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Abstract

We investigate the effects of business model representation techniques, specifically format and presence of causal linkages, on business risk and audit risk assessment. We conduct an experiment involving auditing students with previous audit work experience as participants and business model information based on an existing public company. Participants given business model representation in either diagrammatical or tabular format make more accurate risk assessments than those given the same information in a free-form narrative format. Contrary to our prediction, overall performance in diagram and table conditions does not differ statistically. The inclusion of causal linkages in the business model representation has mixed effects on risk assessment accuracy. We also investigate whether task-specific experience moderates the effects of representation techniques on risk assessment. We find an interaction effect of task-specific experience with causal linkages; specifically, linkage effects are limited to the subsample of participants with no risk documentation experience.

Keywords: Business Model; Business Model Representation; Business Risk Assessment; Audit Risk Assessment; Representation Format; Diagrams vs. Tables vs. Free-form Narrative;

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Introduction

This study investigates how different business model representation techniques affect auditors' assessment of business risk and audit risk. Auditors need to assess a client's business risk as part of their assessment of audit risk for their financial statement audits. Although International Standards in Auditing 315 (IAASB 2013) require auditors to gain an understanding of clients' businesses, there is little official guidance on how this is to be achieved. This research focuses on business model representation techniques because business models are popular tools to communicate a company's strategy and internal processes (Kaplan and Norton 2004). Further, auditing researchers have advocated using business models to identify business risks and their potential financial statement effects (Peecher, Schwartz & Solomon 2007). Prior studies have looked at whether business model information improves auditor decision making (Kochetova-Kozloski and Messier 2011, Wright and Berger 2011, and Wright 2013); this study adds to existing research by examining how differences in business model representation techniques affect auditor risk assessment accuracy. Reviews of relevant information presentation research (e.g., Kelton, Pennington, and Tuttle 2010) find that information presentation format effects are often not generalizable because they depend on cognitive fit, which refers to the alignment among the task characteristics, the presentation format, and the decision maker's mental processes. Since cognitive fit can vary by task, research needs to address presentation methods by task as well. We focus on the representation of business models for use in business risk and audit risk assessment because it is a critical phase of the audit; risk assessments set the stage for subsequent audit program planning decisions.

Knowing which representation technique improves auditor decision making is important for audit firms because the process of documenting client business models consumes valuable time in audit engagements (Alencar et al. 2008). The purpose of documentation is to facilitate individual auditors' understanding of the client's business so that auditors can do a better job identifying risks of misstatement for specific financial statement accounts. Effective documentation can benefit the audit engagement in the current year and beyond, especially when the audit team experiences turnover from year to year. Because an industry best practice has not been developed, audit firms have used a variety of representation techniques to document clients' business models. Our study seeks to provide information on the effectiveness of various representation techniques used by auditors when others have created the representations, but does not address the effectiveness of representations when they are used by the person who created them. Typically, most uses of such representations are by personnel other than the creator of the representation, including other audit team members, reviewers and inspectors both during the current period and in subsequent periods.

We investigate our research question with a laboratory experiment that uses undergraduate accounting students with an average of 8 to 12 months of prior accounting related work experience, 64% have worked inside an accounting firm, and 45% have worked in external audit. We explore three types of business model representation formats, diagram, tabular text, and free-form narrative, a widely used format for documenting business models, and compare them against one another. The diagram consists of circles, arrows, and categorical headings; the tabular format consists of tables with categorical headings; and the free-form narrative consists of randomly ordered bullet points. Except for presentation format-related differences, participants are provided the same business model content across the three different formats. We also explore whether the inclusion of causal linkages improves risk assessment accuracy. Linkages appear as arrows in the diagram condition, but as words in the tabular text and free-

form narrative conditions. In addition, we explore the relative effects of representation techniques on participants with different experience levels. Our participants had a modest amount of audit work experience as well as classroom training in performing the task. Hence, our results provide insights into how representation techniques can affect entry level auditors.

We expect that, compared with the free-form narrative format, structured formats such as diagrams and tabular text will improve auditor risk assessment accuracy. The improvement will be the result of a more complete mental representation of the effects of changes in the client's business environment on the client's strategic goals and related internal processes which are documented in the model. A better mental representation will allow auditors to generate more accurate hypotheses regarding financial statement areas at risk of misstatement. We also expect diagrams to be more effective than tabular text because of their ability to convey more information and demonstrate relationships between business environment factors and business processes (Simon and Larkin 1987). Finally, we expect the presence of causal chains to reduce ambiguity among the relationships inside the business model and aid auditor risk identification (Wright and Berger 2011). However, it is possible that the mere identification of a specific set of economic and business factors is sufficient for auditors to perform well regardless of the information representation techniques used.

We find that participants provided with diagrammatic and tabular business models are, in general, more effective at discerning relevant risk accounts and assertions than those receiving free-form narrative format models. Diagrammatic and tabular representations appear to enhance participants' identification of relevant risk items and their impact on financial statement misstatement risk. We conclude that structuring (i.e., categorizing and organizing) business model information via formats such as a diagram or tabular text can help auditors make more accurate risk assessments. When auditors are presented with an unstructured list of items without categorization or organization, they are more likely to dismiss relevant items as

irrelevant. However, we do not find differences in performance between diagrammatic and tabular representations, suggesting that they may be equally effective given the audit task and type of business model. In addition, we find that providing causal linkages does not always improve risk assessment accuracy for inexperienced auditors, as the presence of many linkages actually hurts performance in one of the two business scenarios used in the study. However, when we focus on the participants with more task-relevant work experience, we find no performance difference between linkage and no-linkage conditions. The results suggest that experience may attenuate the effect of causal linkages as a representation technique.

This study is expected to contribute to academic research, professional practice, and higher education. The research results should contribute to the understanding and evaluation of the techniques available to represent business models, which support business risk assessments and inform practitioners seeking to improve their business risk assessment processes. Since textual narratives are widely used to document business models, our finding that both diagrams and tables are superior to such narratives is an important contribution to practice. Although some educators have recommended that accounting educators should use more diagrams to improve learning (Bradford et al. 2007), academic research about this claim has been sparse. Our findings suggest that, for audit tasks such as business risk and audit risk assessment, diagrammatic representation may not be a superior to a tabular representation method. Finally, our study can contribute to business management by helping to further elucidate the links among external environment factors, business strategies and goals, internal processes and resources for business risk assessments.

Literature Review and Hypothesis Development

This study is at the nexus of several streams of literature: business models in the business strategy literature; business risk identification in the audit literature; systems modeling; and

cognitive science and external knowledge representation, particularly in the context of auditor judgments about business risk and audit risk. The business models literature is useful for explaining which aspects need to be modeled to understand business' economic networks. The systems modeling literature provides insight into current practice and research regarding modeling of complex systems and developing standards for modeling businesses and their economic networks. The cognitive science and external knowledge representation literature shows why and how various information representation techniques affect communication and problem-solving. The auditor judgment literature provides additional information regarding which aspects affect risk assessments.

The Importance of Business Risk Assessment for Auditors

International Standards on Auditing (ISA) 315 state that business risk results from significant conditions or events that could adversely affect an entity's ability to achieve its objectives and to execute its strategies (IAASB 2013). Because business success or failure strongly influences audit risk, existing auditing research has focused on studying how business risk affects other parts of the audit process and what determines proper identification of business risks (Eilifson et al. 2001, O'Donnell and Schultz 2005, Curtis and Turley 2007, Knechel et al. 2010). The focus on business risk is one of reasons behind the development of Business Risk Audit (BRA) or Strategic Systems Audit (Peecher et al. 2007, Knechel 2007). In theory, BRA helps auditors to allocate resources more effectively because this approach prompts auditors to tailor procedures to a client's ever-changing business environment (Peecher et al. 2007). In practice, however, auditors often find BRA too subjective and thus difficult to execute (Curtis and Turley 2007). Scholars in this area have pointed out that auditors' strategy assessment skills must match the demands of BRA and called for changes in auditor education (Wright 2012), audit team composition (Eilifsen et al. 2001, Moroney and Simnett 2009), and the design and use

of decision aids (Dowling et al. 2008, Schultz et al. 2010). The focus of this study is on improving risk assessment decision aids for auditors.

Auditors' strategy assessment skills may be improved through more complete mental representations of the client business environment and processes. Hammersley (2011) states that mental representations are "cognitive models of a domain or situation that are used to run mental simulations and allow decision makers to form inferences" (p. 110). Kochetova-Kozloski and Messier (2011) suggest that using strategic analysis tools such as Porter's Five Forces model could improve auditors' mental representations. Wright and Berger (2011) compare a business model presentation of corporate events with a chronological representation. They find that business models emphasize relationships between business strategies and key performance indicators and can improve auditors' mental representations. Although existing research suggests that some business model representation techniques affect mental representations, other techniques, specifically representation format and causal linkages, have not been investigated.

The Effect of Business Models on Auditors' Risk Assessment

"[H]ow you make money" defines the essence of a business model (Chesbrough and Rosenbloom 2002: 533), which includes

- the business value proposition;
- customers (market segment) and the revenue generation mechanism;
- activities within the firm that provide the value wanted by the customers, and the assets needed to support these activities;
- the costs and profitability of the set of activities given the other assumptions;
- the firm's place within the value network which links the firm with suppliers, customers, competitors, and potential partners; and
- ways to achieve and retain a competitive advantage over potential rivals.

