Pattern Recognition during Analytical Procedures: The Influence of Systems-Thinking Decision Support on Auditor Risk Assessments

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ABSTRACT

This study examined whether using an adaptation of the causal-loop diagram developed in the systems-thinking discipline could improve auditor ability to recognize and respond appropriately to patterns of inconsistent information when they perform analytical procedures. In a laboratory experiment, experienced auditors used either the causal-loop diagram or an informationally equivalent diagram designed to be consistent with the organizational format of the decision support system they use in the field. Auditors who used the systems-thinking decision support tool were more likely to (1) respond appropriately to a pattern of inconsistencies that were seeded to the case materials, and (2) recognize the diagnostic value of information about patterns of changes in accounts involved in the inconsistency.

Key Words: analytical procedures, auditor judgment, causal-loop diagrams, pattern recognition, risk assessment, systems thinking

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I. INTRODUCTION

Auditors use analytical procedures while planning assurance engagements to identify accounts with an elevated risk of misstatement, then target those accounts for extended auditing procedures (Wright and Ashton 1989). During analytical procedures, auditors search for inconsistencies between patterns of interperiod fluctuations in financial statement accounts and information about changes in market conditions or client business practices. When auditors fail to recognize patterns of inconsistent fluctuations, their audit testing plan is likely to be less effective, and they are less likely to detect any financial statement errors that exist (Biggs et al. 1995).

Audit firms have devoted considerable resources to developing audit support systems that help their auditors make better decisions during analytical procedures (O'Donnell and Schultz 2003). Efforts to improve decision support have included identifying and providing more relevant information, and re-structuring the way information is organized and presented so that auditors are more likely to recognize conditions that increase the risk of financial misstatement (Bell et al. 2005; Knechel 2007). This study examines whether a decision tool developed by proponents of the systems-thinking approach could be adapted to help auditors analyze diagnostic patterns of accounting information more effectively.

Systems-thinking has been used for over 40 years to support decisions that involve analyzing and improving business process performance. Systems thinkers strive to develop a more complete understanding of interdependencies among the inputs, throughput, and outputs that drive a business model when they analyze causal patterns among business processes

(Gharajedaghi 1999). A decision support tool that has proven effective and is widely used among systems-thinking practitioners is the causal-loop diagram, which provides a graphical representation of associations among business processes. Causal-loop diagrams illustrate patterns of interdependencies between the output from upstream business processes and the input to downstream business processes, and also account for any feedback loops in the system (Sterman 2000). Systems thinkers argue that making patterns of interdependencies among processes explicit by supporting decision processes with causal-loop diagrams helps business process analysts diagnose causal relationships and solve business problems more effectively (Senge 1990).

Auditors typically become responsible for performing analytical procedures when they are promoted to the rank of senior and begin supervising field work for assurance engagements (Abdolmohammadi 1999; Trompeter and Wright 2006). However, at this stage in their career, research suggests that auditors have considerable difficulty recognizing and responding appropriately to patterns of changes in accounts that could signal financial misstatement (Libby and Frederick 1990; Bedard and Biggs 1991; Hammersley 2006). We present evidence that using an information display designed using systems-thinking principles could help auditors recognize patterns of evidence that increase audit risk at a time in their career when they have become responsible for performing analytical procedures, but before they have developed a significant amount of pattern recognition expertise.

This study examined whether providing auditors at the rank of senior with the accounting equivalent of a causal-loop diagram as decision support for analytical procedures influences their ability to recognize a complex pattern of inconsistent fluctuations in related accounts that increases the risk of financial misstatement. In a laboratory experiment, two groups of senior auditors used analytical procedures either to (1) identify or (2) explain inconsistent fluctuations in accounts, and assess the associated risk of misstatement. Half of the participants in each group evaluated information presented with a causal-loop diagram; the others evaluated identical information presented in a diagram that was organized in a structure consistent with the business-process focus of the audit support software their firm used in the field.

Results provide evidence that auditors who used the systems-thinking decision support tool were more likely to developed mental representations for performing analytical procedures that focused on patterns of inconsistencies among related accounts, and more likely either to target those accounts for extended testing when attempting to identify unexpected fluctuations, or include those accounts in the potential explanations they developed for unexpected fluctuations. These findings provide preliminary evidence that integrating systems-thinking principles into audit support software may help auditors recognize and respond appropriately to patterns of diagnostic information, after they become responsible for performing analytical procedures but before they have the opportunity to develop expertise in pattern recognition through extended auditing experience. Although more research is needed, results from this study suggest that auditing firms may want to explore how the systems-thinking approach could be applied to improve the evaluation of audit evidence.

The remainder of this paper has been organized into sections two through five. The second section provides a review of the systems-thinking literature that lead to the development and application of causal-loop diagrams, and the decision support literature that has helped explain how using alternative graphical representations to provide decision information can influence causal reasoning and judgment. The third section describes the experiment that we conducted to test how causal-loop diagrams could influence judgment during analytical procedures, and the fourth section presents our findings. The last section summarizes our results, acknowledges the limitations of this study, and identifies opportunities for future research.

II. THEORETICAL FOUNDATION

We propose that using a causal-loop diagram will (1) improve pattern recognition during analytical procedures by (2) encouraging auditors to develop mental representations that focus more attention on patterns of relationships among accounts in a double-entry accounting system. We developed these two hypotheses based on research that explains how systems-thinking decision support increases attention to patterns of interdependencies, and how graphical decision aids influence judgment by altering mental representations.

Systems Thinking and Decision Support

Our world is full of outcomes produced by complex systems of causal processes. Systems thinkers diagnose causal associations by focusing on interdependencies among components in a system of interdependent processes. They try to understand system behavior by learning about interactions among components that drive system processes, rather than by identifying and aggregating behavioral characteristics of individual system components (Ackoff and Emory 1972). Theories of systems thinking evolved primarily from the early twentieth-century writings of American philosopher E. A. Singer, who provided a framework for the systems approach to scientific inquiry (Churchman 1968).

