cognitive process by which auditors use this information in planning-stage professional judgment. Research on analytical procedures has accumulated substantial knowledge about how unusual fluctuations, anomalies, and other risk-relevant analytical results are identified, while their subsequent use in planning-stage professional judgment remains less clearly integrated in the literature. This gap connects directly to the next section, which examines risk signals and auditor professional judgment.

6. Risk Signals and Auditor's Professional Judgment

The technological development of analytical procedures has expanded the informational environment for generating risk signals. Subsequent streams of research have focused on how auditors cognitively process these signals and use them in their professional judgment.

6.1. Information Signals and Theoretical Foundations of Professional Decision-Making

The earliest studies on information signals in auditor judgment sought to explain how auditors evaluate and use information in decision-making. Libby, Artman, & Willingham (1985) showed that auditors use various types of information in planning-stage risk assessments, and that such information is not itself a final conclusion but rather input for subsequent professional evaluation. Ashton (1974) experimentally demonstrated that auditors may reach different internal control assessments even when based on the same information. Libby (1975) explained that weighting quantitative information such as financial ratios plays an important role in auditors' judgment.

Later research applied more specific types of information signals, building on the red flag and discrepancy-based signal concepts already distinguished in Section 3.2 (Loebbecke, Eining, & Willingham, 1989; Brazel, Jones, & Zimbelman, 2009).

6.2. Diagnostic Reasoning Theory

Early studies demonstrated that auditors do not merely detect anomalies through analytical procedures but also form professional judgment by explaining their possible causes. Koonce (1992) showed that in analytical review, auditors do not simply accept one explanation but evaluate possible explanations alongside counter explanations, thereby clarifying the basic mechanism of diagnostic reasoning. Anderson & Koonce (1998) extended this by showing that auditors not only identify possible causes but also assess whether a given explanation sufficiently accounts for the observed variance.

Subsequent studies examined this process in greater detail. Yip-Ow & Tan (2000) found that the rationale provided by the preparer of an explanation influences the reviewer's new hypotheses and judgment. Green & Trotman (2003) showed that differences in performance on analytical review tasks are closely linked to the quality of explanations. Plumlee, Rixom, & Rosman (2015) demonstrated that metacognitive training improves the quality of analytical review, while Rose et al. (2020) empirically showed that having more explanations does not necessarily lead to higher-quality audit decisions.

Synthesizing these studies, the process of using analytical review results is not limited to detecting anomalies but involves developing, comparing, and evaluating possible causes, and ultimately selecting the most plausible explanation—a sequential cognitive process.

6.3. Cue Utilization Theory and Information Integration

Cue Utilization Theory, rooted in the lens-model tradition, was developed by Brunswik (1952), who argued that decision-makers evaluate real-world conditions indirectly, through multiple informational cues that represent those conditions. In audit research, this theory was advanced by Libby, Artman, & Willingham (1985), who showed that auditors compare and evaluate various types of information during the planning stage and use them in risk assessment. Bonner (1990) found that experienced auditors select and weight relevant cues more effectively, and that task-related knowledge significantly influences the quality of professional judgment. Similarly, Bedard & Biggs (1991) empirically studied how auditors recognize patterns in information during analytical review and cognitively integrate multiple cues to develop possible explanations.

Later studies examined information integration more broadly. Kochetova-Kozloski, Kozloski, & Messier (2013) showed that incorporating information about an organization's business processes into risk assessment improves the quality of auditors' evaluations. As discussed in Section 5.3.1, Appelbaum, Kogan, Vasarhelyi, & Yan's (2018) Analytical Procedures Framework systematizes analytical procedures as a sequential process; this sequential logic aligns closely with Cue Utilization Theory's account of how multiple cues are compared and integrated. Griffith, Kadous, & Young (2021) provide a complementary framework, supported by empirical evidence, showing that in complex audit environments auditors must integrate information from multiple sources and reasonably evaluate their interrelationships to produce high-quality professional judgment.

Synthesizing these studies shows that professional judgment in audit planning is not based on a single cue but is a sequential cognitive process of comparing, weighting, and integrating multiple informational cues. This provides the theoretical foundation for treating risk signals as important inputs into professional judgment in this study.