Managers often rely on the above information to make strategic decisions; auditors also need this information to understand their client's business and associated business risks in order to conduct an effective audit. Auditors often obtain and update client business information through formal inquiries as well as through engagement partners' ongoing communication with client executives (Hirst and Koonce 1996). Once obtained, the information needs synthesis and structure to be effectively transferred to less experienced personnel, such as staff auditors or those new to the audit team, who have fewer opportunities to communicate with senior client personnel. Structured information can improve performance on tasks, such as analytical procedures, which staff auditors often perform.[1] Such structuring involves a variety of representation techniques. For example, a business model can be represented using primarily diagrammatic elements or using mostly textual elements. Knowing which representation technique is better under different circumstances will help facilitate documentation and knowledge transfer from year to year and team member to team member.

External Knowledge Representation of Business Models

External representation affects interpretation and judgment (Larkin and Simon 1987). Although there are many types of external representations, Larkin and Simon suggest that the greatest distinction can be found when comparing graphical/diagram-based with propositional/sentence-based representations. A diagrammatic representation arranges various visual elements in space (Cheng, Lowe, and Scaife 2001), whereas a textual representation uses natural-language descriptions (Larkin and Simon 1987). Below, we compare and contrast theories about these two representation formats and prior research evidence.

[1] Senior auditors frequently conduct analytical procedures during planning, testing, and concluding stages of the audit (Hirst and Koonce 1996). The effectiveness of this procedure depends on the auditors' ability to form independent expectations, search for information, and obtain corroborative evidence. A good understanding of the client business model and business risk can help auditors determine whether client explanations are sufficient. Junior auditors perform similar tasks except they work in areas of less audit risk.

Diagrammatic reasoning primarily relies on inspection and on direct manipulation of visual elements that represent data and knowledge (Kulpa 1994, Hahn and Kim 1999). A diagram is just one component of an overall representation system, which also includes the target domain, the language used to create the representation, and the representation itself (Stenning and Lemon 2001). Cox and Brna (1994) note that diagrammatic representations can help solve a range of problems including analogical reasoning, programming, logical and analytical reasoning, and physics; Hahn and Kim (1999) also find that diagrammatic representations aid reasoning about economic markets, medical diagnosis, and systems design.

Diagrammatic representations may be better than textual representations with equivalent information for several reasons. Cox and Brna (1994) note that diagrams may reduce search and memory efforts through organizing information by location; they also concur with Larkin's (1989) assertion that diagrams help to illustrate structure and provide specificity because the visual form constrains ways the domain can be fitted together and used. In addition, Cox and Brna suggest that the diagrams may force people to address ambiguities in their perceptions of the problem, in part, because diagrammatic representations limit the amount of abstraction that can be expressed. However, diagrammatic representations may not always be better than their textual counterparts (Cheng, Lowe, and Scaife, 2001; Boritz et al. 2012). The superiority of diagrams is contingent on whether users possess certain skills and knowledge to exploit the constraints on expressiveness (Stenning and Lemon 2001). Also, judgment and decision making errors may occur when domain structures or relationships cannot be represented because of limits in the representational language or because of poor matching of diagram formatting with the cognitive processes that relate to perceiving the representation, finding relevant information, and drawing inferences (Larkin and Simon 1987). In fact, Cox and Brna (1994) find little empirical research addressing the question of what type of representation best suits particular kinds of information. In summary, the effectiveness of a particular representation format

depends on task characteristics (Stenning and Lemon 2001); diagrams may not be unambiguously better as some researchers claim (e.g., Bradford et al. 2007).

An alternative representation is the tabular format. Tables are comprised of mostly textual information but are organized in rows and columns; thus they provide structures that can simplify complex systems to more understandable parts. Boritz (1984) asserts three benefits of applying hierarchical structures to audit problems: structures clarify problems through decomposition and modularization of information sets; structures limit the amount of heuristics and biases of auditors; structures incorporate knowledge and expertise which highlight relationships and information cues. On the other hand, tables still rely on textual descriptions which are often not as specific as diagrammatical elements.

Another representation format that is widely used to document business models is the free-form textual narrative. Free-form narratives can also be represented in a variety of ways; the key feature of these representations is the lack of structures such as borders and categorical headings in tables. Such textual representations are the simplest methods of documenting business models and contain the least visible structure but may nevertheless contain the essential information required to enable an auditor to complete related audit tasks. Since cognitive fit is necessary for a representation technique to be effective (Kelton et al. 2010), it is not known whether in a business risk and audit risk assessment task based on a business model representation diagrams would outperform tables for representation of business models and whether tables would outperform free-form narratives.

Business Models, External Representations, and Auditor Judgment

Recent auditing research (e.g. Ballou and Heitger 2004, Earley 2001, and O'Donnell and Schultz 2003) has examined issues related to the use of business models in the context of business and audit risk assessments, but the literature has not, in general, examined external presentation issues related to the use of business models. On the other hand, management

accounting researchers have examined representation issues, such as whether to present balanced scorecard information in a list or in a causal map. For example, Cheng and Humphreys (2012) finds that the combination of causal linkages and strategy-map representation enhances managers' understanding of strategy-related information. . However, auditing is different from making management decisions. Managers probably do not focus on financial statement accounts and assertions or consider audit risk and materiality while making decisions. Therefore, the task differences between auditing and management decision making warrant further empirical investigation.

Given that most audit problems, including risk assessment, are usually ill-structured or semi-structured (Boritz, 1981), researchers have sought to improve the structuring of audit problems through the use of external representations. Rose (2002) summarizes much of the research related to decision aids and find that, in general, organizing information to better suit task or cognitive characteristics improves auditor judgment. There are, however, tradeoffs in a task's computational complexity and auditors' judgment effectiveness. For example, Boritz (1984) compares auditors' responses to information cues about internal controls arranged according to a hierarchically structured template with cues arranged in a simple list; he finds that the hierarchical information structure plays a role in auditor judgments, but adds difficulty to those judgments.

Boritz, Borthick and Presslee (2012) use an experiment that compares students' performance on a business process risk and control assessment task using two informationally equivalent process documentation methods commonly taught in the classroom: textual narrative and diagrammatic representation based on Business Process Modeling Notation (BPMN). They find that while representation format has no effect on students' accuracy, those receiving the textual representation are more efficient and have a greater weighted-average performance (accuracy plus efficiency) than those receiving the diagrammatic representation. The key

differences between the current study and Boritz et al. (2012) is that we address three representations of business models used in engagement level business risk and audit risk assessments, whereas Boritz et al. (2012) focus on diagrammatic and textual business process documentation of internal controls. Although Boritz et al. do not find diagrammatic representation superior to textual representation, we find it necessary to examine whether Boritz et al.'s (2012) conclusions are robust across audit task settings and whether tabular representations yield similar results as diagrammatic or textual narrative representations.

Auditors' Risk Assessments and Business Model Representational Format

Bell, Peecher, and Solomon (2002) allude to the importance of external knowledge representations to auditors in the context of business risk assessment. According to Bell et al. (2002), development of a reliable mental model by auditors is essential to their risk assessments, and that building such a model considering the clients' complex business environments can be challenging. If human cognitive capacity is the limiting resource, then the appropriate external representation should reduce cognitive load in order to auditor performance. Compared with a simple list of information items, diagrammatic and tabular representations help to categorize and organize business model information in to more understandable chunks. Bell et al. (2002) propose chunking as a technique to reduce cognitive load. We expect lower cognitive load will lead be better encoding and retention of business model information, which in turn will enable auditors to make superior risk assessment judgments. Although both diagrams and tables provide structure, diagrams are more visually salient and better at communicating the dynamic relationships within a business model. For example, flow diagrams based on structure system analysis (DeMarco 1978) use graphic elements such as boxes or circles and linkages drawn using arrows that appear to better highlight discrete information items and linkages among them than using text alone and phrases such as "this is related to XYZ". Therefore, we conjecture that diagrammatic representations will assist auditors to simulate organizational outcomes from

external events and assess the outcomes' impact on the risk of misstatement of financial statement accounts. The above theory development leads to H1a and H1b.

H1a: Using a structured graphical or tabular representation of a business model will lead to more accurate assessment of audit risks than using an unstructured informationally-equivalent textual representation (free-form narrative) of the business model.

H1b: Using a structured graphical representation of a business model will lead to more accurate assessment of audit risks than using a structured informationally-equivalent tabular representation of the business model.

