AN EXAMINATION OF AUDIT TASK COMPLEXITY & AUDIT RISK IN THE CONTEXT OF INFORMATION TECHNOLOGY ARCHITECTURE INTRICACY & STABILITY

A survey & case study based research of medium & large Australian organisations in the area of information systems audit

A thesis submitted by

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This thesis is dedicated to my dear uncle Robert (Bob) Nicholas, who inspired me to take the path of knowledge in my formative years on the Maltese islands.

ABSTRACT

Purpose

This thesis leverages Audit Judgement and Decision-Making, Behavioural Sciences, Information Technology, and Informing Science research, to build on extant Audit Task Complexity and Audit Risk research.

The purpose of this work was to determine empirically, in the context of information systems audit, if Audit Task Complexity and Audit Risk are *each* associated with Information Technology Architecture intricacy and stability.

Design, methodology, and approach

Departing from experimental methods generally adopted in relevant extant research, this study adopted survey and case study research methods to test the hypotheses with real-world data collected from medium to large Australian organisations.

Senior information systems auditors and key information technology personnel pertaining to 30 participating organisations, each completed self-administered questionnaire survey instruments. The researcher completed the same survey questionnaire instruments for 21 case studies, the data for which was derived from information systems audit working papers obtained from a second-tier accounting firm.

Partial Least Squares path modelling was used for hypothesis testing as this is best suited for non-parametric *and* relatively small datasets.

Findings

From hypothesis testing, the results suggest that:

1. The extent of information systems audit findings reported to Management is positively associated with the extent of Information Technology Infrastructure component quantity; and

2. The Risk of Material Systems Failure is positively associated with the extent of Information Technology Infrastructure component diversity and inter-dependency.

Research value

Information technology environments in a number of organisations today can present a challenge to even the most experienced information systems auditors. This research contributes to the body of knowledge pertaining to information systems audit practitioners by identifying those Information Technology Architecture and Infrastructure elements that can present a challenge to practitioners in respect of Audit Task Complexity and Audit Risk. A better understanding of these areas would invariably benefit the profession.

Research exclusions and limitations

Information Technology Architectures comprise many business information systems. This study excludes Personal Information Systems as these systems are generally not audited by information systems auditors and hence will not have any impact on research results. Shadow Information Technology is also excluded as metrics around these environments cannot be captured effectively or reliably; this exclusion is expected to have minimal impact on results.

Measurement limitations exist around a number of variables exist due to the availability, reliability, and extent of resources required to obtain the relevant data.

CERTIFICATE OF THESIS

This thesis is entirely the work of Saviour (Steve) Mario Filletti, except where otherwise acknowledged.

This work is original and has not previously been submitted for any other award, except where acknowledged.

Student and supervisor signatures of endorsement are held by the University of Southern Queensland.

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Saviour (Steve) Mario Filletti, 2017

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List of Abbreviations Used

ASSESSRISK	Extent of the Risk of Material Systems Failure (variable)
CHANGE	Extent of information cues generated from the rate of Information Technology Architecture and Infrastructure changes (variable)
DEPEND (*inc. iDEPEND*)	Extent of information cues generated from the inter-dependencies between information technology parts (variable / DIVERSE indicator)
DIVERSE	Extent of information cues generated from the diversity between information technology parts (variable)
iDBESPOK	Number of different bespoke software systems (DIVERSE indicator)
iDDBSYST	Number of different database publishers (DIVERSE indicator)
iDENDUSR	Number of different end-user appliance brands (DIVERSE indicator)
iDIDSYST	Number of different user authentication management system publishers (DIVERSE indicator)
iDNETDEV	Number of different data network management appliance brands (DIVERSE indicator)
iDOFFSHF	Number of different published software publishers (DIVERSE indicator)
iDOPSYST	Number of different operating system publishers (DIVERSE indicator)
iDSERVER	Number of different server appliance brands purposed for business-critical information systems (DIVERSE indicator)
INDUSTRY	Control for industry sector (variable)
iQBESPOK	Number of business-critical bespoke software applications (QUANTITY indicator)
iQENDUSR	Number of end-user appliances (QUANTITY indicator)
iQITSTAFF	Number of technology personnel (QUANTITY indicator)
iQMODULE	Number of add-on modules for business-critical published software applications (QUANTITY indicator)
iQNETDEV	Number of network management appliances (QUANTITY indicator)

iQOFFSHF	Number of business-critical published software applications (QUANTITY indicator)
iQSERVER	Number of server appliances purposed for business-critical information systems (QUANTITY indicator)
mKNOW	Extent of new but experienced information systems auditor's local knowledge of an organisation's Information Technology Architecture and Infrastructure (variable)
QUANTITY	Extent of information cues generated from the quantity of information technology parts (variable)
REPORTED	Extent of information systems audit findings reported to Management (variable)
SIZE	Control for size (variable)
TASKCOMPLEX	Extent of Audit Task Complexity (variable)

CHAPTER 1 Introduction

1.1 Research purpose and approach

This study represents original work that builds on the body of extant Audit Task Complexity and Audit Risk research. Continuing the *inter-disciplinary* trend in these fields of enquiry (Humphrey 2008), this study integrates concepts, theories and models from the following research disciplines:

- Audit Judgement and Decision-Making
- Behavioural Sciences
- Information Technology; and
- Informing Science.

Leveraging Human Information Processing, Task Complexity, and Relational Complexity theoretical frameworks, the primary aim of this work was to determine empirically, in the context of information systems audit, if Task Complexity and Audit Risk are *each* associated with Information Technology Architecture intricacy and stability.

Generally conducted in organisations where information technology is ubiquitous, information systems audits serve to determine the quality, reliability, security, continuity, effectiveness and efficiency of systems data input, processing, storage and output sub-systems (ISACA 2013; Rainer & Cagielski 2011; Ramamoorti & Weidenmier 2004).

The central hypotheses are that dependent variables in respect of Task Complexity and Audit Risk are each associated with:

1. The quantity of an organisation's information technology parts
2. The inter-dependencies and diversity between these parts; and with
3. The rate of architecture and infrastructure change.

From the list above, Information Technology Architecture *intricacy* is captured by elements one and two, while element three captures Information Technology Architecture *stability*.

Research data was derived from a combination of quantitative questionnaire surveys and case studies of information system audits and information technology environments pertaining to medium to large Australian listed, private, and public organisations.

1.2 Motivation for research

The central hypotheses that Audit Task Complexity and Audit Risk are each associated with Information Technology Architecture intricacy and stability, may arguably be deemed intuitive. However, this research nonetheless tackles a novel research question while contributing to both extant research literature and audit practitioner's body of knowledge. These contributions are discussed in the following sections.

1.2.1 Knowledge gaps

This study serves to address knowledge gaps identified in extant Audit Task Complexity and Audit Risk literature. As demonstrated in the literature review in the following chapter, the body of Task Complexity research in auditing covers a paucity of eighteen studies (refer Table 2.1, p. 26), none of which examine Audit Task Complexity or Audit Risk in the context of Information Technology Architecture intricacy and stability. It is suggested that this literature limitation is due in part to the absence of an integrative Task Complexity framework (Bonner 1994). However, as discussed in the literature review, it would be reasonable to also suggest other contributing factors, such as the absence of archival data, and difficulties in obtaining auditor client data.

1.2.2 Research importance

This research contributes to the understanding of the elements within Information Technology Architectures that are associated with Audit Task Complexity and Audit Risk. Given the increasing pace of technological advancements through, for example, the doubling of computing power every eighteen or so months as per *Moore's Law* (Moore 1965), and the on-going developments in artificial intelligence and quantum computing, it is reasonable to suggest that interest in Audit Task Complexity and Audit Risk research will inevitably be renewed. This suggested renewed interest is particularly plausible as the continuing evolution of information technology inches mankind closer to the theoretical *Technological Singularity* (Magee & Devezas 2011; Sandberg 2010; Vinge 1993), being the point beyond which technological advances will irreversibly transform mankind.

There is no doubt that information technology has transformed how organisations conduct their activities (Han et al. 2016). A far cry from the first commercial information systems built in the early 1950s (Hirschheim & Klein 2012), the intricacy and continual change of information technology in a number of organisations today, can present a challenge to even the most experienced information systems auditors. It is argued that technological progress "not only serves to solve existing problems but also creates new problems of its own. Although we are taking advantage of various automatic and computerised tools when performing tasks, it is undeniable that many tasks are becoming more and more complex" (Liu & Li 2012, p. 553). Whilst improving operational and internal control effectiveness and efficiency, technology progress tends to introduce new and unconventional organisational risk exposures, and thus creating new "challenges for auditors when auditing the effectiveness of internal controls" (Han et al. 2016). In this regard therefore, research around Audit Task Complexity and its relationship with human performance would be indispensable (Liu & Li 2012).

1.2.3 Industry contribution

In addition to addressing the identified knowledge gaps, this research also contributes to the body of knowledge pertaining to information systems audit practitioners. Information systems audit practitioners generally examine the quality, reliability, security, continuity, effectiveness and efficiency of systems data input, processing, storage and output sub-systems (ISACA 2013; Rainer & Cagielski 2011; Ramamoorti & Weidenmier 2004).

Audit Task Complexity and Audit Risk

Practitioners are expected to keep abreast of technological advancements to maintain audit effectiveness (Brazel & Agoglia 2007). Through an understanding of the elements within Information Technology Architectures that are associated with Audit Task Complexity and Audit Risk, practitioners can further reduce Audit Risk by:

- Adjusting systems audit planning cycles accordingly
- Allocating auditors to engagements appropriately; and by
- Developing better targeted systems audit programs.

1.2.4 Researcher's interest and motivation

The interest in this research topic area stemmed from the researcher's professional background. A former information technology engineer, the researcher is a Certified Practising Accountant in Australia with extensive experience in internal and external information systems audit.

Having held senior audit management roles across a broad spectrum of large organisations, this research was motivated by the need to fine-tune the management of systems audit to help further reduce Audit Risk and audit cost.

1.3 Research exclusions

Two areas within information technology, namely Personal Information Systems and Shadow Information Technology, are excluded from the scope of this study. The rationale behind these exclusions are discussed in the following sections.

- *Personal Information Systems*

  Personal Information Systems are employee-generated information systems that are generally not formally sanctioned within the organisational hierarchy (Kilfoyle, Richardson & MacDonald 2013). These 'informal' systems, which are generally developed by end-users with the use of office productivity tools (such as *Microsoft Excel*, *Microsoft Access*, or *Apache Open Office Calc*), lack appropriate levels of internal controls (Kilfoyle, Richardson & MacDonald 2013; Kroenke

& Hooper 2011) and hence "are unreliable and may not be auditable" (Kilfoyle, Richardson & MacDonald 2013). These systems are generally standalone systems and "not the product of [any] centralised design", and as such will not have any inter-dependencies with other corporate information systems.

Given their lack of appropriate levels of internal controls, in the context of medium to large organisations it is unlikely that these informal systems will be utilised to support any business-critical processes. For this reason, Personal Information Systems have been excluded from the scope of this study with no material impact envisaged on the results from this research.

- *Shadow Information Technology*

Shadow Information Technology is the phenomenon where functional areas or individuals within an organisation, source and manage standalone information systems, without the knowledge or involvement of an organisation's information technology functional area (Silic & Back 2014). Shadow Information Technology is excluded from this study as the Information Technology Infrastructure therein cannot be quantified effectively or reliably. As the research methodology adopted in this study is based primarily on survey questionnaires of information systems audit and of information technology environments within the respondent organisations, information pertaining to shadow Information Technology Infrastructure is unlikely to be captured effectively or reliably.

It is not known to what extent information systems auditors include Shadow Information Technology systems as part of their annual audit program. However, given that these are generally standalone systems, it is expected that the exclusion of Shadow Information Technology will have minimal impact on the results from this study. The implications of standalone versus inter-dependent systems are covered in Chapters 2 and 3.

1.4 Research limitations

Due to the availability, reliability, and extent of resources required to obtain certain data, the following limitations exist around the measurement of a number of variables pertaining to the hypotheses developed in Chapter 4:

- The measurement of the extent of local knowledge in respect of newly engaged but experienced information systems auditors (refer Section 5.7, p. 61), and the measurement of Audit Task Complexity (refer Section 5.10, p. 65), are both incomplete as the data pertaining to external auditors cannot be readily obtained. This limitation is expected to weaken any associations between the respective variables. However, given that the scope of external information systems audits is *limited to* financial information systems that impact the production of the set of financial statements at year-end, this limitation should not have a significant impact on the results from this study.

- Further to the limitation above, Audit Task Complexity (refer Section 5.10, p. 65) is measured by the total of audit labour hours consumed by internal information systems auditors and by consultants. This measurement is affected by audit labour hour differences between audits conducted by internal auditors and consultants, internal audit budgetary constraints, management push-back over planned internal audits, and the extent to which internal audit programs are standardised.

- Risk of Material Systems Failure is measured by the extent of incidents recorded by an organisation (refer Section 5.3, p. 55). This measurement is affected by the maturity of the internal control structure, the extent of preventative measures and continuous controls monitoring implemented, and the effectiveness of the internal audit function.

- The extent of Information Technology Architecture and Infrastructure change (refer Section 5.4, p. 57) is measured by the number of Requests for Change implemented. This measurement is affected by the extent of the impact and risk exposure these changes have on the information technology environment, and by the extent of required levels of technical expertise and resources for the implementation of these changes.