Bertalanffy (1968) helped to pioneer the development of a general systems theory to advance a philosophy of science that focused interdependencies. He explains that "*in the past, science tried to explain observable phenomena by reducing them to an interplay of elementary units investigable independently of each other … [but] problems of organization [are] not* *resolvable into local events … [because] systems [are] not understandable by investigation of their respective parts in isolation*" (Bertalanffy 1968, 36-37). Based on a similar philosophy, Ackoff and Emery (1972) extended the systems-thinking paradigm to create a framework for evaluating organizational performance.

Although systems thinking has not evolved into the pervasive philosophy of science that the early pioneers envisioned, it inspired an alternative paradigm for inquiry, one that shifts the focus from analyzing characteristics of component parts to understanding behavior of the systems as an integrated whole (Laszlo 1996). After becoming institutionalized through the development of mathematically-expressed general theories (for example, see Bertalanffy 1968; Ackoff and Emery 1972), systems thinking diverged into two distinct streams of inquiry. A "hard-systems methodology" developed for design tasks that require engineering complex systems of interdependent components, and a "soft-systems methodology" developed for diagnostic tasks that require understanding complex systems of interdependent causal processes. The soft-systems approach evolved into a learning model for managers to use for analyzing performance anomalies and developing interventions to address problems related to organizational behavior (Checkland 1999).

Focusing on interdependencies among system components helps managers to recognize the influence of interactions among variables rather than only focusing on the behavior of individual variables that create the system (Senge 1990, 68-76). Systems-thinking proponents have come to appreciate the importance of understanding the effect of feedback from interdependencies when analyzing performance anomalies in complex systems (Richardson 1991). Forrester (1961) integrated feedback as a causal construct into analyses of the economic systems that drive industrial production, and pioneered a systems-thinking discipline known as systems dynamics. The rich problem representation provided by a comprehensive understanding of the interdependencies inherent in systems dynamics helps analysts design appropriate policies for managing economic systems (Richardson 1991, 297-313).

Systems thinkers have developed a variety of tools for analyzing business problems (see Sterman 2000 for an in-depth discussion). A decision support tool that has proven effective for helping analysts develop a better understanding of interdependencies that influence performance is a causal diagram that accounts for the looping influence that feedback from downstream processes have on upstream processes that precede them (Senge 1990, 68-76). Without effective guidance from decision support tools, people tend to use heuristic strategies for analyzing business processes that ignore interdependent cause-and-effect relationships (Sterman 1989), and usually fail to fully understand and recognize the nature of interdependencies that influence causal structures (Jacobson 2001).

Causal-loop diagrams help decision makers recognize interdependencies among system components by activating existing knowledge structures that specify how changes in one component can cause changes in another (Repenning 2003). Evidence suggests that managers who use causal-loop diagrams as a decision support tool develop a richer understanding of the interdependencies that drive system dynamics. For example, claims managers at an insurance company who used causal-loop diagrams and other systems-thinking learning tools developed new insight into causal relations that influenced business process performance (Cavaleri and Sterman 1997). Managers who use causal-loop diagrams as a aid for analyzing business problems are more likely to use the knowledge they bring to a task to develop mental representations that recognize causal interdependencies among business processes (Doyle 1997).

More effective mental representations are likely to generate more effective solutions for business problems (Doyle and Ford 1999).

In summary, the systems-thinking paradigm emerged from efforts to understand interdependencies within a system rather than the collective influence of individual elements, and evolved into a framework for analyzing anomalies in dynamic systems of business processes. Recognizing how fluctuations in one variable influence fluctuations in another variable (interdependencies), and accounting for these interactions during diagnostic reasoning helps business analysts develop a more effective understanding of causal systems. Systems thinkers use causal-loop diagrams to support diagnostic reasoning, and research suggests that using causal-loop diagrams for decision support increases the likelihood analysts will recognize diagnostic patterns of associations among systems variables.

Causal-loop Diagrams and Analytical Procedures

During analytical procedures auditors search for inconsistencies among patterns of related fluctuations in a system of double-entry accounts. Patterns of fluctuations that are inconsistent with the auditor's knowledge of client business activities signal an increased potential for financial misstatement, and should be targeted for more thorough evaluation with evidence gathered during substantive audit tests (Bedard and Biggs 1991). The likelihood that auditors will recognize inconsistent patterns depends, in large measure, on whether auditors develop an effective mental representation of how client financial performance should be reflected by a predictable pattern of fluctuations in related accounts (Biggs et al. 1995).

By the time auditors achieve the rank of senior and become responsible for performing analytical procedures in the field, they generally have not developed a level of expertise that provides them with the ability to recognize a wide variety of diagnostic patterns of account fluctuations (Hammersley 2006). Although senior auditors generally have knowledge of associations among accounts essential for recognizing diagnostic patterns, they often fail to develop mental representations that account for more complex patterns (Bedard and Biggs 1991). As a result, senior auditors often perform poorly during analytical procedures tasks that require the recognition of more complex patterns of inconsistent fluctuations in related accounts (Libby and Frederick 1990).

Systems thinkers believe that causal-loop diagrams help analysts recognize diagnostic patterns by encouraging them to assemble their knowledge into mental representations that account for interdependencies among system variables. Perhaps a causal-loop diagram that helps seniors assemble their knowledge of associations among accounts in a double-entry system into a mental representation that provides a richer model of interdependencies among account fluctuations will help them recognize patterns more effectively. Providing information for analytical procedures with a graphical display (like a causal-loop diagram) that illustrates associations among related accounts might help seniors recognize patterns of inconsistencies that would otherwise go unnoticed by auditors with limited pattern recognition expertise. Figure 1 depicts our interpretation of a causal-loop diagram that illustrates interdependencies among financial statement accounts for a manufacturing client.

Insert Figure 1 here

In the diagram presented as Figure 1, a causal link from one account to another account is positive (negative) if a change in the first account should be associated with a change in the second account in the same (opposite) direction. For example, if sales revenue increases, cost of goods sold also increase. Therefore the sign on the link between those two accounts is positive. Our objective in creating the diagram presented as Figure 1 was to reflect basic associations among financial statement accounts by explicitly linking those accounts using the diagramming conventions that systems thinkers use for creating causal-loop diagrams of business processes (see Sterman 1989 for a detailed description of conventions and processes used to create causal-loop diagrams).