It should be noted that business model representations can increase, as well as reduce, auditors' cognitive load. Research of systems modeling in accounting and auditing has only recently started to consider business modeling issues, and there is no prior research on the use of alternative representation formats during the business risk assessment phase of the audit other than Alencar, Boritz and Carnaghan (2008). As part of their research instrument development, Alencar et al. conducted interviews of Big 4 technical partners to learn about the types of documentation formats being used to document business models for planning and risk assessment purposes. Alencar et al. (2008) found that the formats ranged from structured tabular formats to free form narratives and that diagrammatic representations may be useful for some, but not all, aspects of business risk assessment; in particular, a tabular text representation helps auditors to understand how environmental changes affect a business model and a company's financial statement accounts, whereas a diagrammatic representation helps auditors link strategic goals to those internal processes and resources that support the goals. Our research is distinct from Alencar et al. (2008) because we examine representation format in more detail by adding the free-form narrative format, separately test the effect of representation format and linkages, and use different business model information as well as different measures of risk assessment accuracy.

Auditors' Risk Assessment and Presence of Causal Linkages in Business Models

As part of our study of representation format, we explicitly consider the effect of adding linkages within business models on auditor risk assessment accuracy. Linkages convey information about the causal relationships among different elements of the business model, making the model more dynamic and map-like. Linkages can appear in the form of "if…then" statements, cross-references such as "see note x" or graphical in the form of arrows connecting two items.[2] The presence of causal linkages may help decision makers form mental representations, cognitive models of a domain that are used to run mental simulations (Hammersley 2011). Hammersley suggests that better-developed representations allow auditors to identify clues about possible financial statement misstatements, including fraud. Extending the theory to risk assessments, it is likely that adding causal linkages can improve auditor judgment through better mental representations.

Some supporting evidence is found in the management decision making literature. Banker et al. (2004) find that a strategy map perspective limited the common-measure bias in managerial performance evaluations. Tayler (2010) finds that when components of a business strategy are connected by causal links and when managers are involved in the development of causal links, managers' decisions are less susceptible to motivated reasoning. In a study on the effect of causal linkages on judgment performance involving the Balanced Scorecard, Cheng and Humphreys (2012) find that, when managers receive a strategy map with causal linkages, versus information in a random list, they become better at differentiating relevant and irrelevant external information with respect to a firm's strategies. Interestingly, the same information, presented without causal linkages, is not superior to the random list. Thus, Cheng and Humphreys suggest that causal linkages help managers to consider the relevance of external information with respect

[2] Both forms of causal linkages have been studied in prior research. Cheng and Humphreys (2012) operationalize causal linkages using arrows; in contrast, Farrell et al. (2012) operationalize causal linkages using textual phrases.

to a single connected strategy theme; in contrast, when causal linkages are absent, managers must consider how the external information connects with multiple strategic themes, making its implications unclear. .

The strategy maps in Cheng and Humphreys (2012) have a lot in common with the business models examined in our study. A key difference between our studies is that they layer the causal link condition on top of the scorecard condition. We independently manipulate causal linkages and representation format; this design enables us to assess whether causal linkage can benefit the users when an organizing structure does not exist – the free-form narrative condition. In addition, we examine the audit risk assessment setting which enables us to test the generalizability of Cheng and Humphrey's findings in the managers' strategy assessment setting. We predict that such effects will generalize to the audit risk assessment setting. In particular, causal links would be important to help auditors consider how each external environment factor affects multiple inter-connected, rather than unconnected, goals and financial statement accounts.

H2: Business models with causal linkages will lead auditors to make more accurate audit risk assessments than business models without causal linkages in all three representation formats – diagram, tabular text, and free-form narrative.

Business Model Representations and Task-Specific Experience

As noted earlier, the effectiveness of various representations depends on whether users possess the expertise (i.e., the skills and knowledge) required to exploit the constraints on expressiveness (Stenning and Lemon 2001) associated with various representational "languages." Judgment and decision making errors may occur because of limits in the representational language or because of poor matching of diagram formatting with the cognitive processes that relate to aspects of the task such as perceiving the representation, finding relevant information, and drawing inferences (Larkin and Simon 1987).

The techniques we investigate in this study represent tools used to enhance auditor performance. Libby and Luft (1993) categorize such tools as audit technologies, which are defined as "apparatuses of guidance and support made available to auditors with the purpose of aiding and controlling their judgments" (p. 436). Although we expect that certain external representation formats and the presence of causal linkages will improve auditors' risk assessments, a pertinent question is whether these tools improve risk assessments regardless of the auditors' level of experience with various representations.

Libby and Luft (1993) devise a model in which knowledge affects performance and experience affects knowledge. They also propose that audit technologies could interact with knowledge in two ways. First, the audit technology may act as a substitute for deficiencies in knowledge. Because individual cognition is limited, novice auditors, who lack task-specific knowledge gained through experience, may be overwhelmed by complexity of a client's business model. Business model representation techniques can help novice auditors construct mental representations by reducing task complexity, something novices may not be able to do if the information is provided in a random list. Thus, audit technology may help novices improve their performance. Second, audit technology can act as complement to existing knowledge. In this type of interaction, only knowledgeable subjects would perform better with the technology. Libby and Luft cite examples such as the study by Frederick (1991), which shows that schematic (causal) information presentation, compared with taxonomic presentation, enhanced the memory for experienced auditors. Therefore, audit technologies can help experts to be even better.

In Frederick (1991), experience is used to proxy for knowledge. We also use experience to proxy for knowledge in our study. It should be noted that Bonner and Lewis (1990) suggest that it is task-specific experience that promotes task-specific knowledge, not general auditing work experience. Thus, we test the effect of the interaction of task-specific risk documentation experience and representation techniques through the following hypothesis:

H3: The representation format and presence of causal linkages interact with risk documentation experience to affect the accuracy of auditors' risk assessment

Research Method

Participants and Risk-documentation Experience

Participants were 167 students with 8 to 12 months of accounting related work experience taking a 4th year undergraduate auditing course at a large North American university.[3,4] The experiment was administered as an optional assignment in the course. Participants were informed prior to participating that only their performance on risk assessment questions counted toward their course grade and that they could omit the demographic questions in the study. Participants were also provided with the option to withdraw their quiz responses from the research study at no penalty to their class mark. On average, participants spent 37 minutes on the task; 63% were female, and all had classroom training in audit risk assessment techniques. Also, 49% had some risk documentation experience from formal employment in accounting. Of those who had risk documentation experience, 60% worked in audit firms and 44% had participated in audit planning meetings. Of those who had not had risk documentation experience, 66% had worked in audit firms but only 9% had participated in audit planning meetings.

[3] Include audit and non-audit experience. 44.2% have worked in the audit function in accounting firms.
[4] A total of 223 students participated in two separate administrations of the experiment. We ran four different linkage conditions, two of which were partial linkages and two of which were either full linkage or no linkage conditions. Partial linkage means that we connected two levels of the business model rather than all three levels. Because the partial linkages conditions are mostly exploratory, we removed them from discussion to simplify this paper. Thus we dropped 56 participants from the sample. Since each participant completed two scenarios, some viewed a combination of partial and full/no linkages while some only saw full/no linkage scenarios. Because we only analyze the full/no linkage data, the exposure to partial linkages represent a limitation to our study. To address this concern, we compared the means of our main dependent variables for the two groups and did not find any significant differences ($p>0.05$). Nevertheless, we acknowledge the possibility of a confound between our linkage variable and the two cohorts participating in the study.

Setting

We conducted a laboratory experiment to test our hypotheses. The case company is an existing public company in the technology sector experiencing perturbations in their environment such as changes to competition and new regulatory requirements that could disrupt their business model. This setting provides a good opportunity for research because it introduces an array of business and audit risks which auditors need to detect and to address using appropriate procedures. A good understanding of the business model is beneficial to both of these goals.[5]

Experimental Design

We use a 3 x 2 x 2 between-subjects design to test how business model representation format, presence of linkages, and risk documentation experience affect audit risk assessments. The three representation formats are: Diagrammatic, Tabular, and Free-form Narrative/Bullet Format. We also manipulate two linkage conditions, such that linkages are either Present or Absent within the business model. However, risk documentation experience is a measured variable separating participants with some risk documentation experience from those with no experience.[6]

Because there are numerous elements affecting the audit risk of the actual firm, we were selective in the information used in the instrument. We use two separate scenarios with different information sets, A and B, rather than having a single large and complex scenario. We ask each participant to complete both scenarios and to think of them as independent cases. To avoid confounds generated by order effects, we counterbalance the presentation order of scenarios A and B. The representation format (i.e. diagram, table, or bullet) of A and B is kept consistent

[5] The case permits testing of auditors' ability to design / modify procedures to address new risks, which could be an extension of this study. We focus our testing on risk assessment only.

[6] We initially measured Risk Documentation Experience as a continuous variable between 0 (no experience) to 7 (very experienced). The resulting distribution showed that roughly half of the participants did not have such experience and the most experienced individual self-rated a 4 only. Thus we treated this as a dichotomous variable.

within-subject. For each scenario, presence of causal linkages is randomly assigned; however as the participants move to the second scenario, the presence of linkages is allowed to change. In other words, one may see linkages in scenario A, but no linkages in scenario B, or vice versa. The experiment materials can be found in the Instrument Supplement.