6.4. Belief-Adjustment Theory and Sequential Evidence Evaluation

While Cue Utilization Theory and Diagnostic Reasoning explain, respectively, how auditors weight informational cues and evaluate competing explanations, neither addresses how an assessment already formed is revised once additional evidence arrives. Belief-Adjustment Theory (Hogarth & Einhorn, 1992) addresses this remaining stage: it models professional judgment as an anchoring-and-adjustment process in which auditors revise a prior belief incrementally as each new piece of evidence is evaluated, rather than re-forming their assessment from scratch. A central implication of this theory is that the order in which evidence is encountered—not only its content—can influence the final judgment, particularly when evidence is evaluated sequentially, one item at a time, rather than all at once.

This logic is consistent with the sequential view of professional judgment already noted in section 3.3, where Libby (1981) describes judgment as a process of collecting, evaluating, integrating, and concluding rather than a single-step evaluation. In the context of audit planning, this suggests that risk signals arising from analytical procedures are unlikely to be evaluated independently; instead, each new signal is assessed against the auditor's existing risk assessment, and the resulting judgment reflects both the evidence itself and the sequence in which it was processed.

Compared with Cue Utilization Theory and Diagnostic Reasoning, direct empirical application of Belief-Adjustment Theory within audit risk-assessment settings remains scarce; most audit judgment research citing the theory does so to motivate the design of experimental tasks rather than to test order effects in planning-stage risk signal evaluation specifically. This relative scarcity is itself informative: it indicates that while the theoretical logic of sequential belief updating is well established in the psychology literature, its role in explaining how auditors revise planning-stage judgments as successive risk signals emerge has not been systematically examined in the planning-stage risk-signal literature synthesized in this review—a gap that is developed further in section 8.1.

6.5. Professional Skepticism

Professional skepticism is the cognitive attitude by which auditors critically evaluate information and consider alternative explanations. It does not replace the processes of cue utilization or diagnostic reasoning described in section 3.4, but rather influences their quality. Peecher (1996) explained that auditors use cognitive processes of reasoning when evaluating evidence. Bonner (1999) emphasized that the quality of this process depends on auditors' knowledge, experience, and the quality of information. Nelson & Tan (2005) identified the evaluation of reliability and relevance of information as the foundation of professional judgment, while Nelson (2009) developed a theoretical model explaining how professional skepticism affects risk assessment and evidence evaluation. Hurtt (2010) developed measures of professional skepticism, enabling its use in empirical research.

Recent literature increasingly emphasizes that as advanced analytics, big data, and AI become more prevalent, the role of professional skepticism becomes more salient. Brown-Liburd, Issa, & Lombardi (2015) explained that analytic information creates new challenges for auditors' judgment. Commerford et al. (2022, 2024) found that reliance on AI is closely linked to auditor involvement and professional evaluation. Griffith, Kadous, & Young (2016) also emphasized that in complex audit environments auditors must critically evaluate and integrate information from multiple sources.

Synthesizing these studies shows that professional skepticism plays a crucial role in critically evaluating risk signals and other evidence, thereby enabling auditors to make well-founded professional judgments.

6.6. Judgment in the Context of Big Data and Automation

Building on this pattern (Section 6.5), research on big data and automation reaches a similar conclusion: these technologies transform the informational environment and methods of evaluating evidence without replacing auditors' professional judgment. Peecher, Solomon, & Trotman (2013) similarly argued that responsibility for audit decisions must remain with auditors, not analytic tools.

Subsequent research examined more specific dimensions of this transformation. Koreff & Perreault (2023) found that perceptions of analytic tool sophistication can positively influence evidence evaluation. Hammersley, Leiby, & Nielson (2025) studied how auditors integrate conflicting evidence, while Li, Brazel, Gold, & Leiby (2026) showed that whether auditors design their own data analysis tests or use pre-developed ones affects differences in professional skepticism and evaluation.