- The extent of information systems audit findings reported to Management (refer Section 5.9, p. 64) is measured by the number of findings reported to Management. This measurement is affected by the extent of consistency of risk ratings given to reported findings, the extent of finding-*bundling* in reported findings, and Management pressure over the extent of findings that get reported and over the risk ratings given to reported findings.

1.5 Thesis structure

The following chapters in this thesis are structured in the following manner:

- Chapter 2 (*Literature Review*) provides a review of extant literature in respect of Audit Task Complexity and Audit Risk studies
- Chapter 3 (*Information Technology Overview*) provides foundational material around information technology environments
- Chapter 4 (*Hypothesis Development*) provides a set of testable hypotheses
- Chapter 5 (*Variable Measurement*) discusses the measurement approach in respect of the variables pertaining to the formulated hypotheses
- Chapter 6 (*Research Methodology*) describes the research methodology approach adopted, and also describes the processes undertaken to collect the required dataset for the purposes of hypothesis testing
- Chapter 7 (*Descriptive Statistics*) provides a detailed descriptive analysis of the collected dataset
- Chapter 8 (*Results and Analysis*) provides an overview of the hypothesis testing procedures performed, and also discusses the testing results and their interpretation; and

- Chapter 9 (*Conclusion*) provides a summary of this study and its results, discusses audit industry implications of these results, and points to further research opportunities.

CHAPTER 2 Literature Review

This chapter provides a review of extant literature in respect of the research topic. This review begins with a description of the nature of a Task, an analysis of Task Complexity theoretical frameworks, and a brief overview of the audit profession. This is then followed by a critique of extant Task Complexity studies in auditing and of extant studies in Audit Risk. This chapter concludes with a discussion of identified knowledge gaps therein.

2.1 Models of a Task

The nature of a Task can be illustrated with two simple models (Gill & Hicks 2006), as shown in Figure 2.1 below, that capture the relationship between the elements *Task*, *Problem Space*, and *Task Performance*, in the contexts of low and high *Discretion* settings, respectively (these elements are explained in the following sub-sections).

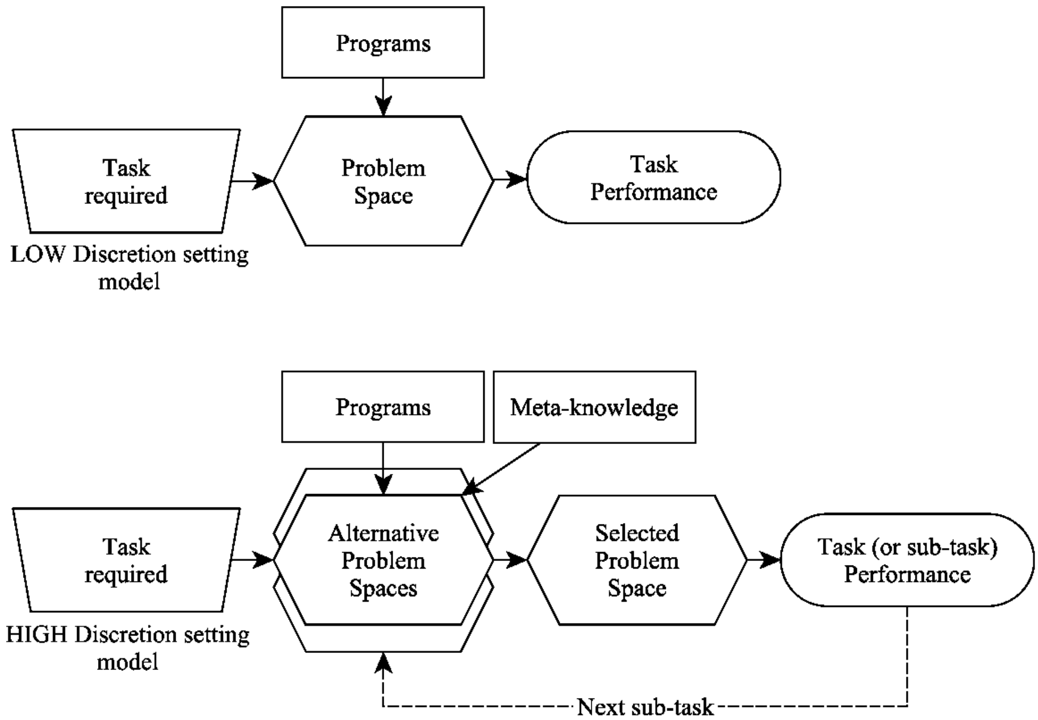


Figure 2.1, Models of a Task

2.1.1 Task element

In the Behavioural Sciences, a Task can be found to be described along one of the following four approaches (Hackman 1969, pp. 103-7):

- As a pattern of stimuli inputs affecting the task-performer
- As required (expected) task-performer responses for the given stimuli
- As actual task-performer's responses for the given stimuli; or
- As a task-performer's set of abilities requirements.

However, for the purposes of this study, the following commonly cited definition (Gill & Hicks 2006) was adopted:

> "*A task may be assigned to a person (or group) by an external agent or may be self-generated. It consists of a stimulus complex and a set of instructions which specify what is to be done vis a vis the stimuli. The instructions indicate what operations are to be performed by the subject(s) with respect to the stimuli and/or what goal is to be achieved*" (Hackman 1969, p. 113).

2.1.2 Problem Space element

Put simply, a Problem Space represents the cognitive problem-solving processes undertaken by the task-performer to achieve Task Performance (Abdolmohammadi 1999; Gill & Hicks 2006).

In the Behavioural Sciences, Problem Space is "a representation of the cognitive system that will be used to perform a task" (Gill & Hicks 2006, p. 4), and is generally described in terms of:

> "*(a) an initial state, (b) a goal state that is to be achieved, (c) operators for transforming the problem from the initial state to the goal state in a sequence of steps, and (d) constraints on application of the operators that must be satisfied. The problem-solving process itself is conceived of as a search for a path that connects the initial and goal states*" (Jacko 2012, p. 56).

Within a Problem Space, the task-performer utilises the following two types of knowledge (Gill & Hicks 2006, p. 4) to transition from the *initial* state to the *goal* state:

- *Program Knowledge*, which refers to learned subject-matter knowledge relevant to the Task; and
- *Meta-Knowledge*, which refers to general problem-solving knowledge (for example, cost-benefit analysis and evaluation matrices) that will allow the task-performer to perform a Task in the absence of relevant Program Knowledge.

2.1.3 Discretion and Task Performance elements

Discretion refers to the task-performer's ability, where required, to choose between available Problem Spaces utilising the task-performer's Meta-Knowledge (Gill & Hicks 2006).

In high Discretion settings, the task-performer selects between available Problem Spaces, invariably increasing relative Task Complexity (*ibid*). Further, in *high* Discretion settings where no Problem Space provides a single clear pathway to Task Performance, a task-performer may decompose a Task into a series of sub-tasks, each with its own Problem Space(s) (*ibid*). This decomposition adds an iterative component to the process of achieving ultimate Task Performance.

2.2 Human Information Processing theories

The Models of a Task (refer Figure 2.1, p. 9) align with Human Information Processing theories in the Behavioural Sciences. Emerging during the development of computers in the 1950's, these theories use the computer analogy to explain human cognitive processes (Gray 2002). There is a debate as to whether this computer analogy is appropriate given that the human mind is also "a biological survival machine with motives and emotions that are foreign to computers but which colour all aspects of human thought and behaviour" (*ibid*).

At a basic level, Human Information Processing models comprise the three components shown below (Libby & Lewis 1982), where each component is mapped to the corresponding Models of a Task element:

- *Input* component - Task element
- *Process* component - Problem Space element
- *Output* component - Task Performance element.

Taken together, Task *inputs* in the form of information sets (or *cues*) are *processed* by the task-performer to achieve the desired *output*, being Task Performance (Libby & Lewis 1977).

2.3 Task Complexity theoretical frameworks

2.3.1 A myriad of frameworks

While problem solving and "coping with complexity is central to human decision making" (Simon et al. 1987, p. 13), defining the nature of Task Complexity has, thus far, proved to be a complex task in itself. Despite extensive research in the Behavioural Sciences and other research domains, which have yielded no less than twenty-four distinct definitions (Liu & Li 2012), there is as yet no integrative framework for Task Complexity (Bonner 1994; Haerem, Pentland & Miller 2015; Liu & Li 2012; Maynard & Hakel 1997).

Unified only in their attempt to explain this phenomenon, this myriad of Task Complexity frameworks are generally classified under one of three schools of thought (Campbell 1988); these are discussed below.

- *Psychological Experience Perspective*

  This is a subjective approach that argues that Task Complexity can be defined solely in terms of the psychological impact on the task-performer in achieving Task Performance. Some examples of the task-performer's psychological attributes used to capture the extent of Task Complexity under this framework include:

- Extent of autonomy in Task Performance
- Extent of stimulation in Task Performance; and
- Extent of Task variety.

• *Person-Task Interaction Perspective*

This perspective, also subjective in its approach, defines Task Complexity by simultaneously taking into account the attributes of the Task and of the task-performer. Attributes used to capture the extent of Task Complexity under this perspective include for example:

- Cognitive demands of Task Performance
- Experience in Task Performance
- Interest in Task Performance
- Task familiarity; and
- Task requirements relative to task-performer's capabilities.

• *Objective Task Characteristics Perspective*

This school of thought, generally referred to as *Objective Task Complexity*, acknowledges the interactive effects of the task-performer, but defines Task Complexity solely in terms of the objective and measureable characteristics of the Task itself. Therefore, any quantifiable objective characteristic of a Task that causes an increase in the following factors, is considered to contribute to Task Complexity:

- Information diversity
- Information load
- Number of information relationships; or
- Rate of information change.

2.3.2 Comprehensive Task Complexity Classes

The Informing Sciences are an inter-disciplinary field of enquiry that explore how best to inform clients using information technology (refer to the *Informing Science Institute, www.informingscience.org*). In the Informing Sciences, the plethora of Task Complexity frameworks have been classified in terms of the five distinct classes discussed further below (Gill & Hicks 2006). Referred to as the *Comprehensive Task Complexity Classes*, this approach is novel in that it allows the focus area of each framework class to be mapped to particular elements pertaining to the Models of a Task, as shown in Figure 2.2, below.

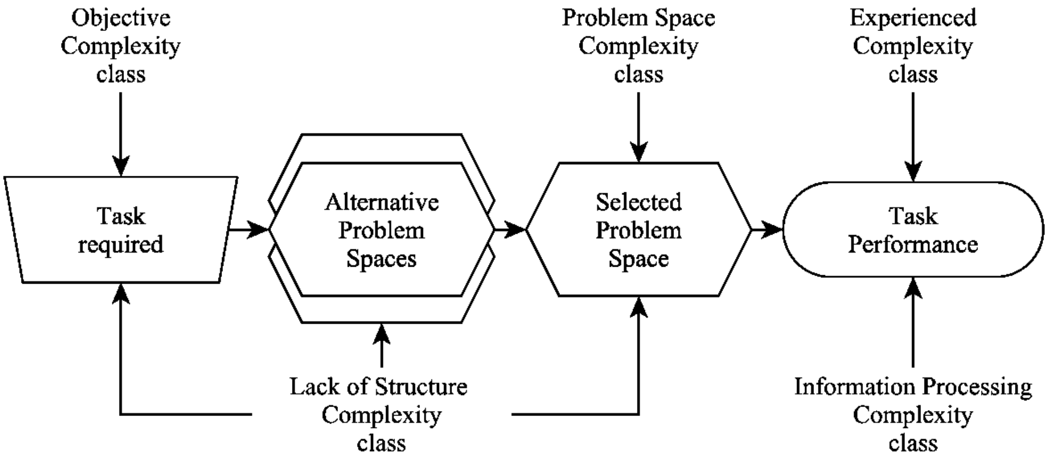


Figure 2.2, Task Complexity classes and area of focus

- *Objective Complexity class*

  This classification captures frameworks that measure Task Complexity as a function of the characteristics specified by the task itself. In this regard, these frameworks are those that fall under the Objective Task Characteristics Perspective (refer Sub-Section 2.3.1, p. 12).

- *Lack of Structure Complexity class*

  This classification defines Task Complexity in terms of the extent that Task requirements and Problem Space(s) are either *structured* (programmed tasks; routine tasks) or *unstructured* (non-programmed tasks; novel tasks) activities. This approach draws on *Simon's Model* in Judgement and Decision-Making research, which suggests that routine (structured) activities are relatively less complex, and that the interactive effects of experience will increase as Task Complexity increases (Simon 1960). Simon's Model also suggests that decision-making falls along a continuum with highly *programmed* decisions at one end, and highly *un-programmed* decisions on the other (Simon 1960, pp. 5-6). Programmed decisions are defined as repetitive and routine decision-making tasks for which "a definite procedure has been worked out for handling them" (*ibid*). In contrast, non-programmed decisions are "novel, unstructured, and consequential" (*ibid*) tasks for which no procedures exist as these may have not arisen or been experienced before, or their "precise nature and structure is elusive or complex" (*ibid*).

- *Problem Space Complexity class*

  This class of frameworks defines Task Complexity in terms of the extent of possible pathways (Problem Spaces) available to the task-performer to achieve Task Performance.

- *Experienced Complexity class*

  This class pertains to frameworks that define Task Complexity solely in terms of the extent of Task Complexity as *perceived* by the task-performer.