Instrument

We adapted the instrument from Alencar, Boritz, and Carnegan (2008). Alencar et al. recruited and interviewed audit partners to validate the instrument; the interviews show that partners start from external and strategic issues and work down to internal processes, and then to financial statement accounts, suggesting that business models should be drawn in a similar fashion.[7] Unlike Alencar et al., we use multiple choice questions to evaluate participants' business and audit risk assessments.[8] Multiple choice questions increase the consistency of data, ease of interpretation, and speed of collection; however, this testing format cannot ask participants to clarify so as to probe their depth of understanding.[9] Also, we introduce an additional presentation format, the free-form narrative representation format, to separate the effect of structuring the task from the use of graphical techniques such as circles and arrows rather than an informationally equivalent structured textual presentation.

Business Model. Our analysis of the literature (e.g., Bell, Marrs, Solomon and Thomas, 1997) suggest that at least four elements are necessary to document a business model: 1) the external environment in which the entity operates its business; 2) the entity's strategic goals in that environment; 3) the internal processes and resources that support the achievement of the entity's strategic goals; and 4) the financial performance of the business model, represented by

[7] ISA 315 "Understanding the Entity and its Environment and Assessing the Risks of Material Misstatement" also suggests the top-down approach operationalized in Alencar et al. (2008)

[8] We used Qualtrics (www.qualtrics.com), an online survey and experiment software to collect the data, but the students must attend the laboratory session to complete this study.

9 After pilot testing the instrument with an independent group of advanced level students, we further simplified the scenarios for use with current auditing students and reduced the number of financial statement accounts.

the entity's financial statements. Thus, we simplified the common components of a business model into: the external environment, the company's strategic goals, and the company's internal processes and resources (combined into a single section rather than having two sections) and a limited number of financial statement accounts to consider. Appendix B in the Instrument Supplement contains the operationalization of the business model.

Presentation Format. We investigated three presentation formats: Diagram, Table and Unstructured List. All information across these three formats is the same except for the implicit information contained within the presentation format itself. For example, the tabular representation of the business model is organized into rows and columns representing explicit hierarchical layers which are given categorical headings; these explicit rows and columns are not present in the free-form narrative format. The diagrammatic format is organized in layers like the tabular format with the addition of two basic graphical symbols: circles representing information elements associated with the business model and arrows representing links between elements. The tabular format does not have the circles beside information elements and uses verbal links instead of arrows to connect elements. For all three formats, each information element may be connected or isolated. Connected elements contain sequential causal relationships; for example, in Scenario A the company faces increasing competition that is adversely affecting the company's goal of increasing U.S. market share. These pressures have led sales personnel to provide credit to less dependable customers; hence the company has established a formal unit to manage contracts and related terms. Alternatively, external factors may be isolated. An example is professional associations are lobbying the government to establish licensing for software developers; although this element suggests potential cost increases in the future, nothing has materialized and it has not impacted any current strategic goals which, in turn, has not affected any internal processes or expenses. In other words, a group

of connected elements forms a causal chain, whereas isolated elements do not. Causal chains are most visible in the diagram format, but much less so in the free-form narrative format.

Independent variables

The format variable consists of diagram, table, and bullet conditions. In the Diagrammatic format (Part 1, Appendix B), business model information are represented using blue circles called elements, organized under three headings, and connected by arrows. In Tabular format, (Part 2, Appendix B) circles and arrows are replaced by word phrases, but headings and categorical organization are retained. The table resembles the diagram because it possesses similar traits such as categorization, hierarchical presentation, and markers of inter-relationships. In other words, the table and the diagram are similarly structured, with the difference between them being the use of graphical symbols such as circles and arrows in the diagram rather than informationally equivalent textual presentation. Finally, in the Free-form narrative /Bullet format (Part 3, Appendix B), elements are listed in random order and headings are removed. However, the same links in word phrases are kept.

The linkage variable consists of Linkage Present and Linkage Absent conditions. Both conditions can be found in Part A, B, and C of Appendix B. In the Linkage Absent condition, such as scenarios A1 and B1, there are no linkages among various elements in different levels; while in the Linkage present Condition, such as scenarios A2 and B2, all the relevant links are drawn. Combined with the Diagram format, a linkage appears as an actual arrow connecting one element with another; combined with the Tabular format, a linkage appears as the phrase "see the following items below"; in the Bullet format, linkages appear as the phrase "this affects items X, Y, Z in this list" because items are in a random list, whereas the other two formats have category headings.

Participants' risk documentation experience is collected after the students finish the task. We ask participants to self-report on a 7-point Likert scale where 0 means no experience and 7 is

a lot of experience. Because approximately half of the participants answered 0 and no one answered higher than 4, we split this variable into two parts: No Experience and Some Experience.

Experimental Procedures

1. Participants arrive at the laboratory and log on to the study's website.
2. Participants read the case background information. They also receive an abbreviated balance sheet and income statement (Appendix A).
3. Participants read scenario information according to their experimental condition and respond to five process measure questions that allow for covariance analysis (Appendix C). The first three questions assess participants' self-efficacy regarding identifying the audit risks and business risks (Bandura, 1977; Bandura, 2006; Boritz et al. 2012); the last two assess initial levels of risk assessed by the participants (Loewenstein et al. 2000; Slovic et al. 2002). Participants respond using a slider bar across a 100-point scale.
4. Participants answer multiple-choice questions for scenarios A and B (Appendix D). The order presentation for A and B is random. Unlike the typical multiple choice question, participants can select multiple answers from the list or 'none of the above'.
5. Participants respond to manipulation check questions (Appendix E). First we ask whether participants recognize the format of representation for the scenarios reviewed. Further, following Borthick et al. (2012), we ask participants about the ease of understanding of the scenarios and how realistic they find the two scenarios.
6. Finally, participants respond to demographic questions that ask for gender, work experience, and risk documentation experience (Appendix F).

Dependent Variables

We measure participant performance using two main variables, Relevant and Irrelevant Scores. A higher Relevant_Score means that the auditor's risk assessment is accurate and may

lead to proper use audit firm's resources; a high Irrelevant_Score means risk assessment may lead to wasted resources. In each scenario, participants are asked whether each element from the environment / external factors and from the internal processes and resources levels affects the audit risk of five listed financial statement accounts. Our answer key is based on the first author's intimate knowledge of the company in real life and interviews of experienced partners from Big 4 accounting firms (Appendix D).[10] If participants correctly select an account having increased audit risk, then they get a plus 1 to their Relevant_Score. If an account having negligible risk is picked, then the participants get a +1 to their Irrelevant_Score. Relevant and irrelevant scores are not correlated in theory because the participant may select all or none of the listed accounts. For scenario A(B), the maximum possible score for relevant account is 11(14), while maximum score for irrelevant account is 29(21).

We also use a variable called the Accuracy_Score which incorporates the relevant accounts, irrelevant accounts, management assertions.[11] To construct this score, the relevant accounts within each question provide positive marks and irrelevant accounts negative marks. The relative weights are set such that participants who guess by selecting all choices would earn zero marks, the same score as those who select no accounts. Further, when participants select a relevant account, they will receive a follow-up question asking which management assertion regarding the financial statement is most at risk. We select these assertions from ISA315 and

[10] In reality, the accuracy of audit risk assessment is often determined in hindsight. For example, the auditor may be audited by the PCAOB against the generally accepted standards. Audit firms sometimes conduct concurrent reviews in which independent partners from the same firm inspect the working papers of finished audits.

[11] Accuracy_Score is an aggregate measure of Relevant_Score, Irrelevant_Score, and correct identification of the management assertions affected. The maximum Accuracy_Score is 10 and the minimum is -5. There are two parts to the calculation. The first part deals with the identification of the relevant/irrelevant accounts. For example, assume that the multiple choice question has selections A, B, C, D, E and None-of-the-Above as potential answers but only A and B are correct answers. Selecting both A and B and none of the others would earn a score of 5. Conversely if the participant picks C, D, and E, then the score is -5. If the actual selection is A and C then the score is (5 / 2 * 1) + (-5 / 3 * 1) = 0.83. If the actual selection is A, C, and D then the score is (5 / 2 * 1) + (-5 / 3 *2) = -0.83. Selecting all options would earn zero by this formula, so is selecting 'None-of-the-Above'. The second part deals with the assertions. If the person selects relevant account(s), she has the opportunity to earn 5 more points on the question. She would need to select all the correct assertions for all the possible relevant accounts to receive 5 out of 5. If there are 4 assertions but she only selected 1, then she earns 1.25 (25% of 5). The assertion portion of the score is strictly positive. The Accuracy_Score is the sum of the scores for the two parts.

provide marks if the correct ones (written in brackets next to accounts in Appendix D) are selected. Therefore, the Accuracy_Score represents an estimate of the effectiveness and efficiency of the audit plan.[12] Although this variable provides the basis for assessing participant performance, we do not claim that this variable and the weights for relevant and irrelevant accounts match how evidence is valued in real world audit engagements.

Covariates

Following Boritz et al. (2012), we use student course grades and self-efficacy measures as covariates. Students' final course grade in their auditing class proxies for their general ability; we control for general ability because it is possible that students with higher ability may get more job opportunities thus more experience documenting risk. Since experience is measured rather than randomly assigned, we need to control for the possible confound in order to isolate the effect of experience on audit risk assessment.[13] Self-efficacy is measured because Boritz et al. find it negatively correlated with task performance.