These patterns need not be read as directly conflicting, because the underlying studies examine different tasks and conditions. The evidence therefore suggests that the effects of analytic-tool support on auditor judgment are conditional on task, auditor involvement, and tool characteristics rather than uniformly positive or negative. Taken together, the studies reviewed in Sections 6.1–6.6 show that research on risk signals and professional judgment has developed along three directions—defining risk signals as inputs to decision-making, explaining them within cognitive theory (Cue Utilization Theory, Diagnostic Reasoning, Belief-Adjustment Theory), and examining auditor responsibility and skepticism in big data and AI environments. Most of this research, however, addresses these mechanisms in terms of general informational cues rather than distinguishing how different types of risk signals (e.g., ratio signals, general ledger signals, algorithmic signals) are weighted, compared, or updated. This research gap forms the theoretical foundation for the issues discussed in Section 8.

7. Synthesis of Prior Research

Table 2 presents a purposive analytical synthesis of selected studies that are most directly relevant to the review question and the conceptual framework developed in Section 3.4. Studies were selected to represent the principal stages in the development of analytical-procedure research and the key cognitive mechanisms through which risk-relevant information is evaluated and incorporated into auditor judgment. The table is therefore illustrative rather than exhaustive and is intended to compare the thematic direction, context, methodology, audit stage, theoretical relevance, principal findings, and limitations of studies that provide key evidence for the synthesis developed in Sections 5 and 6.

Table 2. Analytical Synthesis of Selected Studies

Study	Thematic Direction	Context Method /	Audit Stage / Task	Framework Relevance	Key Finding	Limitation Boundary /
Kinney (1979)	Analytical Procedures	Archival empirical study (setting not independently verified)	Planning (preliminary AP)	Expectation formation, risk-signal identification	Limited information can support expectations used to detect unusual fluctuations.	Does not examine cognitive integration into judgment.
Hirst & Koonce (1996)	Analytical Procedures	Field study, practicing auditors	Planning, performance, final review	AP information across audit stages	APs serve different purposes across planning, performance, and final review.	Documents AP use, not the evaluation process itself.
Eimers (2002)	Analytical Procedures	Field study, 149 PwC practitioners (doctoral dissertation)	Planning (analytical review)	Expectation quality and risk assessment	AP effectiveness depends on expectation quality, client knowledge, and risk assessment.	Focuses on effectiveness, not cognitive integration.
Cao, Chychyla, & Stewart (2015)	Analytical Procedures	Conceptual paper, illustrative examples	Planning + Execution	Technology-enabled AP information scope	Big data can expand information available for risk assessment.	Conceptual, not empirical evidence of cognition.
Libby, Artman, & Willingham (1985)	Risk Signals & Professional Judgment	Empirical study, planning-stage judgment task	Planning	Cue Utilization Theory (cue weighting and integration)	Auditors evaluate and integrate multiple signals as decision inputs.	Addresses cues broadly, not AP-specific signals.
Bonner (1990)	Risk Signals & Professional Judgment	Experimental, two experiments (2x2)	Planning (analytical/control risk assessment)	Task knowledge, cue selection/weighting	Experience affects ability to select and weight signals.	Examines selection/weighting, not full integration.
Bedard & Biggs (1991)	Risk Signals & Professional Judgment	Experimental study, analytical task	Planning (analytical review)	Cue integration, hypothesis generation (interactive link)	Auditors recognize patterns and integrate cues to generate explanations.	Links processing to explanation, not belief updating.
Koonce (1992)	Risk Signals & Professional Judgment	Experimental study, analytical review task	Planning (analytical review)	Diagnostic Reasoning (explanation/counterexplanations comparison)	Auditors compare explanations and counterexplanations during review.	Explains reasoning, not the full cue-to-belief process.
Hogarth & Einhorn (1992)	Risk Signals & Professional Judgment, Supporting Theory	Theoretical/model, general JDM (no audit-specific data)	Not audit-stage specific	Belief-Adjustment Theory (sequential updating)	Evidence sequence affects updating via an anchor-and-adjust process.	General theory, not audit-planning evidence.
Nelson (2009)	Risk Signals &	Theoretical model and	Planning	Professional Skepticism	Explains mechanisms	Theoretical synthesis, not direct

	Professional Judgment	literature review		(cross-cutting moderator)	linking skepticism to evaluation quality.	signal-integration evidence.
Brown-Liburd, Issa, & Lombardi (2015)	Risk Signals & Professional Judgment	Conceptual paper, big-data context	Planning + Execution	Big-data behavioral challenges	Big data creates overload and new decision challenges.	Conceptual; does not directly test AP-signal integration.
Li, Brazel, Gold, & Leiby (2026)	Risk Signals & Professional Judgment	Experimental, technology-tool context	Not planning-stage specific	Skepticism in technology-tool context	Self-designed vs. pre-developed tests affect skepticism and confidence.	Technology-specific evidence, not the full risk-signal-to-judgment sequence.