- *Information Processing Complexity class**

  Under this classification, frameworks define Task Complexity in terms of the information processing capacity requirements or information throughput, as experienced by the task-performer in achieving Task Performance.

  * *It should be noted that* the naming of this classification may *erroneously* suggest a connection with Human Information Processing theories. This class has no connection with these theories.

2.3.3 Relational Complexity Theory

In the Behavioural Sciences, *Relational Complexity Theory* seems to support objective Task Complexity frameworks as an explanation for the phenomenon of Task Complexity. Assuming the path of least *processing demand* (defined further below) is taken by the task-performer, this theory suggests that the processing complexity of a Task will be positively associated with the number of concurrent and interacting variables required to perform a Task (Halford, Wilson & Phillips

1998). Therefore, if resources, procedures and knowledge are kept at a constant, this theory predicts that Tasks with two interacting factors, for example, would be less complex than those with four interacting factors.

This theory provides that the processing complexity of a Task is a function of the following constructs (*ibid*):

- *Processing demand*

  Synonymous with the terms 'processing load' and 'processing effort', this construct refers to the effort exerted by a task-performer in achieving Task Performance. Relational Complexity Theory predicts that processing demand increases as the number of interacting variables to be processed increases.

- *Resources*

  This construct refers to the cognitive processing resources a task-performer allocates in commensurate with the processing demand of a Task.

- *Processing capacity*

  This refers to the limit of a task-performer's cognitive processing capacity and as such this would vary between individuals.

2.3.4 Observed deficiencies across frameworks

Aside from the absence of an integrated framework (refer Sub-Section 2.3.1, p. 12), there are a number of observed deficiencies common to all Task Complexity frameworks; there are discussed in the following paragraphs.

The first observation is the lack of consideration given as to whether Task Complexity elements for a particular framework should be individually weighted or added together for an overall determination of Task Complexity (Bonner 1994). In the Objective Complexity Classes, for example, it is unlikely that *information load*, *information diversity*, *rate of information change* and *number of information relationships* will each determine the extent of Task Complexity equally. However, it is plausible that in combination, these elements may produce more reliable measurement of Task Complexity between different Tasks.

There is also no consideration given in respect of task-performers completing shared or inter-dependent Tasks. This is particularly pertinent to audit practitioners who "often are simultaneously working on multiple tasks and even multiple clients in the same work sessions" (Bhattacharjee, Maletta & Moreno 2013). While work in this area is still emerging, it appears that the set of assumptions on which extant frameworks are based on, may need to be revisited (Haerem, Pentland & Miller 2015).

These frameworks also make the assumption that their respective Task Complexity elements are present in all types of Tasks. Any integrative framework should be robust enough to handle different types of Tasks in a manner that would provide accurate comparative measurements of the extent of Task Complexity between these Tasks.

Lastly, while both objective and subjective frameworks predict Task Complexity (Campbell 1988; Liu & Li 2012; Wood 1986), empirical research suggests that these frameworks predict the extent of Task Complexity "uniquely" (Maynard & Hakel 1997, p. 324). This further suggests that framework classes are not inter-changeable, hence prompting the need for frameworks to specify the types of Tasks each is best suited for.

2.3.5 Objective Task Complexity

Despite the suggested uniqueness between objective and subjective frameworks (Maynard & Hakel 1997), proponents of Objective Task Complexity argue that:

- Objective frameworks are "likely to exhibit construct validity" (Gill & Hicks 2006) given that these are solely a function of the objective properties of a Task; and
- Movements in the objective properties of a Task also indirectly capture the subjective cognitive demands experienced by the task-performer (Campbell 1988; Maynard & Hakel 1997).

Given that objective frameworks are more likely to exhibit construct validity relative to subjective frameworks, this study is therefore based on the Objective Task Complexity framework. This framework is generally defined as a function of the following three dimensions of a Task (Wood 1986):

- *Component Complexity*, the extent of distinct components and informational cues necessary for the completion of the Task
- *Coordinative Complexity*, the extent of relationship patterns between informational cues, actions, and products; and
- *Dynamic Complexity*, the stability of these relationship patterns over time.

Under this framework, "an objective task characteristic that implies an increase in information load, information diversity, or rate of information change can be considered a contributor to complexity" (Campbell 1988, p. 43).

2.3.6 Task Complexity and Task Difficulty

Task Difficulty is not considered in this study. However, the distinction between Task Complexity and Task Difficulty is worthy of some discussion given the confusion observed between the two constructs in early literature (Liu & Li 2012).

While there is agreement that Task Difficulty is a subjective assessment in respect of the task-performer, there is debate as to whether:

- Task Difficulty is a subset of Task Complexity (Bonner 1994); or *vice versa* (Braarud & Kirwan 2011); or whether
- These constructs are interchangeable (Bell & Ruthven 2004); or independent concepts (Robinson 2001).

With reference to the elements within the Models of a Task (refer p. 9), Task Difficulty can be defined in terms of the following factors (Gill & Hicks 2006; Robinson 2001; Sasayama 2016):

- The extent of Programs and Meta-knowledge a task-performer brings to a given Task
- The extent to which a task-performer's Programs and Meta-knowledge is affected by temporarily limiting factors such as motivation; and
- A task-performer's perception of how difficult a given Task is to perform.

This study adopts the argument that while complex Tasks are inherently difficult, Task Complexity and Task Difficulty are not interchangeable constructs as it is possible for Task Difficulty to increase without any increase in Task Complexity (Campbell 1988). Given the approach adopted, Task Difficulty is not considered in this study.

2.4 An overview of the audit profession

To provide context to the subsequent literature review (refer Sections 2.5, 2.6, and 2.7) in respect of Task Complexity in auditing and Audit Risk, this section will provide an overview of the genesis and definition of auditing, the nature of the demand for audit services, and key personal attributes of expert auditors.

2.4.1 Genesis and definition

The earliest formal record-keeping systems are believed to have emerged as far back as 4,000 B.C. in Mesopotamia (modern day Middle East) for the collection of taxes, and for the correct accounting of receipts and disbursements (Ramamoorti 2003; Teck-Heang & Ali 2008). Whilst it is not known when the first audits were conducted, indications of audit activity have been traced back to the civilisations of Babylonia, Ancient Greece, and the Roman Empire (*ibid*).

It is argued that the audit profession exists as interested parties are unable to obtain for themselves, the information or assurance they require (Flint 1988, as quoted in Teck-Heang & Ali 2008). This observation is captured in the definition of auditing provided by The American Accounting Association:

"*Auditing is a systematic process of objectively obtaining and evaluating evidence regarding assertions about economic actions and events to ascertain the degree of correspondence between those assertions and established criteria and communicating the results to interested users*" (AAA 1972, p. 18)

2.4.2 Demand for audit services

The demand for external and internal audit services stems primarily from the need for independent verification over data, management assertions, internal controls, compliance with internal and external requirements, and alignment with corporate strategies. This demand can be explained by the following hypotheses (Gay & Simnett 2007; Wallace 2004):

- *The stewardship hypothesis* (Agency Theory)

  Principals in an agency relationship entrust agents with the stewardship of their resources. This hypothesis suggests that audits serve to monitor this stewardship to minimise the unauthorised consumption and reallocation of these resources for the benefit of agents, or their associates.

- *The information hypothesis*

  This hypothesis suggests that audits serve to improve the quality of information for the purposes of addressing information asymmetry concerns from internal and external stakeholders of the auditee.

- *The insurance hypothesis*

  Given external auditors are required to maintain professional indemnity insurance, this hypothesis posits that demand for top tier audit firms stems from their "deep pocket" advantage. As such, this hypothesis is only relevant in the context of the *external* audit environment.

2.4.3 Personal attributes of expert auditors

The subsequent literature review of Task Complexity in auditing (refer Section 2.5) will show that the effects of auditor attributes feature predominately in extant Task Complexity studies in auditing. Therefore, a brief overview of the personal attributes of skilled and experienced auditors is warranted at this point.

Given the highly technical nature of auditing (Abdolmohammadi & Wright 1987; Bonner 1994), the audit profession relies principally on skilled and experienced auditors, whose judgement processes are often not structured, or are unable to be structured (Abdolmohammadi & Wright 1987), due to the dynamic nature of client environments.

From a study of personal attributes associated with auditors (Abdolmohammadi & Shanteau 1992), the following key attributes were identified for senior auditors and audit supervisors (shown below in alphabetical order):

- Assumes responsibility
- Confidence
- Creativity
- Decisiveness
- Experience
- Knows what is relevant
- Relevant technical knowledge
- Sound analytical skills
- Sound communication skills; and
- Sound organisation skills.

2.5 Review of Task Complexity literature in auditing

Empirical research in Task Complexity in auditing had its genesis in the 1980's (Abdolmohammadi & Wright 1987; Blocher, Moffie & Zmud 1986; Jiambalvo & Pratt 1982) having evolved from Task Complexity research in accounting (Libby & Lewis 1977).

From an extensive review of peer-reviewed academic journals, it was identified that the body of Task Complexity research in auditing covers a paucity of eighteen studies (as listed in Table 2.1, p. 26). It is suggested that this limited literature is due in part to the absence of an integrative Task Complexity framework (Bonner 1994). However, it would be reasonable to also suggest the following likely contributing factors:

- The absence of archival data from which to conduct meaningful research in this field of enquiry
- Difficulties in obtaining auditor client data due to requirements under professional ethical standards
- The reliance on research data collection from complex and time-consuming experimental research methods that generally also present problems associated with experimental settings; and
- Construct validity issues around subjective Task Complexity frameworks.

The following sub-sections will analyse the breadth and depth of the eighteen studies identified, the Task Complexity frameworks adopted, research methodologies applied, and approaches to the Task Complexity variable manipulation.

2.5.1 Breadth and depth of extant research

Task Complexity research in auditing is a sub-set of *Judgement and Decision-Making* research in accounting (Bonner 1994; Trotman 2005), an area of enquiry that is now around fifty years old (Bonner 1999). This area of enquiry has primarily examined the relationship between Task Complexity and Judgement Quality, and also the effects of auditor attributes on this relationship (refer Table 2.1, p. 26).

Notwithstanding the absence of an integrative Task Complexity framework, this body of research has established that increases in Task Complexity tend to decrease Judgement Quality (Bonner 1994; Sanusi & Iskandar 2007; Sanusi, Iskandar & Poon 2007).

Auditor attributes and audit factors have been found to moderate the relationship between Task Complexity and Judgement Quality; these attributes and factors are listed below:

- *Auditor attributes:*
    - Auditor experience (Abdolmohammadi & Wright 1987; Simnett 1996); this moderator has been subsequently confirmed in a related study where the extent of fraud detection was found to increase with audit and fraud detection experience (Moyes & Hasan 1996)
    - Auditor confidence (Chung & Monroe 2000), in the context of internal control risk evaluation tasks, this study found that auditor judgement confidence decreases as perceived task difficulty increases
    - Auditor gender (Chung & Monroe 2001; O'Donnell & Johnson 2001)
    - Auditor knowledge and skill (Bonner 1994; Mascha & Miller 2010; Tan, Ng & Mak 2002); this has also been confirmed in a separate study where the lack of relevant expertise amongst external auditors was found to weaken corporate fraud detection capabilities (Hassink, Meuwissen & Bollen 2010); and
    - Auditor motivation (Tan & Kao 1999b; Tan, Ng & Mak 2002); in these studies, *auditor accountability* is used as a proxy for *auditor motivation*.
- *Audit factors:*
    - Firm-wide structured audit processes (Stuart & Prawitt 2012); the moderating effect of structured audit processes is consistent with Simon's Model (refer p. 14)

- Preparer and reviewer familiarity (Asare & McDaniel 1996), in the context of internal quality reviews of audit working papers

- Time pressure (Bowrin & King 2010; Sanusi & Iskandar 2007), in the context of completing assigned audit procedures within allocated budgets; and

- Types of data presentation formats used (Blocher, Moffie & Zmud 1986); this has also been confirmed in a separate study which found that analyst forecasting errors increased with the extent of information complexity (Plumlee 2003).

Two other studies in this field of research have examined the effects of Task Complexity in respect of:

- Management leadership behaviour on the satisfaction and motivation of staff (Jiambalvo & Pratt 1982); and

- Process-focus *versus* taxonomic-focus audit methodology frameworks in the context of information systems audit (O'Donnell 2003).

2.5.2 Theoretical frameworks adopted

The theoretical frameworks applied in these studies were analysed in the context of the Comprehensive Task Complexity Classes classification scheme (refer p. 14), and in the context of the Models of a Task (refer Figure 2.2, p. 14). These studies are tabulated in Table 2.1 (p. 26).

Consistent with expectations (Gill & Hicks 2006), the majority of these studies (thirteen) were found to have adopted Objective Complexity class frameworks where the Task element (as per the Models of a Task) is the area of focus. Whilst the basis for this approach has generally not been articulated in these studies, it is reasonable to suggest that the preference for this class of frameworks has likely stemmed from the relatively stronger validity of the Task Complexity construct (refer Sub-Section 2.3.5, p. 17). Four of the remaining studies applied frameworks that fell under the Experience and Information Processing Complexity classes with the focus area being the Task Performance element. The last remaining study applied the Lack of Structure Complexity framework which focuses on the Problem Space element.