Results

Manipulation Check, Self-efficacy and Perceived Risk

Table 1 provides descriptive statistics by Representation Format for our manipulation check question (Q1) as well as for questions regarding the ease of understanding the case information and realism of the information (Q2 and Q3). In response to Q1, 10 out of 133 participants either identified the diagram as a table or the table as a bullet form.[14] Results and

[12] Although this variable provides the basis for assigning grades, we do not claim that this variable and the weights for relevant and irrelevant accounts match how evidence is valued in real world audit engagements.

[13] We use final grades in the auditing course as the proxy for innate ability. A similar approach is taken by Bonner and Lewis (1990) who use GRE questions to represent general problem-solving ability. We acknowledge that the final grade is an imperfect proxy and that the inability to random assign participants based experience levels represents a limitation.

[14] The confusion between diagram and table is probably caused by the fact that our diagrams have descriptions next to dots and placed within rectangular frames, thus look like tables. Similarly, participants mistook tables as bullet format because elements within each cell of a table resemble bullet form. We are confident in this interpretation

interpretations do not change if we remove these subjects. Untabulated results show means(SD) of participants' assessments of ease of understanding are 4.28(1.66), 4.73(1.58), and 4.18(1.54) (out of 7) for diagram, table, and bullet form conditions, respectively. Planned contrasts following ANOVA show that the table format is easier to understand than the bullet format, however the difference is only marginally significant ($p<0.075$, two tail). The mean(SD) scores for manipulation question 3, scenario realism, are 5.04(1.24), 5.07(1.14), and 5.33(0.88) for the three conditions respectively, they indicate that participants view all three formats as similarly realistic.

[Insert Table 1 here]

Participants were asked to report their self-efficacy and preliminary risk assessments after reviewing the case materials but before responding to any questions about each scenario. There are three self-efficacy questions and two risk assessment questions. We take their respective averages because a factor analysis on these five questions reveals two factors, with the three self-efficacy question loading on the first factor and the two risk questions on the second factor. We do not find differences among conditions for these two variables.

Hypothesis Testing

Although we used three dependent variables to measure performance, Relevant_Score, Irrelevant_Score, and Accuracy_Score, Irrelevant Score is not significant for most of the following tests so the discussion excludes Irrelevant_Score unless it is important to the interpretation of results. The fact that we generally do not find differences for the Irrelevant_Score variable rules out the possibility that directional results for the Relevant_Score

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because no participant mistook formats in the opposite direction, e.g. identify bullet format as diagram. Thus we conclude that our manipulation of format is successful.

variable are caused by mechanically selecting more accounts. All p-values reported are two-tailed unless specifically noted.

Format Effects

In H1a, we predicted that diagram and table formats, compared with the bullet format, would facilitate information processing and help participant to select more relevant accounts. Table 2, Panel A shows that for Scenario A, diagram and table formats have higher Relevant_Score and Accuracy_Score than bullet format (adjusted means[SD] of 5.90[1.90], 5.59[1.93], and 4.62[2.24] for Relevant Score; adjusted means[SD] of 21.10[8.99], 21.50[9.12], 16.32[10.60]). Results from a MANOVA model show $F(2, 87) = 3.80$, $p = .026$ for Relevant_Score and $F(2,87) = 3.07$, $p = .052$ for Accuracy_Score, see Table 2, Panel B) and planned contrasts for Relevant_Score and Accuracy_Score (Diagram vs. Bullet, $p = .008$ and $p = .037$; Table vs. Bullet, $p = .048$ and $p = .026$; untabulated) confirm that these differences are statistically significant, supporting H1a.

For H1b, we do not find diagram condition to be superior to the table condition for either variable, $p = .479$ and $p = .847$. Although the relative means for Relevant_Score are suggestive of this directional effect, there is no statistical significance. Table 3, Panels A and B document results for scenario B; we do not find any significant effect caused by format manipulations. although the adjusted means for the Relevant_Score, Irrelevant_Score and Accuracy_Score are directionally consistent with diagram being superior to both the Table and Bullet conditions. As shown in Appendix B Parts 1 and 2, Scenario A is more complex than scenario B as it has about twice as many linkages between information items. We address this issue in the next section.

[Insert Table 2 here]

[Insert Table 3 here]

Linkage and Experience Effects

For H2, we predicted that auditors in the Linkage Present condition will have more accurate risk assessments than those in the Linkage Absent condition because the links reduce the task complexity. We find support for this for scenario B. Table 3, Panels A (descriptive statistics) and B (MANOVA) show that Linkage Present condition identifies more relevant accounts than the Linkage Absent condition (adjusted means [SD] are 5.48[2.14] and 4.47[2.29], respectively), $F(1, 83) = 5.39$, $p = .023$). However, Accuracy_Score does not reflect the same differences, $F(1, 83) < 1$. Additionally, this effect appears to be mainly caused by a Linkage * Risk Documentation Experience interaction for Relevant_Score, $F(1,83) = 4.63$, $p = .034$,. As shown in Figure 2, under No Experience, the Relevant_Score is lower when the links are absent, but this effect disappears in the Some Experience condition. This result suggests that linkages in business models interact with risk documentation experience and that they enhance the performance of the less experienced auditors in our audit risk assessment task.

We observe an interesting result for scenario A. Contrary to our prediction, Table 2, Panels A (descriptive statistics) and B (MANOVA) show that the Linkage Absent condition achieved a higher Relevant_Score and Accuracy_Score than Linkage Present (adjusted means[SD] are 5.78[1.93] and 4.96[2.07]), $F (1, 87) = 4.47$, $p = .037$ for Relevant_Score; 4.96[2.08] and 3.42[2.94], $F (1, 87) = 4.77$, $p = .032$ for Accuracy_Score). As noted previously, Scenario A was more complex than scenario B with about twice as many linkages among business model elements. These findings suggest that the presence of so many linkages may have reduced the differences between the presentation formats. Despite finding the opposite directional main effect, we also find a significant interaction between Experience and Linkage, $F(1, 87)= 6.38$, $p = .013$; see Table 2, Panel B). Figure 1 shows that, similar to the effect observed for Scenario B in Figure 2, in the Experience condition, the difference caused by

presence of linkages disappears. We do not find a significant interaction for Accuracy_Score, $F(1, 87) < 1$

[Insert Figure 1 here]

[Insert Figure 2 here]

Summary of main results

In summary, we find support for H1, that diagrams and tables with equivalent information and categorization are superior to the free-form narrative format with no headings. Specifically, participants in both diagrammatic and tabular representation formats recognized more relevant accounts than those in the bullet (free-form narrative) condition. However, this result is restricted to Scenario A. In addition, we find the efficiency measure, Accuracy_Score, to be higher in diagram and tabular representations. We find mixed results for H2 in the two scenarios, and conclude that contextual information in the scenarios interacted with the linkage variable in an unpredicted way. For H3 we find a consistent interaction effect for linkages and risk documentation experience, such that more experience reduces the effect of linkages. Evidence across both scenarios suggests that causal linkages may substitute for task-specific experience in constructing mental business models. We do not find interaction effects for representation format and experience.

Supplemental Analysis

To further investigate possible difference between diagrammatic and tabular representations, we perform a MANOVA on the Linkage Present subsample (Scenario A2). The rationale is that the tabular and diagrammatic conditions are very similar in their content and structure, therefore if differences exist, they are more likely to be found in the linkage present

condition.[15] The results (untabulated) show a significant format main effect for Relevant_Score, $F(2, 33) = 3.84$, $p = .032$; in contrast, using the Linkage Absent subsample (Scenario A1), MANOVA shows no format main effect $(F2, 52) = 1.20$, $p = .31$. Our conjecture is only weakly supported, however - a direct comparison between the diagram format (mean = 5.97) and the tabular format (mean = 4.99) shows only marginal significance ($p = .068$, one-tail).

We also investigated possible intermediate measures for the format affect. Because we predicted that the accuracy of audit risk assessment is driven by understanding of the business model and the business risks, we also asked the participants in the Linkages Absent subsample to respond to 8 questions about the missing links in Scenario A1 and B1; in other words, we wanted to know whether representation format affects auditors' ability to intuit the missing causal linkages in Scenario A2 and B2. At the same time, if the participants can avoid selecting the non-existent links, we also consider it to be a demonstration of superior understanding of the business model and business risks. For Scenario A1, using the same MANOVA model, we find an overall effect for format for Irrelevant_Score, $F(2, 52) = 3.47$, $p = .039$ (untabulated). Planned contrasts show that participants in the diagrammatic condition selected more irrelevant links than those in the bullet condition. We ran the same test for Scenario B2 and found no significant differences. This result suggests that more structured representation such as diagrams do not lead to better understanding of the linkages. This does not invalidate the main results as there are other differences between diagrams and bullet representation formats, for example, the graphical symbols that are unique to diagrammatic formats and the layered structure used in both the diagrams and tabular representations. Further research is needed to investigate other possible intermediate processes that exist between representation format and audit risk assessment.

[15] We thank James Wainberg for this insight.