Systems thinkers use causal-loop diagrams to help analysts assemble knowledge they already possess into mental representations that account for interdependencies among system variables. In other words, causal-loop diagrams don't provide new knowledge, instead, these graphical representations of causal associations help business analysts use a pattern-oriented structure for organizing knowledge they have already acquired (Senge 1990; Gharajedaghi 1999; Repenning 2003). We designed the diagram presented in Figure 1 to help seniors assemble accounting knowledge they should already posses into mental representations that account for patterns of associations among client operations and fluctuations in metrics used to track financial performance. Like a causal-loop diagram, our double-entry diagram is not intended to convey new knowledge of interdependencies. It simply helps auditors remember to account for associations they already know about by encouraging them to focus more attention toward patterns of fluctuations in related accounts.

The causal-loop diagram presented in Figure 1 could be populated with information about interperiod fluctuations in accounts to provide the evidence that auditors need to perform analytical procedures. The result would be a graphical display that illustrates associations among related accounts. Because auditors generally use a tabular display that does not create explicit links among related accounts, the causal-loop diagram would provide decision support for analytical procedures with features that differ from traditional audit support systems (see

Trompeter and Wright 2006 for a description of the types of information auditors use for analytical procedures).

Decision support systems that use graphical displays to focus user attention toward diagnostic features of decision information can help decision makers recognize relevant information they might otherwise overlook (see O'Donnell and David 2000 for a review of this literature). The next section reviews research on using graphical interfaces to provide decision support, and explains how features of graphical presentations can influence judgment and decision making by altering mental representations.

Decision Support and Mental Representations

Decision support has proven useful for improving auditor judgment when the support system helps auditors use their knowledge more effectively, for example, by presenting decision information in a way that provides a more effective mapping between knowledge brought to the task and diagnostic cues acquired during the task (Messier 1995). Decision effectiveness generally improves when the organization features of the technology used to support decision making "fits" well with the organization of the knowledge that decision makers use to evaluate diagnostic cues (Vessey 1991). Decision support that provides task information in a way that helps decision makers retrieve relevant knowledge from memory and organize that knowledge into more effective mental representations is, not surprisingly, more likely to produce superior decision performance (Kotterman and Remus 1989). Support tools that encourage the development of mental representations that match the diagnostic requirements of the decision task increase the likelihood of a successful diagnosis either by reducing the amount of cognitive effort needed to integrate decision cues, or by increasing attention to diagnostic configurations (patterns) of decision cues (Goodhue and Thompson 1995).

Information displays that explicitly illustrate associations between variables increase attention to diagnostic patterns of causal relationships by reduce the cognitive effort required for recognizing those associations and integrating diagnostic implications into decisions. Increasing attention to causal patterns increases the likelihood of an effective diagnosis (Larkin and Simon 1987). By explicitly illustrating causal associations, causal-loop diagrams reduce the cognitive effort needed to recall and reconstruct diagnostic patterns from knowledge stored in memory (Doyle and Ford 1998). As a result, providing decision information in the form of a causal-loop diagram increases the likelihood that decision makers will recognize and integrate diagnostic patterns of decision information into the mental representations they develop to support their analyses (Doyle and Ford 1999; Repenning 2003).

We propose that using the equivalent of a causal-loop diagram to illustrate associations among accounts will help auditors recall and integrate those associations into the mental representations they develop to support diagnostic reasoning during analytical procedures. The next section provides an example of how this systems-thinking decision support tool could help auditors recognize diagnostic patterns. Based on the associations described in this example, we develop research hypotheses that provide a basis for testing whether auditors who use causal-loop diagrams are more likely to recognize diagnostic patterns during analytical procedures.

Research Hypotheses

Using analytical procedures to assess the risk that an account could be misstated involves two distinct diagnosing reasoning processes (Koonce 1993). First, auditors must learn about client operations and industry conditions to develop expectations about how accounts should have changed during the period under investigation. Auditors compare the benchmarks provided by their expectations against actual changes in accounts to identify unexpected patterns of fluctuations that could signal misstatement. Second, when auditors encounter an unexpected fluctuation, they are likely to evaluate the cause for that change in account balance by, among other things, examining diagnostic changes in patterns of related accounts. When unexpected fluctuations are inconsistent either with client business activities, or patterns of fluctuations in related accounts, or both, auditors document their concerns and refer to this documentation when they develop the audit program and finalize the audit plan.

Consider the following example, based on the seeded inconsistency used by Bedard and Biggs (1991), to illustrate how auditors (1) search for inconsistent patterns of fluctuations and (2) develop plausible explanations to evaluate whether inconsistencies signal increased misstatement risk. Suppose a client tells the auditor that there were no significant changes in product mix or manufacturing costs during the year, and that the client initiated an aggressive marketing campaign. Armed with this knowledge, the auditor observes that sales revenues have increased from last year to this year, which would be consistent with knowledge of the aggressive marketing campaign. However, selling expenses had actually decreased slightly from last year to this year, which is not consistent with aggressive marketing campaign, and cost of sales has increased more than sales, which is not consistent with a stable product mix and no increase in manufacturing costs.

According to Bedard and Biggs (1991), this pattern of information was uncovered during the audit of a company that had inappropriately allocated marketing expenses to manufacturing costs, which caused selling expenses to be understated and cost of sales to be overstated. To identify the accounts that could be misstated, auditors would have to recognize that the pattern of fluctuations among sales revenue, selling expenses, and cost of sales was inconsistent with information about client operating activities. In their study, Bedard and Biggs found that auditors at the rank of senior were unlikely to recognize the pattern of inconsistencies that suggested an elevated potential for misstatements in the three accounts involved.

As explained above, systems-thinkers assert that using a causal-loop diagram increases the likelihood of recognizing inconsistent patterns by providing a graphical illustration of links among variables that create patterns of causal associations, thereby decreasing the cognitive effort associated with recognizing diagnostic patterns (as suggested by Larkin and Simon 1987). Several studies have provided evidence that the way decision support systems present decision information can influence decision performance by incorporating graphical features that alter the cognitive effort needed to process decision information. In tasks where effective performance requires recognizing patterns of related cues, presentation formats that alter spatial relationships (adjacency) to make interdependencies more salient can improve decision performance (Dennis and Carte 1998) and reduce decision bias by fostering development of more effective mental representations (Roy and Lerch 1996).