2.5.3 Research methodologies

From an examination of the eighteen studies (refer Table 2.1, p. 26) it was found that experimental research methods were used in all but one study (Bonner 1994, this study used analytical methods). Further, most of these experimental studies engaged either less experienced auditors, or surrogate tertiary students with some level of training in auditing.

The predominate use of experimental methods is not surprising as there is little, if any, archival data available from which to conduct meaningful research in this field of enquiry. Further, given the nature of audit, access to audit working papers and supporting material would generally be restricted solely to the respective audit team.

In addition to the exposure to the *Hawthorne Effect* (subject behaviour altered under experimental conditions) (Jones 1992) and to the *Demand Effect* (dependent variable affected by experimental demands) (Orne 1962), the external validity of experimental methods in auditing have been questioned (Sanusi & Iskandar 2007) on the basis that case studies generally contain less information than that actually presented to auditors in the course of conducting ‘real-world’ audit procedures.

Further, while the practical considerations (in terms of convenience, time, and money) around the use of less experienced auditors and student surrogates as experimental subjects are understood, the external validity of these studies has been questioned on the basis that, in practice, complex audit decisions are generally delegated to more experienced and technical auditors (Abdolmohammadi & Wright 1987).

Studies (by publication date)	Task Complexity framework class applied	Model of a Task element targeted	Task Complexity manipulation
Jiambalvo & Pratt (1982)	Experience	Task Performance	Within-subject variable
Blocher, Moffie & Zmud (1986)	Objective	Task	Task characteristic
Abdolmohammadi & Wright (1987)	Experience	Task Performance	Rating of level of complexity by expert panel
Bonner (1994)	Information Processing	Task Performance	Rating of amount of cues
Asare & McDaniel (1996)	Lack of Structure	Problem Space	Use of structured and unstructured case studies
Simnett (1996)	Objective	Task	Between-subject variable
Hun-Tong & Kao (1999)	Objective	Task	Within-subject variable
Chung & Monroe (2000)	Objective	Task	Within-subject variable
Chung & Monroe (2001)	Objective	Task	Within-subject variable
O'Donnell & Johnson (2001)	Objective	Task	Use of problem-free and problem-seeded case studies
Tan, Ng & Mak (2002)	Objective	Task	Within-subject variable
O'Donnell (2003)	Experience	Task Performance	Rating of perceived complexity by subjects
Sanusi, Iskandar & Poon (2007)	Objective	Task	Within-subject variable
Sanusi & Iskandar (2007)	Objective	Task	Within-subject variable
Bowrin & King (2010)	Objective	Task	Within-subject variable
Mascha & Miller (2010)	Objective	Task	Between-subject variable
Iskandar & Sanusi (2011)	Objective	Task	Between-subject variable
Stuart & Prawitt (2012)	Objective	Task	Within-subject variable

Table 2.1, List and analysis of Audit Task Complexity studies

2.5.4 Measurement of Task Complexity variable

Continuing from the preceding analysis, it was found that the Task Complexity construct was predominately manipulated as either a *within*-subject variable (nine studies) or as a *between*-subject variable (three studies), through the application of a case study for each experimental condition.

This preference for within-subject designs is not optimal given that the external validity of between-subject designs is generally considered higher (Zikmund et al. 2010) due to the reduced exposure to the Demand Effect.

2.6 An overview of the Audit Risk Model

The nature of audit is such that audit practitioners are often required to make risk assessments in the absence of complete information. This prevalence of ambiguity distinguishes this profession from many others (Fukukawa & Mock 2011).

Audit Risk is generally defined as "the risk that information may contain a material error that may go undetected during the course of the audit" (ISACA 2013, p. 51), resulting in the provision of an incorrect audit opinion (Akresh 2010; Shibano 1990).

Central to the concept of Audit Risk is the *Audit Risk Model* (Akresh 2010), a model developed by Kenneth W. Stringer (Deloitte Haskins & Sells) and Professor Frederick Stephan (Princeton University) between 1957 and 1962 (Tucker 1989). The Audit Risk Model, which was founded on professional practice rather than on theory, was developed to address the mounting costs of conducting full detailed testing procedures over steadily growing populations of financial transactions (*ibid*).

The Audit Risk Model is essentially a conceptual framework for financial statement audits. Financial Statement Audit practitioners generally apply this model at the relevant assertion levels to make an assessment of the extent of detailed sample testing required to keep Audit Risk at an acceptable low level (Allen et al. 2006; Peecher, Schwartz & Solomon 2007). This model is generally applied only to the extent necessary for an audit to be effective so as to increase audit efficiency and reduce audit costs (Dusenbury, Reimers & Wheeler 2000).

As illustrated in Figure 2.3 (p. 29), the Audit Risk Model provides that Audit Risk is derived from two factors: *Risk of Material Misstatement* and *Detection Risk*; these are explained below:

- *Risk of Material Misstatement*

  This represents the risk that financial statements are materially misstated prior to the commencement of an audit engagement (Miller, Cipriano & Ramsay 2012; Peecher, Schwartz & Solomon 2007).

  The extent of Risk of Material Misstatement is derived from *Inherent Risk* and *Control Risk*. The former relates to the susceptibility of a financial process to generate material errors or irregularities in the absence of relevant mitigating controls; while the latter refers to the risk that mitigating controls fail to detect or prevent material errors and irregularities (Ohta 2009; Peecher, Schwartz & Solomon 2007; Shibano 1990; Watts 1990). Both Inherent Risk and Control Risk are exposures incurred by the auditee, and as such these cannot be influenced by the auditor (Blokdijk 2004).

- *Detection Risk*

  Detection Risk represents the failure of audit procedures to detect material financial errors or irregularities (Ohta 2009; Peecher, Schwartz & Solomon 2007; Shibano 1990; Watts 1990). Unlike the Risk of Material Misstatement, Detection Risk is within the control of the auditor (Blokdijk 2004).

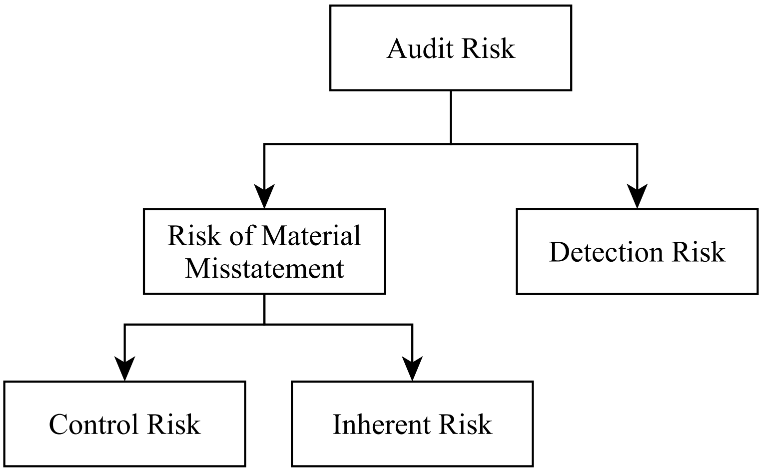


Figure 2.3, Basic Audit Risk Model for Financial Statement Audit

The Audit Risk Model is "based on the idea that an auditor's detection risk is influenced by inherent risk and control risk" (Blokdijk 2004). In other words, if Audit Risk is to be kept at a constant low level, the auditor's appetite for Detection Risk will move inversely to the extent of assessed Risk of Material Misstatement (refer Table 2.2, below). Further, the extent of the auditor's appetite for Detection Risk inversely influences the extent of audit procedures performed. These movements in the extent of audit procedures performed are illustrated in the table below.

Assessment of Risk of Material Misstatement	***Detection Risk***	***Extent of audit procedures performed***
Elevated risk assessment	Risk appetite *lowered*	Procedures *increased*
Lowered risk assessment	Risk appetite *elevated*	Procedures *reduced*

Table 2.2, Audit Risk appetite

2.7 Review of Audit Risk literature

Audit Risk studies in peer-reviewed academic journals are predominately based on experimental methods that engaged experienced auditors (Asare & Wright 2004; Dusenbury, Reimers & Wheeler 2000; Fukukawa & Mock 2011; Houston, Peters & Pratt 1999; Jiambalvo & Waller 1984; Messier Jr & Austen 2000; Strawser 1990). Other studies were either based on archival data (Calderon, Wang & Klenotic 2012; Han et al. 2016; Haskins & Dirsmith 1995; Hogan & Wilkins 2008; Jiang & Son 2015), or on survey and interview research methods, also involving experienced auditors (Eilifsen, Knechel & Wallage 2001; Miller, Cipriano & Ramsay 2012).

A significant proportion of this literature has examined the weaknesses and limitations of the Audit Risk Model. The following two sub-sections will review extant Audit Risk literature.

2.7.1 Audit Risk Model weaknesses and limitations

While some research results are consistent with practitioner claims that the Audit Risk Model does *not* systematically underestimate the Risk of Material Misstatement (Dusenbury, Reimers & Wheeler 2000), the model has attracted debate stemming from mixed empirical results around its adequacy and application in the field (Akresh 2010; Allen et al. 2006; Hogan & Wilkins 2008). Results suggest that this divergence is attributed to whether practitioners approach the Audit Risk Model as a conceptual guidance model, or as a "precise mathematical equation" (Allen et al. 2006; Daniel 1988; Knechel et al. 2013; Strawser 1990), where:

$$Audit\ Risk = (Inherent\ Risk \times Control\ Risk) \times Detection\ Risk$$

Other results suggest that Inherent Risk assessments and Control Risk assessments "are closely intertwined in actual practice" (Haskins & Dirsmith 1995) to the point where practitioners blur or confuse the distinction between the two (Allen et al. 2006). This finding is attributed to the practitioner's general awareness of the inter-dependencies that exists between Inherent Risk and Control Risk (Kinney Jr 1989; Messier Jr & Austen 2000).

It has been argued that the Audit Risk Model does not capture a number of factors that may also contribute to Audit Risk (Allen et al. 2006; Sennetti 1990; Smieliauskas 2007), such as the following:

- Extent of audit evidence quality (Dusenbury, Reimers & Wheeler 2000)
- Internal control management override (Kinney Jr 1989); and
- Preventative and detective effects of internal controls (Waller 1993).

Further, the Audit Risk Model is optimised for the purposes of determining the extent of substantive testing required in respect of representative samples from large financial transaction populations. On this basis, this model may not be suitable for use in operational audits (Akresh 2010).

2.7.2 Breadth and depth of other extant research

In addition to the weaknesses and limitations discussed above, extant Audit Risk literature has also examined the following areas:

- Effects of Audit Risk on external audit fees (Calderon, Wang & Klenotic 2012; Hogan & Wilkins 2008; Jiang & Son 2015)
- Effects of information technology investment on Audit Risk (Han et al. 2016)
- Effects of irregularities and errors on Audit Risk (Houston, Peters & Pratt 1999; Shibano 1990; Watts 1990)
- Effects of practitioner's assessment approach of each risk factor within the Audit Risk Model (Asare & Wright 2004; Dusenbury, Reimers & Wheeler 2000; Fukukawa & Mock 2011; Haskins & Dirsmith 1995; Jiambalvo & Waller 1984; Messier Jr & Austen 2000; Miller, Cipriano & Ramsay 2012; Strawser 1990); and
- Identification of information systems risk factors deemed important by practitioners in Audit Risk assessments (Bedard, Graham & Jackson 2005).

2.8 Extant knowledge gaps

From the preceding analysis, two knowledge gaps have been identified in extant literature reviewed. These knowledge gaps are discussed below.

2.8.1 Audit function stakeholders

It would be safe to suggest that extant Task Complexity research in auditing has to date been exclusively *auditor-centric*. For example, no research has been conducted to explore Task Complexity in auditing in the context of the primary consumers of audit reports, this being Audit and Risk Committees. Chief Audit Executives would invariably be keen to understand if an association exists between Audit and Risk Committee confidence and information systems audit Task Complexity. Further, if such an association exists, Chief Audit Executives would also be keen to understand if Audit and Risk Committee size and gender composition, and if the timing of media reporting of security related issues, impact this association.

2.8.2 Information systems audit

Research opportunities in respect of Task Complexity and Audit Risk in the context of information systems audit (an overview for which can be found in Section 3.3 on p. 38) have yet to be explored. To date, no empirical research has been conducted to examine Information Technology Architecture intricacy and stability in the context of either Task Complexity or Audit Risk, in the area of information systems audit. It is anticipated that research in these areas will invigorate interest in Audit Task Complexity and Audit Risk research. These knowledge gaps are the basis of this thesis.

2.9 Chapter summary

This chapter provided a detailed review of extant literature. Audit Task Complexity literature was examined with a focus on theoretical frameworks and research methodologies adopted in the various studies, while Audit Risk literature was reviewed with a focus on the weaknesses and limitations of the Audit Risk Model.

This review also included an examination of the nature of a Task, an analysis of Task Complexity theoretical frameworks, and a brief overview of the audit profession. This chapter concluded with a discussion of identified knowledge gaps around information systems audit and audit function stakeholders.

CHAPTER 3 Information Technology Overview

The preceding literature review has shown that research in an Information Technology setting has not been explored in any depth in either Task Complexity research in auditing or Audit Risk research. This chapter provides foundational material relevant to the subsequent hypothesis development presented in Chapter 4. This material will be of particular benefit to readers who may not have a reasonable working knowledge of Information Technology Architecture and Infrastructure, or of information systems audit.

3.1 Information Technology Architecture explained

The concept of Information Technology Architecture cannot be explained without first providing an overview of Business Information Systems.