Response Patterns

Although we find differences among conditions, the overall performance on the task is low (below 60% of maximum score). Hence, we investigate where participants made critical mistakes. We first collect the actual response rates for each question in Scenarios A and B, and compare them with the correct answers. Second, we subtract the actual response from 100% for actual relevant item and subtract 0% from the actual response for actual irrelevant items; this process generates the absolute values of the deviations. Table 4 Panel A lists Scenario A's actual response rates and the percentage deviation for each question, as well as the amount of deviation from the correct response for each financial statement account. We focus the balance of the discussion on the accounts with the greatest amount of deviation.

[Insert Table 4 here]

First we observe that participants are quite adept at detecting risk to the revenue account caused by environmental factors, as 94% (average of 98% and 90%) correctly identified it for questions 1 and 4, both of which highlight intense competition. However, 67% (average of 45% and 70%) of participants fail to recognize that marketing expense could be understated (because of the pressure to sustain profit levels), and 62% (average of 57% and 69%) of participants fail to see that receivables could be overstated because revenue could be fictitious or recognized prematurely. This suggests that participants may not have connected external events such as increasing competition and mergers by competitors to the Company's internal activities such as increasing scouting of competitors and creating a new unit to manage contracts.

Second, participants often make mistakes selecting seeded irrelevant items, such as a professional association lobbying the government (Question 2, 43% wrong), the company planning an innovation campaign (Question 5, 61% wrong), and a survey of salaries by an

outside organization (Question 8, 46% wrong). Although all such items can potentially affect the business's profitability down the road, they are not concrete events and have no impact on the financial statements of this year. These results suggest that many participants did not integrate external events, company strategies, and internal processes into a single picture.

Results for scenario B can be found in Table 5. Participants generally did not identify revenue having heightened audit risk. Most did not consider the company's initiatives to add HIPAA requirements (Question 4) and HIPAA training courses (Question 5) as responses to maintain revenue in a changing regulatory environment; over 60% of participants failed to select revenue. In contrast, participants were able to connect severance payments, which are isolated from other parts of the model, to higher audit risk in the General and Administrative Expense account (86% picked the right account).

[Insert Table 5 here]

Overall, the high error rates may be caused by limitations in the participants' business and auditing knowledge and ability to think of audit risk as a system of events. Frederick et al. (1994) show that while managers and staff accountants demonstrate 'deeper processing' ability by being able to classify financial statement errors by audit objectives and transaction cycles, students do not. Rather, students appear to rely on simple heuristics such as matching similar words and phrases, which Frederick et al. call 'surface features'. The performance discrepancies are attributed to knowledge gained through work experience. Similarly, we conjecture that the tendency to consider items in isolation of the overall business model contributed to the high error rates observed in Table 4 and 5. It is probable that a group with more business knowledge/acumen would commit fewer errors.

Discussion, Limitations, Conclusion

Because business risk assessment is an important component of audit risk assessment, we tested whether business model representation techniques would affect auditors' business risk and audit risk assessment accuracy. We hypothesized that auditor performance would increase if they could link external environment factors affecting a company's strategic goals to the goals' cascading impact on internal processes and resources and on financial statement accounts. We created and compared three informationally equivalent methods of documenting a business model: a diagrammatical format, a tabular text format, and a free-form narrative format which has similar information but does not have the categorizations inherent in the other two formats. We find that both diagram and tabular representations contribute to more accurate risk assessment than the free-form narrative format. However, our prediction that diagrams will lead to superior results relative to tables is only weakly supported. A possible reason is that the tables operationalized in our study possess traits such as categorization, hierarchical presentation, and markers of inter-relationships that are similar to those of diagrams, and that this structure provides auditors with the information needed to make more accurate judgments (Boritz 1984). Thus, our results suggest that, for certain types of business model information, an audit team would be similarly effective using a tabular and diagrammatic business model representation, and possibly more efficient with a tabular representation if creating or using a diagrammatic business model is more costly.

We also studied variations in business model representation by adding or removing causal linkages. Past research (Cheng and Humphreys 2012) shows that causal linkages can improve recall and judgment accuracy. We find mixed support for this theory in the audit setting where linkages help in one context (Scenario B) but have the opposite effect in another (Scenario A). Interestingly, we find that task-specific experience attenuates the effect linkages have on risk assessment; specifically, more experienced participants were less influenced by the presence of

causal linkages. This finding suggests that less experienced auditors may rely on business model documentation as an aid in their risk assessments, but more experienced auditors may not have much use for such documentation.

A limitation of our study is that the specific diagram format used was only one of many possible diagram formats, so our findings do not necessarily generalize to all possible design choices. A similar criticism can be made about our choice of using bullet format to represent the free-form narrative. We acknowledge that different firms could have different templates for documenting business risks and none may match ours exactly. We chose to study the representation effects of two key elements of any business model representation format – hierarchical structuring of information cues and the use of basic graphic symbols such as circles and arrows representing causal linkages - with a very basic diagram; hence, our results would inform designers of such documentation looking to incorporate these two features. Future research could examine the effects of other techniques such as manipulating the size and shape of diagram elements.

Another limitation of our study is that the sample participants have significantly less experience than partners and managers who typically perform more risk judgments and decisions in more important areas. Hence it is possible that more audit experience will attenuate the effects associated with the formats and linkages found in this study. Nonetheless, given that a large portion of business model documentation is designed to help junior level auditors, we believe that our results would be of interest to firms considering using such models as decision aids. For example, junior auditors frequently perform analytical procedures on financial statement sections such as general and administrative expenses. A superior understanding of the client's business model could make junior auditors more effective by helping them form independent expectations of various audit issues. Further, because junior auditors are rapidly promoted and will be responsible for most of the analytical procedures (Hirst and Koonce 1995),

discovering ways to expedite understanding of the client's business without increasing training time would be valuable to practitioners.

Finally, our study provides information on the effectiveness of various representation techniques used by auditors when others have created the representations, but does not address the effectiveness of representations when they are used by the person who created them. Tayler (2010) finds that managers who are involved in the selection of the strategic objectives for a balanced scorecard exhibited fewer biases when they subsequently use the scorecard to make decisions. An interesting extension of this research would be to examine the effectiveness of representations used by the personnel who created them as contrasted with their use by others.

In conclusion, although not all of our main predictions are supported, we do find some interesting results that warrant additional research. When we created two separate scenarios for this study, we were not thinking of manipulating complexity, which is a function of the number of elements and the number of linkages among them. However, upon comparing the number of linkages in these two scenarios, it is obvious that Scenario A (with 20 links) is more complex than B (with 10 links). We find that the effects of linkages are reversed for Scenario A (Table 2, Panel A) and Scenario B (Table 2, Panel A). Although we expected linkages to benefit auditors by helping them to construct a more complete mental model, the results show that this is not always true. One way that representation techniques could represent a business model would be to use links to map out all the connections among related elements, but our results suggest that drawing too many connections may be counterproductive. Note that we are not suggesting that linkages do not help, but that there may be a non-linear relationship between the number of linkages and performance. Other studies from the management accounting literature that have included linkages (e.g., Cheng and Humphries 2012; Banker et al. 2004) have used very simple models that depict one to one connections. Our representation is much more complex and depicts several one-to-many and many-to-one connections. We conjecture that the large number

of linkages depicted in Scenario A negatively affected participants' mental models and lowered their performance. This conjecture is consistent with our theory that representation format can reduce cognitive load; if the inherent cognitive load of a business model is low, then the effect of format is attenuated. This conjecture could be tested in an extension of this study that uses several scenarios of varying complexity. An interesting extension of this study would be to investigate the optimal balance between the number of elements in the model and the number of linkages.

Unlike previous studies that compare diagrammatic and textual representations (e.g., Boritz, Borthick and Presslee 2012), our study enables us to separate the impact of key components of representations, namely graphical symbols, structure, and linkages. This separation helped us gain a more nuanced understanding of how and when a diagrammatic representation is likely to help the decision maker. Specifically, using graphical symbols and structure are beneficial in complex business models, but drawing too many linkages can actually hurt performance. Moreover, the performance improvements associated with the use of graphical symbols and structure cannot compensate for the decrease in performance caused by too many linkages. For practicing auditors, our results imply that although clients' business models are getting increasingly complex, auditors may benefit more if documentation focuses on a few important linkages rather than trying to incorporate all the potential linkages. From a training perspective, our results suggest that graphical and tabular presentations of business models improve understanding and performance in a risk assessment task relative to the use of a free-form narrative.