Research that examined judgment developed by analyzing accounting information have found that graphical presentations may improve auditor judgment in tasks that involve assessing misstatement risk (Blocker et al. 1986), evaluating loan collectability (Wright 1995), analyzing potential debt covenant violations (Amer 1991), making financial predictions (Hard and Vanacek 1991), and require the use of holistic versus analytic decision strategies (Tuttle and Kershaw 1998). Studies that have examined how alternative presentation formats influence judgment in other decision contexts provide evidence that graphical presentations reduce the negative association between information load and decision performance (Diamond and Lerch 1992; Umanath and Vessey 1994), and improve co-variation estimates by reducing time-on-task (Schultz and Booth 1995).

Based on the findings of these studies and the prescriptions offered by the systems-thinking literature, we propose that presenting accounting information in the form of a causal-loop diagram could influence pattern recognition during analytical procedures. If graphical presentation of associations among related accounts helps auditors recognize diagnostic patterns of inconsistencies, then:

H1: Auditors who use a causal-loop diagram for analytical procedures will be more likely to recognized increased misstatement risk for accounts involved in patterns of inconsistent fluctuations than auditors who do not use a diagram that illustrates causal associations.

If graphical presentation of associations among related accounts reduces the cognitive effort required to assemble a mental representation that accounts for diagnostic patterns of changes, then:

H2: For accounts involved in an inconsistent pattern of fluctuations, auditors who use a causal-loop diagram for analytical procedures will perceive the diagnostic value of information about fluctuations in related accounts to be greater than auditors who do not use diagram that illustrates causal associations.

III. METHOD

We conducted a laboratory experiment to test whether using a causal-loop diagram could improve pattern recognition during analytical procedures. Auditors at the rank of senior, who all worked for the same international accounting firm, performed one of two analytical procedures tasks: one group search for and identified unexpected fluctuations, and another group developed and evaluated potential explanations for an unexpected fluctuation that had been already been identified. For both groups, half of the participants evaluated interperiod fluctuations in accounts presented in the form of a causal-loop diagram, and half evaluated identical information presented in the form of a diagram that which was designed to be consistent with the organizational structure of the audit support software participants used in the field.

All participants completed the experiment during a one-hour period that was set aside for research at a national training session conducted by their employer. All participants held the rank of senior and had been assigned (by their firm) to training groups of 25 to 30 individuals. Each group was housed in a separate room, and a research proctor was present in each room to monitor participants while they completed the experimental task.

Materials

We created an experimental instrument based on the case for a manufacturing client used by Bedard and Biggs (1991). The case included a seeded misstatement that increased income because a portion of selling expenses had been improperly capitalized to inventory. This misstatement caused cost of sales to increase by a higher percentage than sales because, even though material and labor costs had remained comparable to the previous year, an improper allocation of selling expenses increased inventory costs.

Bedard and Biggs (1991) explain how diagnosing this misstatement requires auditors to recognize a pattern that includes two inconsistent fluctuations between related accounts. First, cost of sales increased by a larger proportion than sales because (1) most of the selling expenses that had been capitalized to inventory flowed through cost of sales, and (2) labor and raw material costs had not increased from the previous year. Second, even though sales increased due to more aggressive marketing programs, selling expense decreased.

Our experimental instrument described engagement background and client business activities during the year under audit, and provided information about changes in accounts from the previous to the current year formatted either as a causal-loop diagram or a business-process diagram (explained below). Both diagrams are each illustrated in Figure 2 and the experimental instrument is presented in an appendix.

Insert Figure 2 here

At the time we conducted this experiment, the firm that provided participants used audit support software that organizes information for analytical procedures around client business processes. The firm required auditors to prepare a diagram called the "entity-level business model" to document business processes for each audit client. However, the firm's audit support software presented comparative accounting metrics in a tabular rather than a graphical format. Pilot tests revealed that auditors who analyzed accounting metrics presented in the more familiar tabular format assessed account-level misstatement risk differently than auditors who analyzed either of the two, unfamiliar diagrams presented in Figure 2.

The objective of our experiment is to examine whether organizing information in a way that supports system thinking influences judgment, not whether using an unfamiliar presentation format influences judgment. Therefore, in an effort to eliminate the possibility that differences in auditor judgment could be attributable to differences in the degree of familiarity with the presentation format, we presented information about account fluctuations using an unfamiliar business-process diagram rather than the more familiar tabular format. Using two unfamiliar graphical formats to present identical metrics provided a basis for evaluating how decision support organized using systems-thinking principles, instead of traditional decision support organized by categories of activities (business processes) could influence judgment and cognition during analytical procedures.

All participants received the same client information and accounting metrics. The only differences between materials used for the two tasks were the question that participants were instructed to answer during analytical procedures, and whether they used a causal-loop or business-process diagram to analyze accounting metrics.

Procedures for the Identify-Unexpected-Fluctuations Task

After reading narrative information about the engagement and the client, participants were instructed to assess the overall likelihood of financial misstatement based solely on the narrative information they had read using an integer scale from one (low risk) to nine (high risk). After documenting their initial risk assessment, participants used accounting metrics provided by either the causal-loop or business-process diagram to (a) decide whether sales, cost of sales, and selling expenses should be targeted for extended testing, (b) document their rationale for all decisions to target an account, and (c) assess misstatement risk for each of those three accounts using an integer scale from one (low risk) to nine (high risk).

Our original intent was to ask participants to evaluate all four accounts involved in the inconsistent pattern of fluctuations (sales, cost of sales, selling expenses, and inventory). However, during pilot tests we noted a relatively pervasive tendency to target merchandise inventory but not target the other three accounts, because the fluctuation in inventory of 8.9% was so much larger compared to the fluctuations in sales (0.7%), cost of sales (1.1%) and selling expenses (− 0.3%). Responses from participants in the pilot test suggest that they tended to use the percent change in inventory as a baseline, which made fluctuations in the other three accounts look insignificant. However, altering our case materials by reducing the increase in inventory would create a pattern that was disproportional to the seeded inconsistency used by Bedard and Biggs (1991). Therefore, we asked participants to analyze only three of the four accounts involved in the pattern of inconsistent fluctuations (sales, cost of sales, and selling expense).