3.1.1 An overview of Business Information Systems

At a high level, Business Information Systems, such as systems designed to manage an organisation's general ledger, accounts receivable, inventory, and customer and sales data, are defined as organised interactions between people, procedures and resources, for the purposes of collecting, transforming and disseminating data for some organisational purpose (Alter 2008; Boddy, Boonstra & Kennedy 2005, p. 10; Cats-Baril & Thompson 1997, pp. 168-73; Davis 1974, p. 5; Dunn, Cherrington & Hollander 2005, p. 1; Kroenke & Hooper 2011, pp. 8-11).

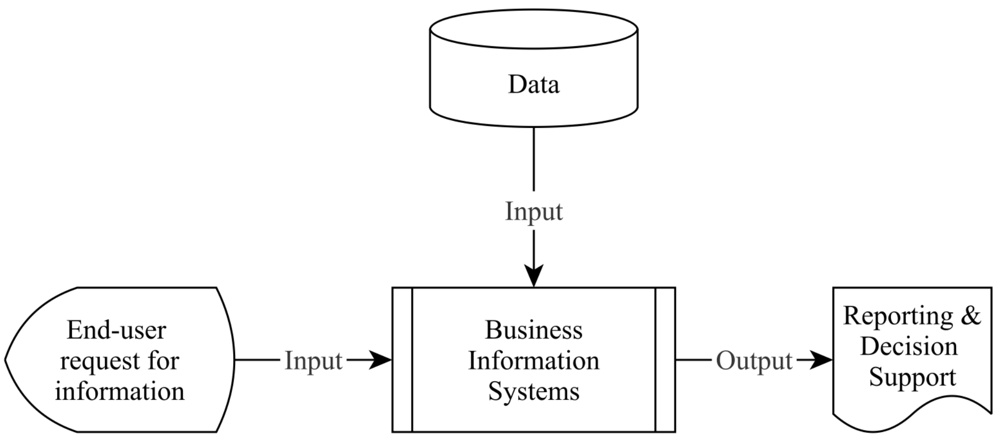


Figure 3.1, Basic Business Information Systems inputs and outputs

As shown in Figure 3.1, *inputs* in the form of data and requests for information, are processed by Business Information Systems to generate *outputs* that represent information reporting and Management decision support (Cats-Baril & Thompson 1997, pp. 168-73; ISACA 2013, p. 27; Kroenke & Hooper 2011, pp. 8-11; Nolan & Wetherbe 1980; Rainer & Turban 2009, pp. 31-3; Sharkey & Acton 2012, pp. 207-24).

This conversion of inputs into outputs relies on five elements (Cats-Baril & Thompson 1997, p. 170); specifically, these are:

- Hardware (computing and peripheral devices)
- Software (computational instructions)
- Transactional and static data
- Procedures (sets of prescribed manual and automated activities around Business Information Systems); and
- People (those engaged in executing the prescribed procedures above).

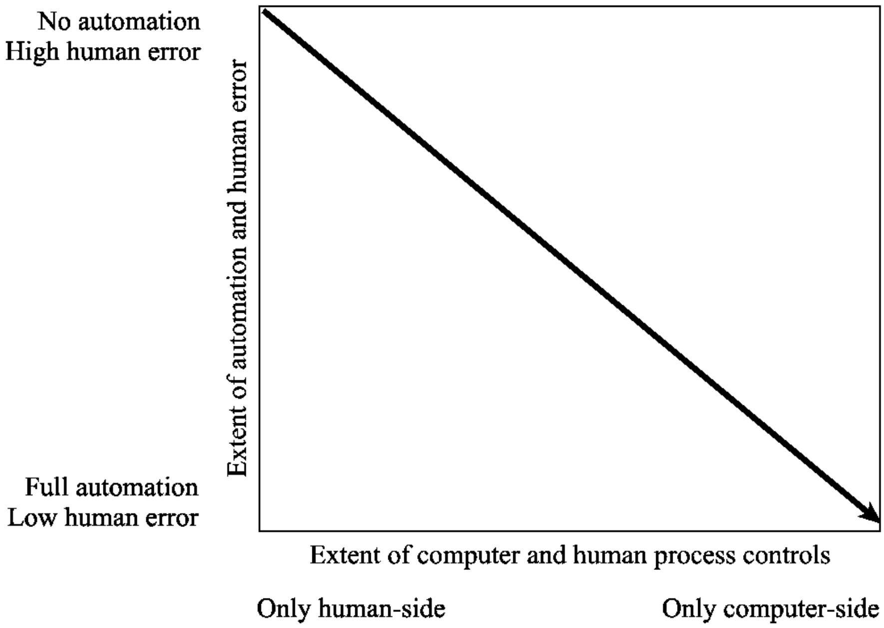


Figure 3.2, Analysis of data conversion elements

If these data conversion elements are categorised under *data*, *computer-side* (Hardware and Software elements) and *human-side* (Procedures and People elements), then as shown in Figure 3.2 above, it can be seen that the extent of Business Information Systems automation will increase as process control shifts from the human-side to the computer-side (Kroenke & Hooper 2011, pp. 8-11). It is reasonable to expect output failure due to human error to increase as process controls shift from fully automated Business Information Systems controls to manual-based controls.

3.1.2 Classification of Business Information Systems

As shown in the following listing, ranking Business Information Systems by their relative organisational scope, highlights their key characteristics in respect of the extent of systems controls and data characteristics, and also in respect of the extent of the organisational impact of systems failures (Kroenke & Hooper 2011, pp. 8-11).

- *Personal Information Systems*

  Personal Information Systems are employee-generated information systems that are generally not formally sanctioned within the organisational hierarchy (Kilfoyle, Richardson & MacDonald 2013). These systems, which are generally developed with the use of office productivity tools (such as *Microsoft Excel*, *Microsoft Access*, or *Apache Open Office Calc*), are characterised by informal operating and change control procedures; data duplication between systems; and by systems failures that would be isolated to individual users. These systems are generally standalone systems and "not the product of [any] centralised design" (Kilfoyle, Richardson & MacDonald 2013) and as such will not have any inter-dependencies with other information systems.

  As outlined in Section 1.3 (p. 4) these systems are excluded from the scope of this study.

- *Workgroup Information Systems*

  These systems are generally confined to a particular team or division, such as *MYOB* accounting systems which is generally restricted to the accounting workgroup.

These systems are categorised by emerging procedural and change control within the workgroup; the existence of data silos between different Workgroup Information Systems; and system failures that are limited to the particular workgroup.

- *Enterprise Information Systems*

  This group, which includes for example *SAP* and *Oracle PeopleSoft* enterprise resource planning systems, are characterised by formalised operating procedures and tight change control processes; minimal data duplication across the organisation; and systems failures that are likely to impact all users within the enterprise.

- *Inter-Enterprise Information Systems*

  This last group includes systems with the largest organisational scope; examples of such systems include *PayPal* and *Travelport* (a global airline reservation system). These systems are categorised by formalised procedures and tight change controls; minimal data duplication between organisations; and systems failures that are likely to impact inter-enterprise-wide.

3.1.3 Information Systems Cube

A less cited classification scheme that expands on the relative organisational scope approach above, the *Information Systems Cube* (shown below) classifies information systems on the basis of the "activities and tasks that are supported by [the] information systems, rather than [by] the specific capabilities of the systems themselves" (Cats-Baril & Thompson 1997, p. 165). The rationale for this classification scheme is that while the technical capabilities of information systems continue to change over time, the "inherent functions that the systems are used for will remain basically the same" (*ibid*).

- *Application Scope*

  This dimension is the same as that for the relative organisational scope approach (refer Sub-Section 3.1.2, p. 35), where application scope is measured along a continuum with single-user systems on one end (Personal Information Systems), and multi-user, inter-organisational systems (Inter-Enterprise Information Systems) on the other.

- *Systems Task Complexity*

  This dimension relates to the degree of decision structure inherent in information systems tasks. This is measured along a continuum with structured decisions on one end (least complex), and unstructured decisions on the other (most complex).

- *Information Richness*

  This third dimension relates to the extent of surplus meaning the information has for end-users, beyond the literal meaning of the alpha-numeric symbols used. This is measured along a continuum with sparse information richness on one end (computer machine language), and robust information richness on the other (for example, interactive video conferencing).

3.1.4 The emergence of the 'IT Department'

Historically, accounting departments were first to introduce Business Information Systems to their organisations (Cats-Baril & Thompson 1997, pp. 168-73; Mukherji 2002; Rainer & Turban 2009, pp. 31-3). The progressive introduction of Business Information Systems to other functional areas, prompted the need for the centralised management of these systems by a specialist technical team (Mukherji 2002). Today, this specialist technical team is generally known as *Information Technology*.

There would be little contention to the suggestion that information technology units generally manage a host of heterogeneous Business Information Systems and their supporting infrastructure, such as servers, and security and backup systems. The entwined inventory of these information technology parts, which includes hardware, software, data networks and communications, databases, and technology personnel and Management (Rainer & Turban 2009, pp. 7-8; Turban & Volonino 2010, p. 58), is generally called the *Information Technology*

Infrastructure (Cats-Baril & Thompson 1997, p. 148; Pearlson, Saunders & Galletta 2016, p. 15), while the way these parts are configured to work together is generally referred to as the *Information Technology Architecture* (*ibid*).

3.2 Intricacy or complexity?

As stated in the Introduction chapter, the objective of this research was to determine if, in the context of information systems audit, Task Complexity and Audit Risk are each associated with Information Technology Architecture intricacy and stability. To avoid confusion with emergent systems (discussed here below), the word *intricacy* has been used in place of *complexity* in this study. In the Complexity Sciences, *complexity* is generally defined in the context of open systems where the individual parts (referred to as *agents*) evolve in response to interactions with other parts within the system and with the environment beyond the systems boundary (Allen & Varga 2006; Kim & Kaplan 2011; Merali 2006), and hence complexity refers to emergent systems.

3.3 Information systems audit, an overview

Information systems audits have been described as "simply 'auditing in a computer environment', with reference to the programmed controls carried out by computer applications […] and the manual controls exercised by their users" in respect of these applications (Chambers & Court 1991, p. 10).

Generally conducted in medium and large organisations where information technology is generally ubiquitous, these specialist audits serve to determine the quality, reliability, security, continuity, effectiveness and efficiency of systems data input, processing, storage and output sub-systems (ISACA 2013; Rainer & Cagielski 2011; Ramamoorti & Weidenmier 2004).

While generally following the same audit methodology that focuses on the quality and operational effectiveness of internal systems controls (Bedard, Graham & Jackson 2005; ISACA 2013), *internal* and *external* information systems auditors have different objectives. Internal auditors are concerned with the operational compliance, economy, effectiveness and efficiency of *all* business-critical Business Information Systems that may impact, in a material way, the achievement of organisational objectives. External auditors, on the other hand, are primarily concerned with processes and controls in respect of data completeness and accuracy around *only* those Business Information Systems that can impact the complete and accurate production of the set of financial statements at year-end (Chambers & Court 1991, pp. 31-2).

3.4 Chapter summary

This chapter introduced the reader to information technology environments by providing an overview of Business Information Systems and how these are generally classified. The distinction between ‘intricacy’ and ‘complexity’ in the context of Information Systems Architecture was also discussed, before concluding with an overview of the function of information systems audit.

CHAPTER 4 Hypothesis Development

This chapter develops a set of four testable hypotheses, built on the theoretical foundation and knowledge gaps discussed in the literature review covered in Chapter 2 (p. 9).

4.1 Information technology environment (H1)

It is safe to suggest that organisations differ in respect of both their informational requirements, and in the relative 'organisational scope' (refer p. 35) of their information systems. To that end, the assumption is made that no two Information Technology Architectures are alike.

As discussed in Section 3.3 (p. 38), information systems audits generally serve to determine the quality, reliability, security, continuity, effectiveness and efficiency, of systems data inputs, processing, storage and outputs. In the process of evaluating systems processes and controls (against for example: corporate policies and procedures; external regulatory requirements; and accepted industry practises), information systems auditors will generally seek to gain an in-depth understanding of the Information Technology Infrastructure and Architecture, before undertaking any controls design analysis and any tests of controls procedures.

Consistent with the Objective Task Complexity framework (refer p. 17), any objective Information Systems Audit Task characteristic that implies an increase in information load or diversity, or rate of information change, can be considered to contribute to Audit Task Complexity (*variable*: TASKCOMPLEX).

In the following paragraphs, contributors to TASKCOMPLEX (load, diversity, and change) are mapped to identified Information Technology Architecture and Infrastructure elements that are likely to generate information cues during an information systems audit (these are summarised in Table 4.1, p. 43).

- *Information load and diversity*

  Information Technology Infrastructures comprise an entwined inventory of information technology parts, which includes hardware, software, data networks and communications, databases, and technology personnel and Management (refer Sub-Section 3.1.4, p. 37). If the information cues pertaining to these parts present an information load to the auditor, then Objective Task Complexity (refer p. 17) predicts that TASKCOMPLEX would increase as the quantity of information technology parts increases (*variable*: QUANTITY).

Further, if the information cues pertaining to the inter-dependencies between these information technology parts also represent an information load to the auditor, then both Objective Task Complexity and Relational Complexity Theory (refer p. 15) predict that TASKCOMPLEX would increase as the number of inter-dependencies between these parts increases (*variable*: DEPEND).