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Table 1

Descriptive Statistics for Manipulation and Self-assessment Questions

		Manipulation check[a]			*Confidence and perceived client risk* [b]					
					Scenario A			*Scenario B*		
		Q1 fail format check	*Q2 Difficult*[c]	*Q3 Realistic*[c]		*A_Efficacy*[d]	*A_Risk*[e]		*B_Efficacy*[d]	*B_Risk*[e]
Mean	Diagram (n=54)	5%	4.28	5.04	Diagram (n=38)	70.62	58.54	Diagram (n=37)	67.05	54.15
Median			5.00	5.00		73.33	65.00		69.67	55.50
SD			1.66	1.24		14.95	18.94		15.40	18.39
Mean	Table (n=48)	13%	4.73	5.07	Table (n=37)	69.67	61.53	Table (n=36)	63.72	51.26
Median			5.00	5.00		71.00	62.50		70.33	50.00
SD			1.58	1.14		12.14	17.22		17.05	16.48
Mean	Bullet average (n=55)	0%	4.18	5.33	Bullet average (n=38)	71.16	60.91	Bullet average (n=36)	67.14	56.60
Median			5.00	5.00		73.50	60.25		71.67	56.75
SD			1.54	.88		10.88	15.20		12.65	20.94
Mean	All conditions (n=167)	6%	4.40	5.14	All conditions (n=113)	70.49	60.31	All conditions (n=109)	67.88	55.08
Median			5.00	5.00		73.33	62.50		71.67	55.00
SD			1.60	1.01		12.68	17.08		14.63	18.38

a Manipulation check questions can be found in Appendix E

b Confidence and perceived client risk questions can be found in Appendix C

c On a scale of 1 (strongly disagree) to 7 (strongly agree)

d On a scale of 0 (cannot do at all) to 100 (highly certain can do)

e On a scale of 0 (low) to 100 (very high)

Table 2 Panel A

Adjusted Means and SD for Relevant_Score, Irrelevant_Score, and Accuracy_Score by Condition [Scenario A][a]

Conditions		Relevant_Score		Irrelevant_Score		Accuracy_Score	
Format	N	Adjusted M	SD	Adjusted M	SD	Adjusted M	SD
Diagram	38	5.90	1.90	3.81	2.68	21.10	8.99
Table	37	5.59	1.93	3.22	2.72	21.50	9.12
Bullet	38	4.62	2.24	3.78	3.17	16.32	10.60
Linkage							
Absent	66	5.78	1.93	3.79	2.73	21.65	9.13
Present	47	4.96	2.08	3.42	2.94	17.63	9.83
Risk Documentation Experience (RiskExp)							
Do Not Have	55	5.03	2.12	3.40	3.00	19.96	10.05
Have	58	5.71	1.94	3.81	2.74	19.32	9.19

[a] *Relevant_Score* measures the number of financial statement accounts with increased audit risk as result of external or internal factors. A higher score indicates greater accuracy in selecting critical accounts to audit. *Irrelevant_Score* measures the number of financial statement accounts unaffected by external or internal factors. A lower score indicates less wasted resources in the audit. *Accuracy_Score* measures efficiency in the audit. For each factor, selecting all relevant accounts, all the correct management assertions, and no irrelevant accounts earns a score of +10, while selecting no relevant accounts and all irrelevant accounts earns -5. If there are some relevant and irrelevant accounts and the subject selects all accounts, then Accuracy_Score is 0. Please see detailed description of Accuracy_Score's calculation in footnote 11

Table 2 Panel B

MANOVA Relevant_Score, Irrelevant_Score, and Accuracy_Score for Scenario A

Between-subject Effects [b, c]

Format		SS	df	MS	F	p
	Relevant_Score	25.95	2	12.98	3.79	.026
	Irrelevant_Score	7.32	2	3.66	.54	.588
	Accuracy_Score	470.40	2	235.20	3.07	.052
Linkage						
	Relevant_Score	15.32	1	15.32	4.47	.037
	Irrelevant_Score	3.20	1	3.20	.47	.496
	Accuracy_Score	365.92	1	365.92	4.77	.032
RiskExp						
	Relevant_Score	10.60	1	10.60	3.09	.082
	Irrelevant_Score	3.97	1	3.97	.58	.448
	Accuracy_Score	9.56	1	9.56	.13	.725
Format * Linkage						
	Relevant_Score	10.77	2	5.38	1.57	.214
	Irrelevant_Score	.93	2	.46	.07	.935
	Accuracy_Score	63.52	2	31.76	.41	.662
Format * RiskExp						
	Relevant_Score	12.03	2	6.02	1.76	.179
	Irrelevant_Score	7.93	2	3.97	.58	.562
	Accuracy_Score	167.73	2	83.87	1.09	.340
Linkage * RiskExp						
	Relevant_Score	21.86	1	21.86	6.38	.013
	Irrelevant_Score	19.95	1	19.95	2.92	.091
	Accuracy_Score	20.16	1	20.16	.26	.610
Format * Linkage * Risk Exp						
	Relevant_Score	.79	2	.40	.12	.891
	Irrelevant_Score	36.95	2	18.48	2.70	.073
	Accuracy_Score	37.42	2	18.71	.24	.784

[b] The order of which scenario A and B are presented is also an independent variable. We omit the results related to order effects to keep this table brief

[c] This model also includes self-efficacy, and course grade as covariates. Their F-statistics are not significant

Table 3 Panel A

Adjusted M and SD for Relevant_Score, Irrelevant_Score, and Accuracy_Score by Condition [Scenario B][a]

Conditions		Relevant_Score		Irrelevant_Score		Accuracy_Score	
Format	N	Adjusted M	SD	Adjusted M	SD	Adjusted M	SD
Diagram	37	5.45	2.45	3.90	2.77	12.91	9.18
Table	36	4.71	1.98	4.26	2.25	9.26	7.44
Bullet	36	4.77	2.35	4.20	2.67	9.57	8.83
Linkage							
Absent	45	4.47	2.29	3.91	2.60	10.02	8.59
Present	64	5.48	2.14	4.34	2.42	11.14	8.02
Risk Documentation Experience (RiskExp)							
Do Not Have	58	4.91	2.27	4.17	2.57	10.35	8.52
Have	51	5.04	2.27	4.08	2.57	10.81	8.50

[a] *Relevant_Score* measures the number of financial statement accounts with increased audit risk as result of external or internal factors. A higher score indicates greater accuracy in selecting critical accounts to audit. *Irrelevant_Score* measures the number of financial statement accounts unaffected by external or internal factors. A lower score indicates less wasted resources in the audit. *Accuracy_Score* measures efficiency in the audit. For each factor, selecting all relevant accounts, all the correct management assertions, and no irrelevant accounts earns a score of +10, while selecting no relevant accounts and all irrelevant accounts earns -5. If there are some relevant and irrelevant accounts and the subject selects all accounts, then Accuracy_Score is 0. Please see detailed description of Accuracy_Score's calculation in footnote 11.

Table 3 Panel B

MANOVA of Relevant_Score, Irrelevant_Score, and Accuracy_Score for Scenario B

Between-subject Effects [b, c]		SS	df	MS	F	Sig.
Format						
	Relevant_Score	8.23	2	4.11	1.13	.329
	Irrelevant_Score	1.89	2	.95	.20	.818
	Accuracy_Score	202.07	2	101.04	1.97	.146
Linkage						
	Relevant_Score	19.66	1	19.66	5.39	.023
	Irrelevant_Score	3.57	1	3.57	.76	.385
	Accuracy_Score	24.65	1	24.65	.48	.490
RiskExp						
	Relevant_Score	.34	1	.34	.09	.761
	Irrelevant_Score	.15	1	.15	.03	.860
	Accuracy_Score	4.00	1	4.00	.08	.781
Format * Linkage						
	Relevant_Score	15.57	2	7.78	2.13	.125
	Irrelevant_Score	1.32	2	.66	.14	.869
	Accuracy_Score	93.57	2	46.78	.91	.406
Format * RiskExp						
	Relevant_Score	4.97	2	2.49	.68	.509
	Irrelevant_Score	10.25	2	5.13	1.09	.340
	Accuracy_Score	21.01	2	10.50	.20	.815
Linkage * RiskExp						
	Relevant_Score	16.89	1	16.89	4.63	.034
	Irrelevant_Score	.48	1	.48	.10	.751
	Accuracy_Score	183.36	1	183.36	3.57	.062
Format * Linkage * Risk Exp						
	Relevant_Score	6.34	2	3.17	.87	.423
	Irrelevant_Score	3.68	2	1.84	.39	.677
	Accuracy_Score	85.17	2	42.59	.83	.440

[b] The order of which scenario A and B are presented is also an independent variable. We omit the results related to order effects to keep this table brief

[c] This model also includes self-efficacy and course grade as covariates. Course grade and self-efficacy are significant at below 5% level.