After completing analytical procedures, participants rated the relevance of information about changes in other accounts presented by the case materials for assessing the risk of misstatement in each account they evaluated. Ratings were provided on an integer scale from one (low relevance) to nine (high relevance). After documenting their relevance ratings, participants reported total audit experience, and experience at the rank of senior.

Procedures for the Explain-Unexpected Fluctuations Task

After reading narrative information about the engagement and the client, participants were told that the engagement manager was concerned that an increase in net income might be the result of financial misstatement. They were instructed to use information provided by either the causal-loop or business-process diagram to (a) determine all possible misstatements that would increase net income and list those explanations in order from most likely to least likely, then (b) assess misstatement risk for all six accounts that were included on the diagram they used for their analysis. After describing possible misstatements, participants provided the same relevance ratings and information about their auditing experience that was elicited from participants assigned to the identify-unexpected-fluctuations task.

Dependent Variables

Our first hypothesis predicts an association between the type of diagram auditors use and the extent to which they recognize potential problems in accounts involved in an inconsistent pattern of fluctuations. In other words, if auditors recognize a diagnostic pattern of fluctuations across a group of related accounts, they will be more concerned about the risk of misstatement in those accounts. In the identify-unexpected-fluctuations task, concern about misstatement should manifest by targeting accounts involved in a pattern of inconsistent fluctuations for extended testing. In the explain-unexpected-fluctuations task, increased concern about risk should result in accounts being included in causal explanations for potential misstatements.

To construct a metric that captures this type of variation in participant judgment, we summed the number of accounts involved in the inconsistent pattern for which participants responded appropriately. In the identify-unexpected-fluctuations task, we construed an appropriate response to be targeting the account for extended testing. In the explain-unexpected-fluctuations task, we construed an appropriate response to be including that account in potential explanations for misstatement. This algorithm produced a metric for testing H1 that ranged from zero to 3, and was based on responses for the same three accounts (sales revenue, cost of sales, and selling expenses) across both tasks.

Our second hypothesis predicts an association between the type of diagram auditors use and the extent to which they perceive information about covariation in accounts involved in the pattern of inconsistent fluctuations to be useful for assessing misstatement risk. We used responses to the final case question on our research instrument to create a metric that captured between-subjects variation in perceptions about the diagnostic value of information about covariation.

Recall that, for sales revenue, cost of sales, and selling expenses, participants rated how relevant information about fluctuations in other accounts was for assessing misstatement risk for the target account, using a scale from one (low) to nine (high). The relevance of covariation information for each of the three accounts involved in the inconsistent pattern of fluctuations was rated twice. For example, the relevance of information about cost of sales was rated for sales, and the relevance of information about sales was rated for cost of sales. As a result, there were a total of six relevance ratings for the three accounts involved in the pattern of inconsistent fluctuations. To measure the dependent variable we used for testing H2, we calculated the average of all six relevance ratings that involved parings of sales revenue, cost of sales, and selling expenses.

IV. RESULTS

A total of 40 participants completed the instrument for the identify-unexpected-fluctuations task, including 20 who used the causal-loop diagram and 20 who used the business-process diagram. Audit experience ranged from 20 to 84 months, with an average of 43.1 months (standard deviation was 12.7 months). Descriptive statistics for accounts that were targeted for extended audit testing are presented in panel A of table 1.

A total of 42 participants completed the instrument for the explain-unexpected-fluctuations task, including 21 who used the causal-loop diagram and 21 who used the business-process diagram. Audit experience ranged from 24 to 60 months, with an average of 40.4 months (standard deviation was 9.3 months). Descriptive statistics for accounts included in causal explanations for the potential misstatement are presented in panel B of table 1.

Insert Table 1 here

Hypothesis Tests

Before testing our first hypothesis, we searched for evidence that participants made appropriate decisions about targeting accounts for further investigation (identify-unexpected-fluctuations task), or included accounts in their explanations for the potential misstatement (explain-unexpected-fluctuations task) based on their concern about the risk of misstatement. Across both tasks, the 53 participants who made appropriate decisions for sales assessed misstatement risk at an average of 5.9 while the 29 participants who did not respond appropriately assessed misstatement risk at an average of 4.0 ($t = 4.63$; $p < .01$). The 49 participants who made correct decisions for cost of sales assessed misstatement risk at an average of 5.6 while the 33 participants who did not respond appropriately assessed misstatement risk at an average of 4.7 ($t = 2.87$; $p < .01$). The 51 participants who made correct decisions for selling expenses assessed misstatement risk at an average of 6.7 while the 31 participants who did not respond appropriately assessed misstatement risk at an average of 3.6 ($t = 7.98$; $p < .01$). We concluded that participant decisions either to target accounts for further investigation or include accounts in misstatement explanations were, as expected, motivated by concern about increased likelihood of misstatement.

H1 predicts that participants who use the causal-loop diagram will be more likely to respond appropriately when analyzing the likelihood of misstatement in sales revenue, cost of sales, and selling expenses. We tested this hypothesis with analysis of variance, where our pattern recognition metric was the dependent variable, type of diagram was one of the independent conditions, and type of task was the other independent condition. Results presented in Panel A of Table 2 provide evidence that type of diagram influenced pattern recognition. Cell means presented in Panel B of Table 2 indicate that participants who used the causal-loop diagram were more likely to target the three accounts involved in the pattern of inconsistent fluctuations than participants who used the business-process diagram. This evidence supports H1.

Insert Table 2 here

H2 predicts that participants who use the causal-loop diagram will perceive information about covariation among accounts involved in the pattern of inconsistent fluctuations to be more relevant for analyzing the potential for financial misstatement than auditors who use the business-process diagram. We tested this hypothesis with analysis of variance, where our perceived relevance metric was the dependent variable, type of diagram was one of the independent conditions, and type of task was the other independent condition. Results presented in Panel A of Table 3 provide evidence that type of diagram influenced perceived relevance. Cell means presented in Panel B of Table 3 indicate that, on average, participants who used the causal-loop diagram rated the relevance of information about accounts involved in the pattern of inconsistent fluctuations at higher levels than participants who used the business process diagram. This evidence supports H2.