Information Technology Infrastructures also comprise multiple 'types' of the same class of information technology parts. For example, to accommodate the specific requirements of different Business Information Systems (such as: *JD Edwards EnterpriseOne*; *Microsoft Dynamics AX*; *Oracle PeopleSoft*), infrastructures will include different databases (for example: *MSSQL*; *MySQL*; *Oracle*) and operating systems (for example: *Linux*; *Windows*). If the information cues pertaining to these diverse parts present an information diversity load to the auditor, then Objective Task Complexity predicts that TASKCOMPLEX would increase as part diversity increases (*variable*: DIVERSE).

It therefore follows that if Information Technology Architecture 'intricacy' is represented by the quantity of information technology parts and the inter-dependencies and diversity between these parts, it is predicted that TASKCOMPLEX would increase as Information Technology Architecture intricacy increases.

- *Rate of information change*

Information Technology Architectures and Infrastructures change over time in response to evolving business needs, technology obsolescence (for example, systems vendor support nearing end-of-life), and technological innovation (Boddy, Boonstra & Kennedy 2005, p. 125). If the information cues pertaining to architecture and infrastructure changes (or 'stability') present an information load to the auditor, then Objective Task Complexity predicts that TASKCOMPLEX would increase as the rate of architecture and infrastructure change increases (*variable*: CHANGE).

Task Complexity Contributors	***Corresponding information cues, (variable)***
Information load and diversity	Information cues generated from the quantity of information technology parts (QUANTITY), and from the inter-dependencies (DEPEND) and diversity between these parts (DIVERSE).
Rate of information change	Information cues generated from the rate of architecture and infrastructure change (CHANGE).

Table 4.1, Task Complexity contributors mapped to information cues

If information systems audit engagements commence at time $'t'$ to retrospectively evaluate the quality and operational effectiveness of information systems processes and internal controls in place during the audit review period, t_{-1}, then it is hypothesised that:

$$TASKCOMPLEX_t : \int QUANTITY_{t-1}\ ;\ DEPEND_{t-1}\ ;\ DIVERSE_{t-1}\ ;\ CHANGE_{t-1}$$

This model posits that Audit Task Complexity is positively associated with the extent of Information Technology Architecture intricacy and stability. On this basis, the following hypothesis is presented:

H1 Information systems audit Task Complexity is positively associated with the quantity of information technology parts, the inter-dependencies and diversity between these parts, and with the rate of architecture and infrastructure change.

4.2 Risk of Material Systems Failure (H2)

Information systems audits generally focus on the design quality and operational effectiveness of internal controls (refer p. 38). Given that the Audit Risk Model (refer p. 27) is not optimised for the audit of internal controls (Akresh 2010), an alternative risk model is hence required.

Consistent with the approach taken in extant Audit Risk literature (Akresh 2010; Kinney 1983; Shibano 1990; Smieliauskas 2007), this thesis proposes an adaption of the Audit Risk Model to overcome its shortcomings, aptly named the *Systems Audit Risk Model*. This alternate model is relevant to information systems audit in both external and internal audit contexts.

Under the Systems Audit Risk Model, elements from the Audit Risk Model are appropriately redefined as shown below.

- *Systems Audit Risk* (adapted from Audit Risk)

  Systems Audit Risk is defined as the risk that material systems failures and risk exposures may go unreported to Management during the course of an information systems audit.

- *Risk of Material Systems Failure* (adapted from Risk of Material Misstatement)

  This refers to the risk that material systems failures (*actual* failures) and risk exposures (*potential* failures) relevant to the scope of the audit, occurred / exist within the audit review period (t_{-1}).

  Risk of Material Systems Failure is derived from:

  - *Systems Inherent Risk*, the susceptibility of systems processes to generate material errors or irregularities in the absence of mitigating systems controls; and

  - *Systems Control Risk*, the risk that mitigating systems controls fail to detect or prevent material systems processing errors and irregularities.

- *Systems Failure Detection Risk* (adapted from Detection Risk)

  This is defined as the failure of information systems audit procedures to detect material systems failures and risk exposures pertaining to the audit review period and that are within the audit scope.

The Systems Audit Risk Model is therefore represented as follows:

$$Systems\ Audit\ Risk_t : \int \begin{matrix} Risk\ of\ Material \\ Systems\ Failure \end{matrix}_{t-1} ; \begin{matrix} Systems\ Failure \\ Detection\ Risk \end{matrix}_{t}$$

Consistent with the Audit Risk Model, auditors would keep Systems Audit Risk at a constant low level by adjusting the appetite for Systems Failure Detection Risk in response to movements in the assessment of the Risk of Material Systems Failure (which combines Systems Inherent Risk and Systems Control Risk) (as demonstrated in Table 4.2 below).

Assessment of the Risk of Material Systems Failure	***Systems Failure Detection Risk response***	***Extent of audit procedures performed***
Elevated assessment	Risk appetite *lowered*	Procedures *increased*
Lowered assessment	Risk appetite *elevated*	Procedures *reduced*

Table 4.2, Systems Audit Risk appetite

4.2.1 Risk of Material Systems Failure

Material systems failures and risk exposures in respect of the entwined inventory of information technology parts that form the Information Technology Architecture (refer Chapter 3), can be attributed to one or both of the following factors (Kroenke & Hooper 2011, pp. 8-11):

- *Equipment failure*

  An example of equipment failure would be the disruption to data exchanges between Business Information Systems due to power failure, a failed server, or a data network failure.

- *Human error*

  Examples of human error would include: incorrect data processing due to poor software development; unauthorised financial transactions due to poor user account management; and loss of critical business data and information due to poor disaster recovery planning.

The extent of equipment failure and human error would invariably differ between organisations due to, for example, the maturity of the internal control structure, the extent of preventative measures and continuous controls monitoring implemented, and the effectiveness of the internal audit function.

If the propensity for equipment failure and human error increases with an increase in the inventory of information technology parts, it is posited that the assessment of the Risk of Material Systems Failure (*variable*: ASSESSRISK) by the auditor at time $'t'$ is positively associated with the extent of Information Technology Architecture intricacy and stability. Therefore, building on hypothesis H1, it is hypothesised that for a given audit review period (t_{-1}):

$$ASSESSRISK_t : \int QUANTITY_{t-1} \; ; \; DEPEND_{t-1} \; ; \; DIVERSE_{t-1} \; ; \; CHANGE_{t-1}$$

On this basis, the following hypothesis is presented:

H2 The assessment of the Risk of Material Systems Failure is positively associated with the quantity of information technology parts, the inter-dependencies and diversity between these parts, and with the rate of architecture and infrastructure change.

4.3 Reported findings and auditor's local knowledge (H3)

This section develops a set of hypotheses in two steps: first a model around reported information systems audit findings is developed, then a moderating variable in respect of the auditor's local knowledge is introduced.

A key auditor attribute is the ability to identify audit findings and to report these objectively to the appropriate level within the organisational hierarchy. To avoid the "tendency for the findings to be biased by opportunistic behaviour of the manager overseeing the internal audit unit" (Spraakman 1997) and maintain auditor independence, audit findings are reported "to a level higher than that of the employee being evaluated" (Penno 1990).

4.3.1 Reported information systems audit findings

Consistent with the Audit Risk Model, the Systems Audit Risk Model provides that elevated (lowered) assessments of the Risk of Material Systems Failures result in lowered (elevated) Systems Failure Detection Risk appetites, which in turn result in increased (reduced) audit procedures (refer Table 4.2, p. 45). This approach serves to keep Systems Audit Risk at a low level between audits.

If hypothesis H2 holds true, then by deduction a positive association should also exist between the extent of audit procedures performed for a given audit review period, and the extent of the entwined inventory of information technology parts that form the Information Technology Architecture. Hence:

$$\begin{matrix} Extent \\ of\ audit \\ procedures_t \end{matrix} : \int QUANTITY_{t-1}\ ;\ DEPEND_{t-1}\ ;\ DIVERSE_{t-1}\ ;\ CHANGE_{t-1}$$

It is further posited that movements in the 'Extent of audit procedures' in the model above, are positively associated with the extent of information systems audit findings reported to Management (*variable*: REPORTED). Hence, if 'Extent of audit procedures' is substituted for REPORTED:

$$REPORTED_t : \int QUANTITY_{t-1}\ ;\ DEPEND_{t-1}\ ;\ DIVERSE_{t-1}\ ;\ CHANGE_{t-1}$$

This model posits that the extent of information systems audit findings reported to Management is positively associated with the extent of Information Technology Architecture intricacy and stability. On this basis, the following hypothesis is presented:

$H3_a$ The extent of information systems audit findings reported to Management is positively associated with the quantity of information technology parts, the inter-dependencies and diversity between these parts, and with the rate of architecture and infrastructure change.

4.3.2 Auditor's local knowledge

Extant Task Complexity research in auditing (Bonner 1994; Tan & Kao 1999a) does not differentiate between the auditor's *transportable* (or common) business process knowledge, and the auditor's *local knowledge* of organisation-specific business processes.

In the context of newly engaged but experienced information systems auditors, it is posited that an auditor's local knowledge (*variable*: mKNOW) of an organisation's intricacy and stability around it's information technology environment, will accumulate with each information systems audit performed and through on-going professional interactions with information technology personnel.

To illustrate this, consider a scenario where a new but experienced information systems auditor joins an organisation's internal audit function, where prior audit working papers *do not* adequately capture local systems knowledge. If elements of an Information Systems Architecture are audited progressively, then the auditor is unlikely to detect *all* material systems failures and risk exposures in the first few audits as some inter-dependent elements would not have as yet been audited (and therefore understood).

From the example above, it can be seen that auditor's local knowledge is not linked with the extent of an auditor's training and professional experience. Rather, this construct is associated with the extent of a new but experienced auditor's accumulation of local knowledge over time.

Hence, building on the model developed in the preceding sub-section:

$REPORTED_t$:

$$\int QUANTITY_{t-1} \, ; \, DEPEND_{t-1} \, ; \, DIVERSE_{t-1} \, ; \, CHANGE_{t-1} \, ; \, mKNOW_t$$

Therefore, moderated by the extent of the auditor's local knowledge, this model posits that the extent of audit findings reported to Management is associated with the extent of Information Technology Architecture intricacy and stability. On this basis, the following hypothesis is presented:

$H3_b$ The relationship between audit findings reported to Management and the quantity of information technology parts, the inter-dependencies and diversity between these parts, and the rate of architecture and infrastructure change, is moderated by the extent of the auditor's local knowledge.

4.4 Management of Systems Audit Risk (H4)

From hypothesis H2 (refer Section 4.2, p. 44), auditors maintain Systems Audit Risk at a constant low level by adjusting the appetite for Systems Failure Detection Risk in response to movements in the assessment of the Risk of Material Systems Failure (represented below).

$$Systems\ Audit\ Risk_t : \int \begin{matrix} Risk\ of\ Material \\ Systems\ Failure \end{matrix}_{t-1} ; \begin{matrix} Systems\ Failure \\ Detection\ Risk \end{matrix}_{t}$$

If auditors maintain Systems Audit Risk at a constant low level, then the assessment of the Risk of Material Systems Failure (ASSESSRISK) should be negatively associated with Systems Failure Detection Risk.

From hypothesis H3a (refer Sub-Section 4.3.1, p. 47), if Systems Failure Detection Risk is negatively associated with the extent of audit findings reported to Management (REPORTED), then a positive association should exist between ASSESSRISK and REPORTED.

$$ASSESSRISK_t : \int REPORTED_t$$

From hypothesis H3b (refer Sub-Section 4.3.2, p. 48), it is posited that the relationship between REPORTED and ASSESSRISK is moderated by the extent of the auditor's local knowledge (mKNOW), hence:

$$ASSESSRISK_t : \int REPORTED_t\ ;\ mKNOW_t$$

On this basis, the following hypotheses are presented:

$H4_a$ The extent of audit findings reported to Management is positively associated with the assessment of the Risk of Material Systems Failure.

$H4_b$ The relationship between the extent of audit findings reported to Management and the assessment of the Risk of Material Systems Failure, is moderated by the extent of the auditor's local knowledge.

4.5 Regression models

The regression models pertaining to the hypotheses above are shown below; these models are controlled for size (*variable*: SIZE) and industry (*variable*: INDUSTRY).

H1 $TASKCOMPLEX_t = \beta_0 + \beta_1 QUANTITY_{t-1} + \beta_2 DEPEND_{t-1} + \beta_3 DIVERSE_{t-1} + \beta_4 CHANGE_{t-1} + \beta_5 SIZE_{t-1} + \beta_6 INDUSTRY + \epsilon_0$

H2 $ASSESSRISK_t = \beta_7 + \beta_8 QUANTITY_{t-1} + \beta_9 DEPEND_{t-1} + \beta_{10} DIVERSE_{t-1} + \beta_{11} CHANGE_{t-1} + \beta_{12} SIZE_{t-1} + \beta_{13} INDUSTRY + \epsilon_1$

H3 $REPORTED_t = \beta_{14} + \beta_{15} QUANTITY_{t-1} + \beta_{16} DEPEND_{t-1} + \beta_{17} DIVERSE_{t-1} + \beta_{18} CHANGE_{t-1} + \beta_{19} mKNOW_t + \beta_{20} SIZE_{t-1} + \beta_{21} INDUSTRY + \epsilon_2$

H4 $REPORTED_t = \beta_{22} + \beta_{23} ASSESSRISK_t + \beta_{24} mKNOW_t + \beta_{25} SIZE_{t-1} + \beta_{26} INDUSTRY + \epsilon_3$

Table 4.3, Statistical regression models

The relationships between hypothesis variables are captured in Figure 4.1 below.