Table 4

Analysis of Responses for Scenario A

Question	*Computer Equipment*	*Sales and Marketing Expense*	*Receivables*	*Inventory*	*Revenue*	*None of the above*	*Impact of business model change*	
Actual response rates (percentage of respondents selecting the account for each question)								
1	7%	55%	43%	46%	98%	1%	Fierce competition	
2	12%	13%	3%	13%	16%	57%	Professional associations lobby	
3	6%	22%	23%	16%	65%	32%	Lost NASDAQ listing	
4	2%	30%	31%	36%	90%	3%	Mergers among competitors	
5	5%	51%	0%	8%	2%	39%	Innovation campaign	
6	3%	35%	35%	8%	37%	19%	Formal unit to manage contracts	
7	4%	48%	0%	5%	4%	45%	Scouting activities	
8	0%	38%	1%	4%	8%	54%	Survey of pay rates above average	
Total	39%	293%	136%	137%	319%	249%		
Average	5%	37%	17%	17%	40%	31%		
Percentage Deviation (100% less actual rate for relevant account, actual rate less 0% for irrelevant account)								
1	7%	45%	57%	46%	2%	1%	Fierce competition	Note 1
2	12%	13%	3%	13%	16%	43%	Professional associations lobby	Note 2
3	6%	22%	77%	16%	35%	32%	Lost NASDAQ listing	Note 3
4	2%	70%	69%	36%	10%	3%	Mergers among competitors	Note 4
5	5%	51%	0%	8%	2%	61%	Innovation campaign	Note 5
6	3%	35%	65%	8%	63%	19%	Formal unit to manage contracts	Note 6
7	4%	52%	0%	5%	4%	45%	Scouting activities	Note 7
8	0%	38%	1%	5%	4%	46%	Survey of pay rates above average	Note 8
Total	39%	327%	271%	138%	135%	250%		
Average	5%	41%	34%	17%	17%	31%		

Notes

Highlighted cells: The cells in blue are the correct answers to each question. Questions 1 to 4 form a cluster of linkages of external environment to financial statement accounts, questions 5 to 8 form a separate cluster of linkages of internal processes and resources to financial statement accounts.

1. They see risk of revenue overstatement but fail to see same risk to receivables overstatement and sales and marketing expense understatement
2. They fail to see irrelevance of this fact
3. They fail to see risk to accounts receivable overstatement
4. They see risk of revenue overstatement but fail to see same risk to receivables overstatement and sales and marketing expense understatement
5. They fail to see that innovation campaign is costless
6. They fail to see the potential risk of a new unit systematically misstating revenues and receivables
7. Fail to see potential misstatement of marketing expense
8. They fail to see irrelevance of this fact

Table 5

Analysis of Responses for Scenario B

Question	*Revenue*	*General and admin expense*	*Cost of sales*	*Inventory*	*R&D expense*	*None of the above*	*Impact of business model change*	
Actual response rates (percentage of respondents selecting the account for each question)								
1	72%	6%	58%	48%	13%	11%	OEM customers	
2	35%	27%	13%	13%	20%	30%	Competitor HIPAA status	
3	35%	66%	35%	8%	17%	9%	Special order OEM customer	
4	7%	35%	53%	31%	34%	6%	HIPAA requirements	
5	2%	71%	4%	2%	11%	25%	HIPAA course	
6	10%	86%	4%	1%	1%	7%	Severance payments	
7	3%	37%	27%	9%	49%	10%	CMM assessor	
Total	163%	327%	193%	112%	145%	99%		
Average	20%	41%	24%	14%	18%	12%		
Percentage Deviation (100% less actual rate for relevant account, actual rate less 0% for irrelevant account)								
1	72%	6%	58%	48%	13%	89%	OEM customers	Note 1
2	65%	27%	87%	87%	20%	30%	Competitor HIPAA status	Note 2
3	65%	34%	35%	8%	83%	9%	Special order OEM customer	Note 3
4	93%	35%	47%	69%	34%	6%	HIPAA requirements	Note 4
5	98%	29%	4%	2%	11%	25%	HIPAA course	Note 5
6	10%	14%	4%	1%	1%	7%	Severance payments	Note 6
7	3%	63%	27%	9%	51%	10%	CMM assessor	Note 7
	406%	207%	261%	224%	213%	177%		
	51%	26%	33%	28%	27%	22%		

Notes

Highlighted cells: The cells in blue are the correct answers to each question. Questions 1 to 3 form a cluster of linkages of external environment to financial statement accounts, questions 4 to 7 form a separate cluster of linkages of internal processes and resources to financial statement accounts.

1 They fail to see that this would be regular sales

2 They fail to see the adverse effect on revenue, cost, and inventory

3 The see the potential audit fee but not impact on revenue

4 They do not link HIPAA requirements with the need to catch up to competitors

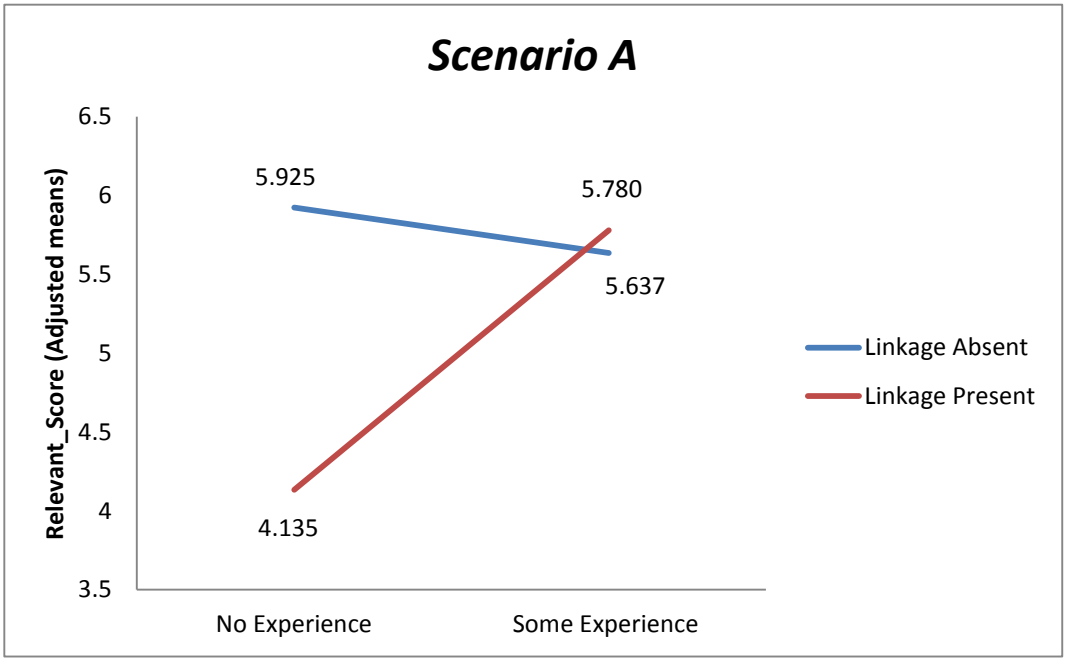
5 They do not link HIPAA courses with the need to catch up to competitors

6 No issues found in this question

7 They failed to see the potential costs to inspection and research

Figure 1

The moderating effect of Linkages on Risk Documentation Experience



Notes:

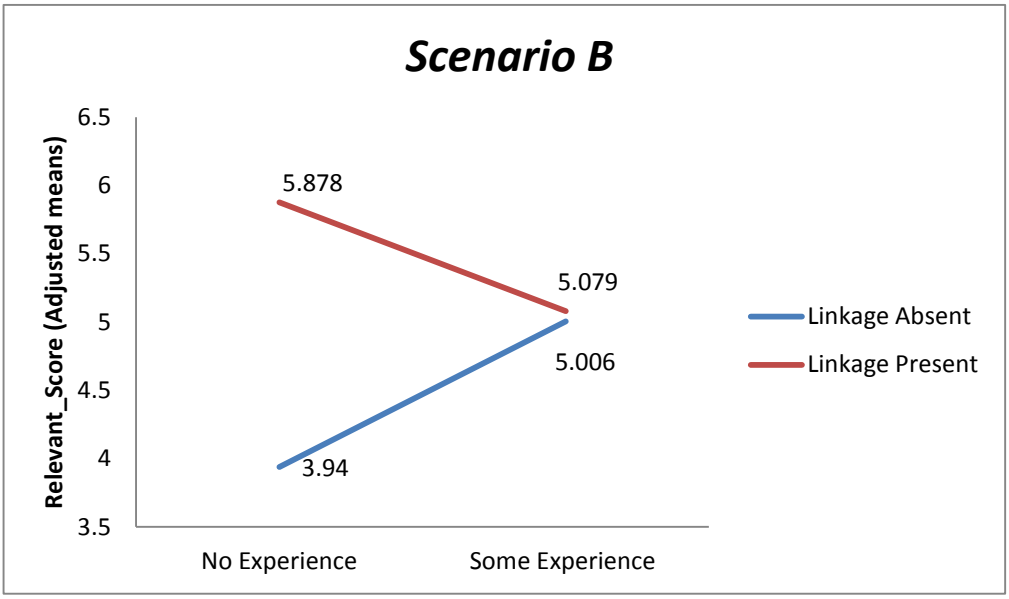
Linkages are causal links drawn between elements in scenario information

Experience is self-reported risk documentation experience. No Experience means subject responded to 1 on a 7 point Likert scale, Some Experience means subject responded 2 to 5 on the scale

Relevant_Score is the number of risk relevant accounts identified in the answers to 8 multiple choice questions. The means are adjusted for the covariates (course grade, self-efficacy, and initial risk assessments) in the model

Figure 2

The moderating effect of Linkages on Risk Documentation Experience



Notes:

Linkages are causal links drawn between elements in scenario information

Experience is self-reported risk documentation experience. No Experience means subject responded to 1 on a 7 point Likert scale, Some Experience means subject responded 2 to 5 on the scale

Relevant_Score is the number of risk relevant accounts identified in the answers to 7 multiple choice questions. The means are adjusted for the covariates (course grade, self-efficacy, and initial risk assessments) in the model