Insert Table 3 here

We conducted additional analyses to evaluate whether our results could have been influenced by outliers or the type of tests we performed. We used separate Wilcoxon (nonparametric) tests for each type of task to examine whether the metrics used for testing H1 and H2 differed based on the type of diagram participants used. Differences were in the same direction for both tasks as differences reported in the hypothesis tests. For the identify-unexpected-fluctuations tasks the difference was marginally significant at the $p < .10$ level, and for the explain-unexpected-fluctuations tasks the difference was significant at the $p < .05$ level.

We also used logistic regression to replicate our test of H1. The dependent variable was assigned a value of one for participants who targeted all three accounts (sales revenue, cost of sales, and selling expenses), zero otherwise. We included both type of task and type of diagram as independent variables. There was a positive association between using a causal-loop diagram and the likelihood that participants would target all three accounts, which was marginally significant at the $p < .10$ level. We concluded that findings from our hypothesis tests were reliable.

V. CONCLUSION

The systems-thinking literature suggests that decision support tools based on graphical representations of interdependencies help business analysts recognize diagnostic patterns when they analyze potential causes for business problems. The literature on decision-support systems suggests that graphical presentations designed to help decision makers develop mental representations that map onto requirements of the decision task improve judgment by reducing the cognitive effort required to recognize diagnostic patterns of information. Based on these findings, we proposed that auditors who used a graphical representation designed to illustrate relationships among accounts in a double-entry system would help them remember to consider diagnostic patterns of account fluctuations when they perform analytical procedures.

We hypothesized that using a causal-loop diagram as decision support for analytical procedures would (1) help auditors respond appropriately when assessing misstatement risk for accounts involved in an inconsistent pattern of fluctuations because they (2) were more likely to develop mental representations that recognized the diagnostic value of information about patterns of changes in related accounts. We conducted a laboratory experiment where experienced auditors used either a causal-loop diagram developed using systems-thinking principles, or an alternative diagram that presented the same information but was consistent with the structure of the decision support system that participants used in the field, which was organized by type of business process. Results provide evidence that supports both hypotheses.

Our findings must be interpreted with care. Systems thinkers use a variety of decision support tools and the causal-loop diagram is only one of many. Results from this experiment provide evidence that one type of systems-thinking tool may help auditors perform analytical procedures more effectively. However, these findings cannot be construed as evidence that concepts developed under the systems-thinking paradigm can readily be transferred to the audit judgment domain. It is possible that using a systems-thinking approach could hinder auditor judgment in ways that this study has not considered. Research that examines the various ways that systems-thinking can influence auditor judgment is essential for evaluating the efficacy of using a systems-thinking approach for evaluating audit evidence.

The decision-support literature provides evidence that links features of graphical presentation formats with reductions in the cognitive effort needed to develop effective mental representations for diagnostic reasoning and problem solving. Although this study provides evidence that auditors who used a causal-loop diagram developed mental representations that encouraged them to consider the diagnostic value of patterns of account fluctuations, we did not measure differences in mental representations or cognitive effort, and we did not examine other characteristics of the perceptions that might be inspired by alternative mental representations. Future research must examine these issues before the potential benefits of using systems-thinking principles to design audit support software can be reliably evaluated.

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Figure 1
Causal-Loop Diagram of Relationships among Financial Statement Accounts

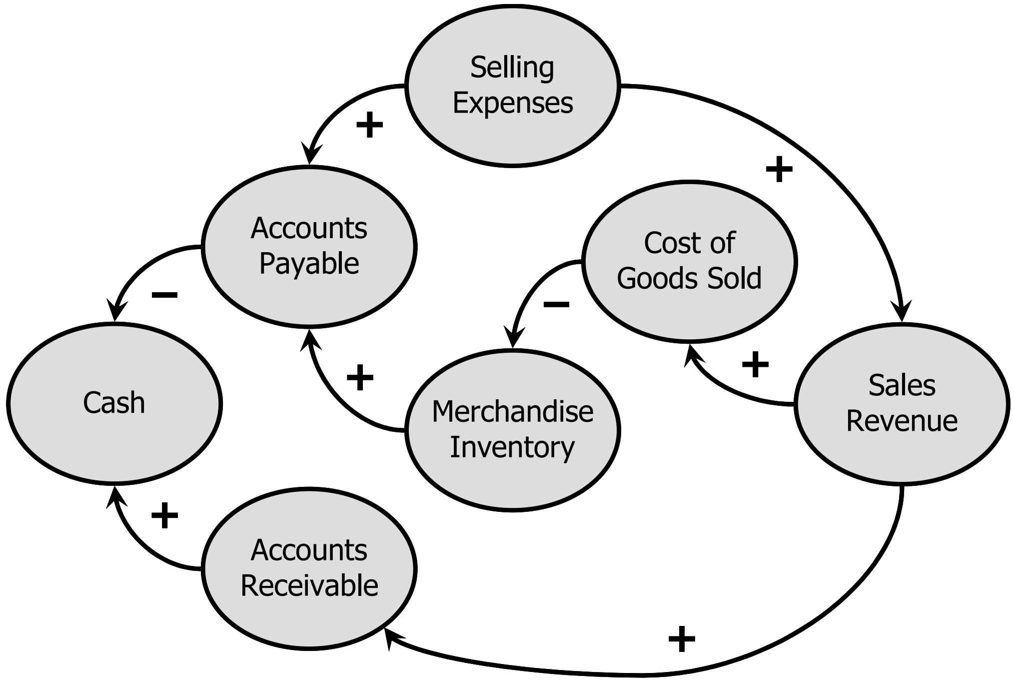
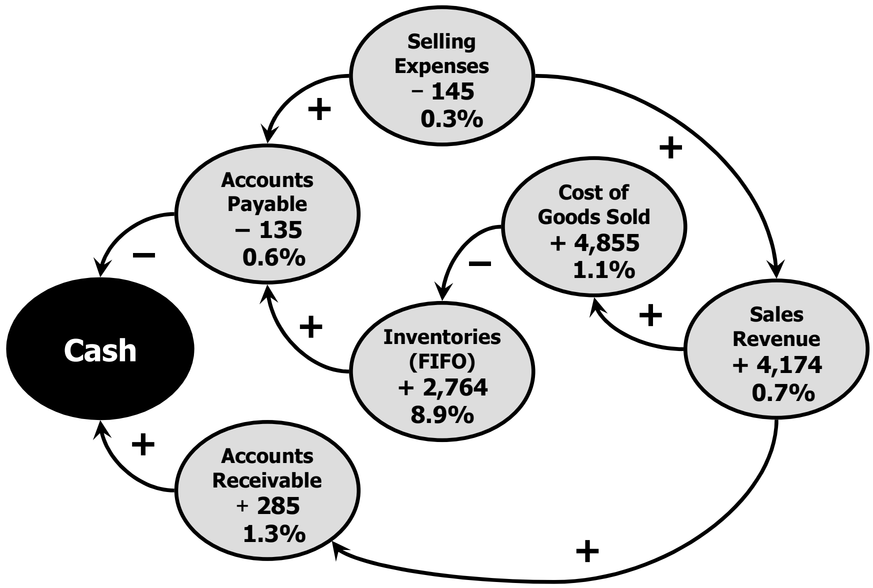