Source: Compiled by the author based on the reviewed literature.

8. Research Gaps and Future Directions

Building on the synthesis in Sections 5–7, the remaining gaps in this literature are considered across three related dimensions—theoretical, empirical, and contextual (Sections 8.1–8.3)—before turning to this review’s specific contribution (Section 8.4).

8.1. Theoretical Gap

Existing research provides complementary theoretical explanations for how auditors evaluate information, develop and test explanations, and revise prior assessments. However, these mechanisms have generally been examined separately, leaving limited theoretical integration of how risk-relevant results from analytical procedures are cognitively processed and incorporated into planning-stage professional judgment. The review-specific framework developed in Section 3.4 addresses this conceptual fragmentation by linking cue weighting and integration, diagnostic reasoning, and belief updating within a sequential but iterative planning-stage process.

8.2. Empirical Gap

At the empirical level, existing studies provide evidence on individual components of the proposed framework. For example, Bonner (1990) showed that experience affects auditors' ability to select and weight cues, while Koonce (1992) demonstrated how auditors develop and compare possible explanations during analytical review. However, the studies synthesized in this review do not establish how these mechanisms operate together as a connected planning-stage process or the conditions under which that process varies. Three related empirical questions therefore remain. First, how the process from identifying a risk-relevant analytical result through cue weighting, diagnostic reasoning, and belief updating operates as an integrated process remains insufficiently established. Second, the literature does not yet provide a consolidated account of whether different types and characteristics of risk signals from analytical procedures are weighted differently or how auditor- and engagement-related conditions shape that weighting. Third, whether and how technology-mediated analytical signals, including those generated through data analytics and AI-based tools, alter auditors' evaluation, weighting, and updating processes remains insufficiently established.

8.3. Contextual Gap

The literature synthesized in this review is predominantly drawn from audit environments in developed countries such as the United States, Western Europe, and Australia. Although research covering audit practices in parts of the Middle East, Asia, and Africa has increased in recent years (Samaha & Hegazy, 2010; Sanoran & Ruangprapun, 2023; Abu Alia et al., 2024), important questions remain regarding the transferability of auditor-judgment findings across different audit environments. Institutional arrangements, technological capability, data availability, audit-firm structure, and professional environments may influence both the analytical information available to auditors and how that information is evaluated and weighted. The contextual gap is therefore not merely the limited number of studies conducted in Mongolia or other developing audit environments; rather, it concerns the extent to which findings derived from established audit settings apply under different institutional and technological conditions. Mongolia provides one relevant context in which these potential boundary conditions can be examined empirically.

Together, these theoretical, empirical, and contextual gaps provide the basis for the review's distinctive contribution, discussed next in Section 8.4.

8.4. Contribution of This Review

In response to these gaps, this review uses the review-specific concept of risk signals to connect research on analytical procedures with research on auditor judgment and decision making. Rather than claiming that the underlying concepts or theories are new, it organizes how risk-relevant results arising from analytical procedures may be evaluated and incorporated into planning-stage professional judgment.

Conceptually, the review brings Cue Utilization Theory, Diagnostic Reasoning, and Belief-Adjustment Theory into a common sequential-but-iterative explanatory framework. The resulting framework links the generation of risk-relevant analytical results with their subsequent cognitive evaluation, weighting, diagnostic interpretation, and incorporation into evolving planning-stage risk assessments, with professional skepticism acting as the cross-cutting condition described in Section 3.4.

Finally, this integration provides a structured basis for the theoretical, empirical, and contextual gaps identified in Sections 8.1–8.3. Its contribution is therefore not the introduction of a new standalone theory, but the organization of existing analytical-procedure and auditor-judgment research into a common planning-stage explanatory account that can guide subsequent empirical investigation.