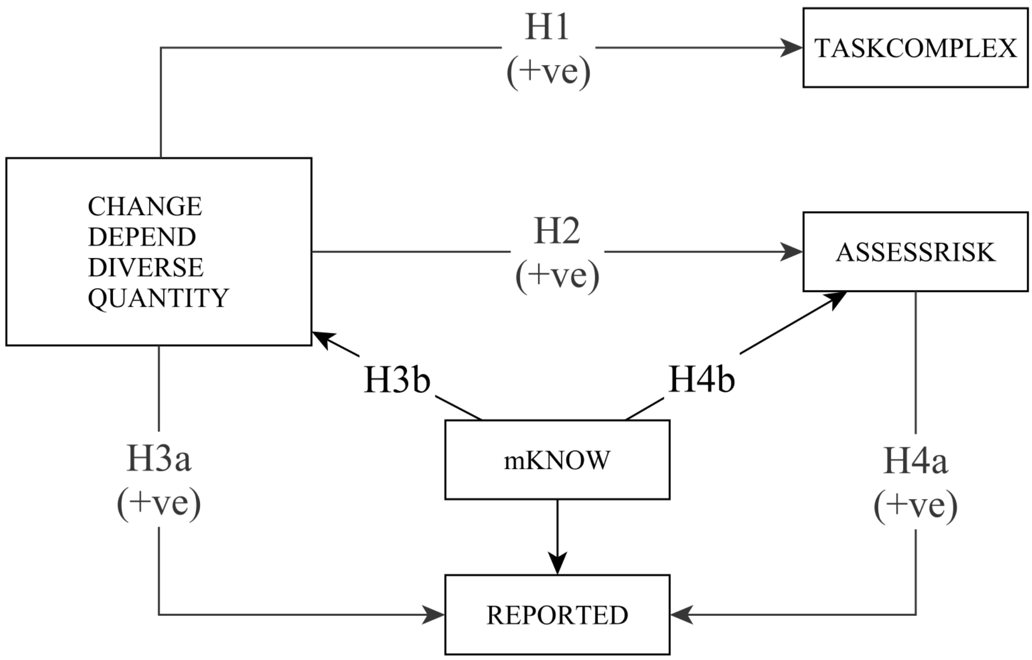


Figure 4.1, Hypothesis relationships

4.6 Chapter summary

Built on the theoretical foundation and knowledge gaps discussed in the literature review, this chapter developed the following testable hypotheses:

- Task Complexity is positively associated with the extent of Information Technology Architecture intricacy and stability (H1)
- Risk of Material Systems Failure is positively associated with the extent of Information Technology Architecture intricacy and stability (H2)
- Extent of information systems audit findings reported to Management is positively associated with the extent of Information Technology Architecture intricacy and stability (H3a)
- Relationship between the extent of information systems audit findings reported to Management and the extent of Information Technology Architecture intricacy and stability, is moderated by the extent of the auditor's local knowledge (H3b)

Audit Task Complexity and Audit Risk

- Extent of audit findings reported to Management is positively associated with the assessment of the Risk of Material Systems Failure (H4a); and
- Relationship between the extent of audit findings reported to Management and the assessment of the Risk of Material Systems Failure, is moderated by the extent of the auditor's local knowledge (H4b).

CHAPTER 5 Variable Measurement

The previous chapter developed a set of testable hypotheses built on the theoretical foundation and knowledge gaps discussed in the literature review. In respect of these hypotheses, this chapter discusses variable measurement assumptions, approaches, and limitations.

5.1 Key variable measurement assumptions

The measurement approaches discussed in this chapter are based on the assumptions in the following sub-sections.

5.1.1 Audit review period

It is assumed that information systems audits commence at time $'t'$ to *retrospectively* evaluate the design quality and operational effectiveness of information systems processes and internal controls during the audit review period t_{-1}.

5.1.2 Risk-based audit plans

Standard number 2010 of the *International Standards for the Professional Practice of Internal Auditing (Standards) 2016*, as issued by the *Institute of Internal Auditors*, provides that "The chief audit executive must establish a risk-based [audit] plan to determine the priorities of the internal audit activity, consistent with the organization's goals". It is assumed that internal audit functions generally adhere to this Standard.

5.1.3 Audit planning cycle

Internal audit functions generally develop their risk-based audit plans (refer above) from the *audit universe*. The audit universe is a comprehensive list of auditable areas within an organisation, that is derived from risk assessments based on the perceived strengths and weaknesses of the internal controls and the reliability of the personnel responsible for these controls (Pickett 2006, p. 8). Internal auditors generally develop a three- to five-year rolling plan to cover all auditable areas within their audit universe (*ibid*, p. 42). However, in larger organisations, information technology audit planning cycles are likely to be synchronised with any third-party certification programs implemented by the business to ensure nominated information technology processes meet good practice standards (such as *ISO 27001 Information Security Management System Standard*). Third-party certifying bodies such as SAI Global generally maintain three-year re-certifications cycles (refer web site www.saiglobal.com).

Given the dynamic nature of information technology and its criticality from an organisational perspective, as well as the three-year third-party re-certification cycles discussed above, it is assumed that information systems auditors generally develop three-year rather than five-year rolling audit plans.

5.1.4 Engagement of consultants

It is assumed that consultants may be engaged by internal audit functions to perform specific information systems audits on a needs basis, and hence these audits are factored in variable measurements where applicable.

5.1.5 External and internal audit cross-reliance

It is further assumed that external and internal information systems auditors place some reliance on each other's work, and hence variable measurements will incorporate both external and internal information systems audits where applicable.

5.1.6 Component classification

As discussed in Chapter 3, Information Technology Infrastructures comprise information technology hardware, software, data networks and communications, databases, and technology personnel and Management. For the purposes of variable measurement, *data networks and communications* are classed as hardware components, while *databases* are classed as software components.

5.1.7 Study period

From Sub-Section 5.1.3 it is assumed that information systems auditors generally develop three-year rolling audit plans. Consequently, this study covers the three-year study period between January 1st, 2012 and December 31st 2014.

5.2 Latent variables identified

In developing variable measurements, it was identified that variables DIVERSE and QUANTITY are latent variables (refer Sections 5.6 and 5.8, pp. 59 and 62, respectively), and as such Partial Least Squares path modelling is best suited for hypothesis analysis.

5.3 ASSESSRISK

The variable ASSESSRISK captures the assessment of the Risk of Material Systems Failure at time $'t'$, which refers to the risk that material systems failures (actual failures) and risk exposures (potential failures) exist in the audit review period t_{-1} (refer Section 4.2, p. 44). As such, ASSESSRISK can be quantified by the number of actual material systems failures and material systems risk exposures during the study period (refer Sub-Section 5.1.7, p. 55). These are discussed further in the following sub-sections.

5.3.1 Actual material systems failures

Actual material systems failures (due to equipment failure and human error, (refer Sub-Section 4.2.1, p. 45) are generally recorded as information technology *incidents*, as part of the Incident Management process which serves to restore unplanned interruptions to information technology services (ISACA 2013, p. 240). These incidents are generally classified in terms of their impact on the business (the generally used classification is Severity 1, 2, 3, or 4, where Severity 1 represents the greatest impact to critical business processes).

Assuming that all actual material failures in respect of business-critical information technology parts are detected by information technology processes and appropriately recorded as incidents, then the actual material systems failures during t_{-1} can be quantified by the aggregate of Severity 1, 2, 3, and 4 incidents recorded during the study period (refer Sub-Section 5.1.7, p. 55).

5.3.2 Material systems risk exposures

The following assumptions are made in respect of the classification of material systems risk exposures (potential) during the audit review period t_{-1}:

- *Exposures known to Management*

  These risk exposures are known by Management and are addressed through the implementation of new processes and controls via the Change Management process. Assuming that known material, systems risk exposures are addressed within period t_{-1} via the Change Management process, these exposures would therefore be captured under the variable CHANGE (refer p. 57) as Request for Change proposals.

- *Exposures accepted by Management*

  Management generally assess risk exposures in terms of the two risk management dimensions: on their *impact* on the organisational strategy, and on their *likelihood* of occurrence. In line with the organisation's risk appetite, Management may choose to accept particular systems risk exposures given their impact and likelihood assessments. It is assumed that *material* systems risk exposures in respect of business-critical information technology parts are not likely to be accepted risk exposures, and hence this class is excluded from ASSESSRISK.

- *Exposures unknown to Management*

  Material systems risk exposures unknown to Management cannot be quantified effectively or reliably. However, it is reasonable to assume that a proportion of these would be detected through information systems audits and duly reported to Management. Therefore, a proportion of these exposures would be captured by the variable REPORTED (refer Section 5.9, p. 64).

5.3.3 Weightings

In respect of actual material systems failures (refer Sub-Section 5.3.1, above), to reflect the relatively higher impact of Severity 1 and 2 incidents, these incidents are weighted by a factor of two over Severity 3 and 4 incidents.

5.3.4 Measurement limitations

Following from Sub-Section 5.3.1, the extent of incidents recorded by an organisation would invariably be affected by, for example, the maturity of the internal control structure, the extent of preventative measures and continuous controls monitoring implemented, and the effectiveness of the internal audit function. These factors are not incorporated in the measurement of ASSESSRISK due to the availability, reliability, and extent of resources required to obtain the relevant data.

5.4 CHANGE

CHANGE captures the extent of Information Technology Architecture and Infrastructure change (refer Section 4.1, p. 41). This is discussed in the following sub-sections.

5.4.1 Requests for Change

The rate of Information Technology Architecture and Infrastructure change can be quantified by the number of completed information technology *Request for Change* proposals during the study period (refer Sub-Section 5.1.7, p. 55). A Request for Change, part of the Change Management process, is defined as a "proposal for a change to be made to a service, service component or the service management system" (ISO 2011, para. 3.24). These requests are subject to formal governance processes implemented by Management, and apply to non-routine *or* significant (and invariably business-critical) changes to the Information Technology Infrastructure or Architecture, for example: hardware replacement; systems installation or upgrade; and implementation of new technology (ISACA 2013, p. 241; Pandey & Mishra 2014).

5.4.2 Service Requests

Information technology *Service Requests* are *not* included in the measurement of this variable. Service Requests are defined as “requests for information, advice, access to a service or a pre-approved change” (ISO 2011, para. 3.33). These requests are characterised as minor *and* routine changes for which strict standard procedures have been implemented by Management. Examples of these requests include: requests for new systems user accounts; password resets; and replacement of printer toner cartridges.

5.4.3 Measurement limitations

It is reasonable to suggest that no two implemented *Requests for Change* would impact Information Technology Architecture and Infrastructure in the same way. Changes vary in the extent of their impact and risk exposure on the information technology environment, and in the required levels of technical expertise and resources. These factors are not incorporated in the measurement of CHANGE due to the availability, reliability, and extent of resources required to obtain the relevant data.

5.5 DEPEND

DEPEND captures the extent of inter-dependencies within Information Technology Infrastructures (refer Section 4.1, p. 41) arising from programmed (automated) data exchanges between information technology parts. Therefore, if the assumption is made that data exchanges between these parts are primarily bi-directional rather than uni-directional, then the inter-dependencies between business-critical information technology parts can be reasonably quantified by the number of physical data links between them, as at the end of the study period (refer Sub-Section 5.1.7, p. 55).

Manual data exchanges between information technology parts (which are often *ad hoc*) are not generally within the scope of information systems audits and hence are not included in the measurement of this variable.

5.6 DIVERSE

DIVERSE captures the extent of part diversity within Information Technology Infrastructures (refer Section 4.1, p. 41). If taken as a latent variable, this variable can be represented by reflective indicators for each *different* type of business-critical hardware, software, and personnel component, as at the end of the study period (refer Sub-Section 5.1.7, p. 55).

The specific reflective indicators are discussed in the following sub-sections.

5.6.1 Hardware related indicators

Appliance vendors (such as *Dell*, *HP*, and *IBM*) tend to release appliance models (such as *IBM eServer xSeries 100*, *130*, *135*, and *150*) that differ primarily in data processing performance and storage capacity, but which share similar (if not the same) underlying appliance management and configuration software sub-systems (*firmware*). In the context of information systems audit, it is assumed that this shared firmware represents transportable knowledge between models would *not* increase the auditor's cognitive demands. On this basis, the *different* brands (and publishers) of business-critical hardware related components can be represented by the following indicators for each relevant hardware category:

- iDENDUSR: End-user appliances, which includes desktops, laptops, and tablets
- iDIDSYST: User authentication management systems
- iDNETDEV: Data network management appliances, which includes communications systems, routers and firewalls, intrusion detection and prevention systems, and wireless access systems
- iDOPSYST: Operating systems; and
- iDSERVER: Server appliances purposed for business-critical information systems.

5.6.2 Business systems indicators

The number of different types of business-critical business systems parts can be measured by the following indicators:

- *iDBESPOK: Bespoke business systems*

  Given the significant investment in the development of bespoke (in-house; custom-built) systems, it is reasonable to assume that these are business-critical systems.