Figure 2
Alternative Information Presentation Formats

Causal-loop Diagram



Business-process Diagram

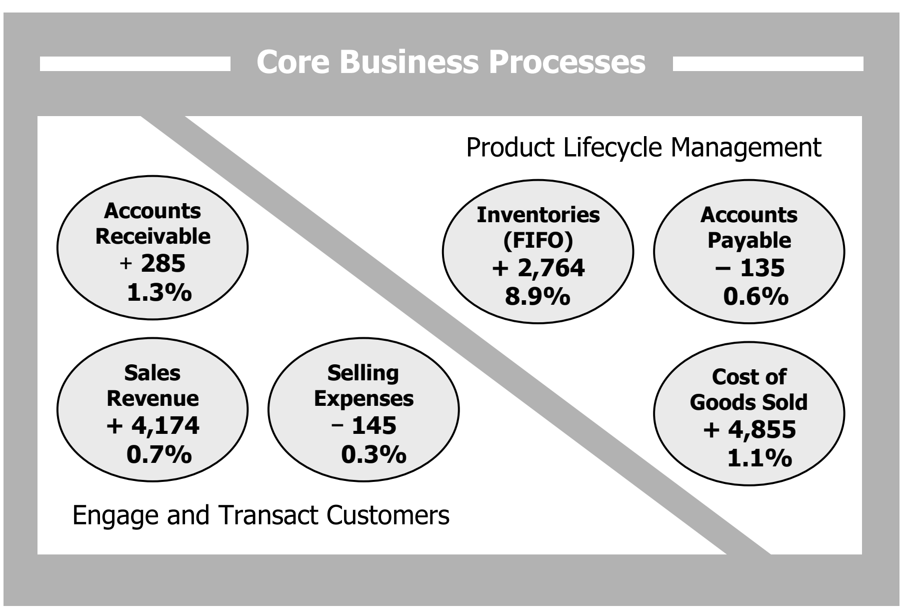


Table 1
Descriptive Statistics

Panel A: Participants Required to Identify Unexpected Fluctuations

	Number of Participants Who Targeted Account for Extended Testing			
Account	All Participants (n = 40)	Causal-Loop Diagram (n = 20)	Business-Process Diagram (n = 20)	P-value for Fisher's Exact Test
Sales Revenue	21	12	9	.2636
Cost of Sales	24	13	11	.3738
Selling Expenses	22	13	9	.1703

Panel B: Participants Required to Explain Unexpected Fluctuations

	Number of Participants Who Included Account in a Potential Explanation			
Account	All Participants (n = 42)	Causal-Loop Diagram (n = 21)	Business-Process Diagram (n = 21)	P-value for Fisher's Exact Test
Accounts Receivable	18	10	8	.3779
Merchandise Inventory	31	17	14	.2420
Accounts Payable	21	12	9	.2689
Sales Revenue	32	19	13	.0335
Cost of Sales	25	15	10	.1041
Selling Expenses	29	15	14	.5000

Table 2
Influence of Type of Diagram and Type of Task on Pattern Recognition
for Accounts Involved in Pattern of Inconsistent Fluctuations

Panel A: Analysis of Variance

Dependent variable: Total number of accounts involved in the seeded pattern of inconsistencies (sales revenue, cost of sales, and selling expenses) that participants either targeted for extended testing or included in misstatement explanations

	Degrees of Freedom	Sum of Squares	F-statistic	P-value
Model	3	8.29	2.79	.0458
error	78	77.22		
Type of task	1	2.84	2.87	.0941
Type of diagram	1	5.34	5.40	.0228
Interaction	1	0.07	0.08	.7831

Panel B: Average Number of Accounts Targeted or Included in Misstatement Explanations

	Used Causal-Loop Diagram	Used Business-Process Diagram
Identified Unexpected Fluctuations	1.9	1.4
Explained Unexpected Fluctuations	2.3	1.7

Table 3
Influence of Type of Diagram and Type of Task on Importance of Information about Pairs of Related Accounts Involved in the Pattern of Inconsistent Fluctuations

Panel A: Analysis of Variance

Dependent variable: Average importance ratings from 1 (low) to 9 (high) for all six possible pairs of accounts involved in the seeded pattern of inconsistencies, including sales revenue, cost of sales, and selling expenses

	Degrees of Freedom	Sum of Squares	F-statistic	P-value
Model	3	11.00	1.51	.2196
error	78	190.01		
Type of task	1	0.44	0.18	.6698
Type of diagram	1	10.23	4.20	.0438
Interaction	1	0.42	0.17	.6790

Panel B: Average Importance Ratings across Experimental Conditions

	Used Causal-Loop Diagram	Used Business-Process Diagram
Identified Unexpected Fluctuations	6.2	5.4
Explained Unexpected Fluctuations	5.9	5.4

Appendix
Case Materials

Information Provided to all Participants

Instructions

This study examines judgment processes that auditors use to perform analytical procedures. You will be asked to evaluate a short audit case and analyze the potential for financial misstatement. Evaluate the information and make decisions using the same criteria and rationale that you would apply in the field. The proctor who distributed these materials will not be able to answer any questions. Please interpret and respond to the case materials on your own, without discussion among your peers. Please complete the materials in the order presented. Once you have completed a section, please do not go back and change any answers that you have already provided.