8.5. Practical Implications

For auditors, the synthesis highlights that identifying an unusual fluctuation or other risk-relevant analytical result is only the starting point of planning-stage judgment. Such signals need to be evaluated for their relevance and reliability, considered alongside other available information,

examined through plausible alternative explanations, and incorporated into the auditor's evolving risk assessment. The integrated framework therefore provides a structured way of understanding the cognitive steps that may support more deliberate evaluation of analytical-procedure results during audit planning.

For audit firms, the review suggests that the usefulness of analytical tools depends not only on their ability to generate risk-relevant information but also on how that information is interpreted and incorporated into professional judgment. Training, review practices, and analytical-tool implementation may therefore benefit from emphasizing the evaluation of signal relevance and reliability, the consideration of alternative explanations, and the continued exercise of professional skepticism. This implication becomes particularly relevant as data analytics and AI-based tools expand the volume and complexity of information available to auditors without removing the auditor's responsibility for professional judgment.

8.6. Future Research Directions

The gaps identified in Sections 8.1–8.3 point toward several specific directions for future empirical research. At the theoretical level, experimental studies could compare how auditors weight different types of risk signals generated by analytical procedures (e.g., ratio signals, general ledger signals, algorithmic signals), directly testing whether the sequential-but-iterative process described in Section 3.4 operates as an integrated whole rather than as separate mechanisms.

At the empirical level, risk signals can be operationalized according to the type of analytical procedure that generates them (e.g., ratio analysis, general ledger analysis, data-driven analytics), while the quality of the resulting professional judgment can be assessed through the plausibility and relevance of the diagnostic explanations developed, the consideration of counter explanations, and the accuracy of final risk assessments—rather than through the sheer number of explanations generated, which prior research suggests does not necessarily correspond to higher-quality judgment (Rose, Rose, Suh, & Thibodeau, 2020). Empirical models that incorporate moderating factors such as firm size, technological capability, auditor experience, and level of professional skepticism may help explain why the cognitive processes described in Section 3.4 vary across engagements and audit environments.

At the contextual level, the boundary conditions discussed in Section 8.3 could be examined empirically among audit firms in developing-country settings such as Mongolia, providing a basis for assessing whether findings on risk-signal evaluation from the reviewed literature—predominantly drawn from developed-market audit environments—extend to institutional and technological conditions elsewhere.

9. Conclusion

This narrative literature review synthesized international research from the 1970s to 2026 on analytical procedures, risk signals, and auditors' professional judgment in audit planning. First,

major prior international reviews were compared to identify their scope, conclusions, and limitations, thereby situating the distinctive position of this study. Then, the literature was synthesized into two thematic directions:

Research on analytical procedures, which evolved from explaining effectiveness, through standardization, to data-driven technologies.

Research on risk signals and professional judgment, which developed from identifying signals as decision inputs, through diagnostic reasoning, cue utilization theory, and sequential belief adjustment—with professional skepticism examined as a cross-cutting influence on these processes—to issues of responsibility in big data and automation contexts.

However, empirical evidence that integrates these two streams—specifically examining how auditors evaluate and integrate risk signals from analytical procedures when forming planning-stage professional judgment—remains limited, particularly in developing-country audit practices. Therefore, this review aims to provide a conceptual foundation for future empirical research among Mongolian audit firms, as further discussed in Section 8.6.

Specifically, the theoretical foundation rests on three complementary theories: Cue Utilization Theory, Diagnostic Reasoning, and Belief-Adjustment Theory. Each explains a distinct cognitive process—weighting signals, evaluating possible explanations, and updating prior assessments with new information. Taken together, they provide a complementary, mutually reinforcing account of planning-stage professional judgment. Professional skepticism, discussed in Section 6.5, is not treated as a separate fourth theory but as a cross-cutting condition that influences the quality of these cognitive processes.

Thus, the principal conceptual contribution of this review is to organize and connect research on how risk-relevant analytical results are generated with research on how auditors evaluate and integrate such information into planning-stage professional judgment, within an integrated conceptual framework drawing on these three complementary theories. This framework provides a basis for future empirical examination, including in developing-country contexts such as Mongolia.

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