Case Information

Assume that you are the senior in-charge of field work for the audit of a furniture manufacturing company and have begun developing the audit program after the fiscal year has ended. Your publicly-traded client designs and fabricates high-end wood furniture for sale to wholesale distributors and large retail chains. The company became a client of your firm four years ago and has always received an unqualified opinion. Your firm's evaluation of internal control has been completed; there were no material deficiencies and control risk has been assessed as low.

Your client focuses heavily on two core business processes: (1) engaging and transacting customers, and (2) product lifecycle management. The strategic focus for engaging and transacting customers is improving customer relationships. During the current year, management funded a customer relationship management program to learn more about the consumer markets that their wholesale customers serve, and also introduced several new and aggressive sales promotion and marketing initiatives. Although the company has a number of new product lines that they plan to roll out next year, their product mix did not change significantly from the prior year. The engagement partner has rated business process risk for engaging and transacting customers as moderate.

The strategic focus for product lifecycle management includes effective product design and quality control. Management has implemented a program for monitoring key production metrics and maximizing product quality while controlling manufacturing costs and throughput efficiency. Because raw material prices are largely fixed by long-term contracts with suppliers, raw material costs have not changed significantly from the prior year. Because the current year was the third and final year of a collective bargaining agreement with the union that represents plant employees, labor costs have also not changed significantly from the prior year. The engagement partner has rated business process risk for product lifecycle management as low.

Information and Required Response for Identify-Unexpected-Fluctuations Task

REQUIRED: Based on the information that has been provided, and before you examine information provided on the next page, rate the overall risk of material misstatement for this client on the scale provided below

1	2	3	4	5	6	7	8	9
Low risk of misstatement				Moderate risk of misstatement				High risk of misstatement

REQUIRED: A portion of the entity-level business model for this client has been reproduced below. The model includes information about the amount of change (in thousands of dollars) and percent change in selected account balances from last year to this year. Based on information provided in the case and patterns of fluctuations in accounts reported in the model, indicate whether the income statement accounts listed beneath the model should be targeted for further investigation because the change from last year to this year is not consistent with your expectations. Please check yes or no for each account. If you check yes for an account, document the reason why the change in account balance is inconsistent with your expectations.

This space contained either the causal-loop diagram or the business-process diagram illustrated in Figure 2.

Account	Target this account for further investigation?	If you checked YES, document why you believe that this fluctuation should be investigated further
Sales revenue	☐ No ☐ Yes	
Cost of goods sold	☐ No ☐ Yes	
Selling expenses	☐ No ☐ Yes	

Based on the analytical procedures you have performed, rate the likelihood that the **<u>sales revenue</u>** account contains a material misstatement.

1	2	3	4	5	6	7	8	9
Low risk of misstatement				Moderate risk of misstatement				High risk of misstatement

Based on the analytical procedures you have performed, rate the likelihood that the **<u>cost of goods sold</u>** account contains a material misstatement.

1	2	3	4	5	6	7	8	9
Low risk of misstatement				Moderate risk of misstatement				High risk of misstatement

Based on the analytical procedures you have performed, rate the likelihood that the **<u>selling expenses</u>** account contains a material misstatement.

1	2	3	4	5	6	7	8	9
Low risk of misstatement				Moderate risk of misstatement				High risk of misstatement

Information and Required Response for Explain-Unexpected-Fluctuations Task

A portion of the entity-level business model for this client has been reproduced on the next page. The model includes information about the amount of change (in thousands of dollars) and percent change in selected account balances from last year to this year. The manager on the engagement has told you that she believes income before interest and taxes increased more than it should have. She has asked you to perform analytical procedures to evaluate the possibility of financial misstatement before she discusses the increase in operating profits with the company controller.

This space contained either the causal-loop diagram or
the business-process diagram illustrated in Figure 2.

REQUIRED: Based on information provided in the case and patterns of fluctuations in accounts reported in the model, compile a list of account misstatements that could account for an unexpected increase in income under conditions described in the case. In Column 1 of the space provided below, describe each potential misstatement and identify the accounts that would be affected. After you have listed all potential misstatements, evaluate the likelihood that each misstatement has occurred. In Column 2, enter the number “1” by the most likely misstatement, enter the number “2” by the next most likely misstatement, and continue numbering the misstatements until a ranking number has been documented for all of the potential misstatements on your list.

Description of Possible Misstatements:

Column 1	Column 2

*Based on the analysis you have performed, rate the likelihood that each of the following accounts has contains a material misstatement.

	Low likelihood			Moderate likelihood			High likelihood		
Accounts receivable	1	2	3	4	5	6	7	8	9
Inventories (FIFO)	1	2	3	4	5	6	7	8	9
Accounts payable	1	2	3	4	5	6	7	8	9
Sales revenue	1	2	3	4	5	6	7	8	9
Cost of goods sold	1	2	3	4	5	6	7	8	9
Selling expenses	1	2	3	4	5	6	7	8	9

Required Response for all Participants

In the table provided below, rate how relevant information about the change in each of the other five accounts was for your evaluation of the likelihood that a target account is misstated. Select a number from the scale below that corresponds to your relevance rating, then enter that number in the appropriate rating box.

1	2	3	4	5	6	7	8	9
Not relevant				Moderately relevant				Very relevant

Target Accounts	Importance Ratings for Information about the Change in Other Accounts					
	Accounts receivable	Merchandise inventory	Accounts payable	Sales revenue	Selling expenses	Cost of goods sold
Sales revenue						
Selling expenses						
Cost of goods sold						

How many months have you been employed as an auditor on a full-time basis? ____________

How many months have you worked as a senior who supervises field work? ____________