- *iDDBSYST: Different database publishers;* and *iDOFFSHF: Different business systems publishers*

  For a given category of business systems (and their respective databases), software publishers (such as *Oracle* and *SAP*) tend to release product versions that differ primarily in functionality and organisational scope (refer p. 35), but which share similar underlying systems configuration parameters. Examples include the following pairs of related software products: *Oracle Database* Enterprise Edition and Standard Edition; and *SAP* R/3 and ECC6.

  In the context of information systems audit, it is assumed that these shared configuration parameters represent transportable knowledge between product versions that would *not* increase an auditor's cognitive demands. On this basis, *different* business systems and database publishers in respect of business-critical applications are included in the measurement of this variable.

5.6.3 Technology personnel and Management

The diversity between information technology technical teams differs significantly between organisations. This diversity depends on the structure and size of the Information Technology Architecture and Infrastructure, the extent of shared and merged technical roles, and the extent of outsourced services. In this respect, it is unlikely that diversity in technical teams can be measured efficiently and reliability, and hence for this reason it is excluded from the measurement of this variable. This approach is not expected to have a significant impact on this measurement.

5.6.4 Weightings

The indicators discussed above cannot be weighted in any meaningful way and hence no weightings would be applied.

5.7 mKNOW

mKNOW is a moderating variable that captures the extent of a new but experienced, information systems auditor's local knowledge (refer Section 4.3, p. 46).

5.7.1 Engagement years

Assuming that information systems auditors make a reasonable effort to accumulate local knowledge, then the variable mKNOW can be measured by the total of information systems auditor *engagement years* as at the end of the study period (refer Sub-Section 5.1.7, p. 55).

To illustrate this, a full-time internal information systems auditor with two years of continuous service within an organisation would have accumulated two years of local knowledge. In contrast, an external information systems auditor who spends a month each year planning the audit and reviewing information systems processes and controls, would have accumulated 0.2 years of local knowledge over the same two-year period.

The calculation of engagement years would be adjusted for annual and personal leave entitlements where relevant.

5.7.2 Measurement limitations

The total of information systems auditor engagement years would include years contributed by internal information systems auditors and consultants (refer Sub-Sections 5.1.4, p. 54). Ordinarily this total would also include engagement years contributed by external information systems auditors, however this will not be included as this information is unlikely to be made available by the respective external audit firms.

This limitation is expected to weaken results in respect of mKNOW. *However*, given that the scope of external information systems audits is limited to financial information systems that impact the production of the set of financial statements at year-end, the impact of this limitation should not be significant.

5.8 QUANTITY

This variable captures the quantity of Information Technology Infrastructure parts (refer Section 4.1, p. 41). If taken as a latent variable, QUANTITY can be represented by a set of reflective indicators that capture the quantity of each business-critical hardware, software, and personnel component, as at the end of the study period (refer Sub-Section 5.1.7, p. 55).

These reflective indicators are discussed in the following sub-sections.

5.8.1 Hardware related indicators

The quantity of business-critical hardware parts can be represented by the following indicators that capture the number of parts in each relevant hardware category:

- iQENDUSR: End-user appliances, which includes desktops, laptops, and tablets
- iQNETDEV: Data network management appliances, which includes communications systems, routers and firewalls, intrusion detection and prevention systems, and wireless access systems; and
- iQSERVER: Server appliances purposed for business-critical information systems.

Note: Indicators for authentication management systems and operating systems are not included to avoid multicollinearity issues as it is assumed that these would equal DIVERSE indications iDIDSYST and iDOPSYST, respectively.

5.8.2 Business systems indictors

The quantity of software parts can be captured by the following indicators that cover the relevant business-critical software categories:

- iQBESPOK: Business-critical bespoke (in-house; custom-built) business applications
- iQOFFSHF: Business-critical published (off-the-shelf) software applications (customised or otherwise); and
- iQMODULE: Add-on modules for business-critical published software applications (this is explained in following paragraph).

Note: It is reasonable to expect iQBESPOK and iQOFFSHF to be highly correlated with DIVERSE indicators iDBESPOK and iDOFFSHF respectively.

For some published software applications, additional add-on modules can be enabled. By way of an example, consider *SAP*, a leading enterprise resource planning system. In addition to the core SAP installation, other modules, such as *Customer Relationship Management* (SAP CRM); *Supply Chain Management* (SAP SCM); and *Sales and Distribution* (SAP SD), may be activated. It is assumed that these add-on modules increase the auditor's cognitive demands and hence are included in the stocktake of software applications.

Databases are not included. As each Business Information System generally includes one database, the inclusion of a separate count of databases would not add any value in this measurement. It should be noted that databases are however included under the variable DIVERSE (refer Section 5.6, p. 59).

5.8.3 Technology personnel and Management indicator

The indicator iQITSTAFF captures the number of information technology personnel, and is based on the number of all full-time personnel as at the end of the study period (refer Sub-Section 5.1.7, p. 55).

Personnel in respect of outsourced services (such as outsourced datacentre and disaster recovery services) are not included as it is assumed that information systems auditors will generally engage with outsource providers *indirectly* through the relevant information technology personnel within the organisation.

5.8.4 Weightings

The indicators discussed above cannot be weighted in any meaningful way and hence no weightings would be applied.

5.9 REPORTED

This variable captures the extent of information systems audit findings reported to Management (refer Section 4.3, p. 46). Reported audit findings are generally risk-rated as either *Opportunity for Process Improvement, Low Risk*, *Moderate Risk,* or *High Risk* to indicate to Management the extent of systems risk exposure to the organisation.

On this basis, the variable REPORTED is therefore quantified by the aggregate of Opportunity for Process Improvement, Low Risk, Moderate Risk, and High Risk information systems audit findings reported to Management during the study period (refer Sub-Section 5.1.7, p. 55). This aggregate of findings reported to Management would include those reported by internal information systems auditors, as well as those reported by consultants and by the external information systems auditor (refer Sub-Sections 5.1.4 and 5.1.5, p. 54, respectively).

5.9.1 Weightings

To reflect the relatively risk exposures between audit finding risk ratings, the following weighting factors would be applied:

- *High Risk*: factor of 3
- *Moderate Risk*: factor of 2
- *Low Risk*: factor of 1; and
- *Opportunity for Process Improvement*: factor of 0.5.

5.9.2 Measurement limitations

REPORTED, measured by the number of reported findings to Management, is affected by the following factors:

- Consistency of risk ratings given to reported findings
- Extent of finding-bundling (i.e. grouping of) in reported findings; and
- Management pressure over the extent of findings that get reported, and over the risk ratings given to reported findings.

These factors are not incorporated in the measurement of REPORTED due to the availability, reliability, and extent of resources required to obtain the relevant data.

5.10 TASKCOMPLEX

As discussed in the literature review (refer Sub-Section 2.5.4, p. 27), extant studies have measured Task Complexity in auditing as either a within- or between-subject variable. An alternative measurement approach is discussed below.

The extent of an organisation's computerisation was found to be positively associated with audit fees (Banker, Chang & Kao 2010), an association that was attributed to Audit Task Complexity (*ibid*, p. 356). Therefore, if audit fees are positively associated with audit labour, then TASKCOMPLEX can be quantified by the total of audit labour hours consumed in performing information systems during the study period (refer Sub-Section 5.1.7, p. 55).

The calculation of audit labour hours would be adjusted for annual and personal leave entitlements where relevant.

5.10.1 Measurement limitations

The total of audit labour hours would include those consumed by internal information systems auditors and consultants (refer Sub-Sections 5.1.4, p. 54). Ordinarily, this total would also include audit labour hours consumed by external information systems auditors, however this will not be included for the following reasons:

- This information is unlikely to be made available by the respective external audit firms; and
- This information cannot be derived from reported external audit fees as financial statement report disclosures do not include itemised audit fees in respect of information systems audit effort.

This limitation is expected to weaken any associations between TASKCOMPLEX and other variables. *However*, given that the scope of external information systems audits is limited to financial information systems that impact the production of the set of financial statements at year-end, the impact of this limitation on measurement should not be significant.

Measured by audit labour hours consumed by internal information systems auditors and consultants, TASKCOMPLEX is likely to be affected by the following factors:

- Audit labour hour differences between audits conducted by internal auditors and consultants
- Limited internal audit budgets, management push-back over planned audits, and the extent of involvement by the External Auditor, will invariably impact coverage over the internal information systems audit universe and restrict audit scope thereof; and
- The extent to which internal audit programs are standardised.

5.11 Control variables

To control for firm-level characteristics that may have an effect of confounding variables in this study, the control variables INDUSTRY and SIZE are included (refer Section 4.5, p. 50).

INDUSTRY is categorised in line with the *Australian and New Zealand Standard Industrial Classification* (ANZSIC), a standard industry classification listing maintained by the *Australian Bureau of Statistics*.

SIZE is quantified by the number of full-time information technology personnel, which is captured by the indicator iQITSTAFF for the latent variable QUANTITY (refer Sub-Section 5.8.3, p. 64). Unlike other studies in accounting and auditing, this study has departed from using traditional control variables around the number of firm employees or the value of firm assets. The reason for this departure is that this study focuses solely on a firm's information technology environment and hence it is pertinent to measure size in terms of the size of the Information Technology team or the value of Information Technology assets (the latter being more difficult to quantify).

5.12 Chapter summary

This chapter discussed variable measurement assumptions, approaches, and limitations in respect of the set of hypotheses developed in the previous chapter.

Table 5.1 below provides a summary of the variable and indicator measurements discussed in this chapter.

Variable	***Variable / Indicator summary***	
ASSESSRISK	Weighted information technology incidents recorded	
CHANGE	Completed information technology Requests for Change proposals	
DEPEND	Physical data links between business-critical information technology parts	
DIVERSE (latent variable)	Reflective indicators in respect of different business-critical components:	
	iDBESPOK	Bespoke software systems
	iDDBSYST	Database publishers

	iDENDUSR	End-user appliances
	iDIDSYST	Authentication management systems
	iDNETDEV	Network management appliances
	iDOFFSHF	Software publishers
	iDOPSYST	Operating systems
	iDSERVER	Server appliances
INDUSTRY (control)	Industry classified in line with ANZSIC code	
mKNOW (moderator)	Information systems auditor engagement years, adjusted for leave entitlements where relevant	
QUANTITY (latent variable)	Reflective indicators in respect of quantity of business-critical components:	
	iQBESPOK	Bespoke software systems
	iQENDUSR	End-user appliances
	iQITSTAFF	Information technology personnel
	iQMODULE	Software application add-on modules
	iQNETDEV	Network management appliances
	iQOFFSHF	Software publishers
	iQSERVER	Server appliances
REPORTED	Weighted information systems audit findings reported to Management	
SIZE (control)	*iQITSTAFF*	Information technology personnel – as per indicator as for latent variable QUANTITY
TASKCOMPLEX	Information systems audit labour hours, adjusted for leave entitlements where relevant	

Table 5.1, Variable and indicator measurement summary

CHAPTER 6 Research Methodology

This chapter describes the methodology approach adopted, and details processes undertaken to collect the required dataset for the purposes of hypothesis testing. *Some sections in this chapter are procedural in nature and are included for completeness.*

6.1 Research method

As provided in the literature review (pp. 21 and 29), extant empirical research in respect of both Task Complexity in auditing and Audit Risk, has been primarily experimental in nature. The reason for this general approach is likely to be the absence of archival data from which meaningful research can be conducted in this field of enquiry.

It is generally accepted that experimental research methods tend to throw into question the external validity of studies as these methods cannot adequately capture real-world environments. Given that the variables pertaining to the hypotheses (refer Chapter 5) are based on specific *real-world* quantitative measurements of an organisation's information systems audits and of its information technology environment (such as the number of audit hours consumed and the number of physical data links between business-critical technology parts), experimental research methods are therefore not well suited.

An effective research approach for this quantitative research would therefore be obtaining real-world data from organisations likely to have ubiquitous information technology, the collection of which is possible via either survey or case study research methods.

For the purposes of statistically-reliable regression analysis, a large sample size is required for this study. Given that the collection of large sample sizes via case study research methods are generally more resource intensive and time consuming, data collection via survey methods was deemed to be the more viable option.

After careful assessment of the different modes of survey delivery (face-to-face personal interviews; telephone; traditional mail; web-based) in respect of time, cost, feasibility, and risk, the decision was made to deliver the survey via online, self-administered questionnaire surveys (Internet surveys). Whilst response rates and security issues are key concerns with Internet surveys, their strengths include cost-effectiveness, and the potential to leverage visual appeal, interactivity, as well as personalised and flexible questioning capabilities (McPeake, Bateson & O'Neill 2014; Zikmund et al. 2010, pp. 227-31).

Given that the cost of acquiring targeted email listing of prospective survey participants is generally prohibitive, it was decided to issue survey invitations to targeted prospective participants via traditional mailed letter invitations. Corporate mailing address listings of many medium to large organisations in Australia are readily available and inexpensive.

Whilst the application of survey research methods departs from the approach generally adopted in Task Complexity in auditing and Audit Risk empirical research, this approach is however consistent with Judgement and Decision-Making studies in *accounting*, as published in top-tier accounting journals (Chand & Patel 2011, p. 56).

6.2 Risk mitigation

It is generally accepted that exposure to the risk of errors is common to all survey methods (Zikmund et al. 2010, pp. 188-95). The key survey risk exposures are listed below:

- Common method bias
- Data-processing error
- Incorrect or missing responses
- Low participation rate
- Random sampling error; and
- Response bias.

As part of the risk assessment process, the identified risk exposures were mitigated to reduce inherent risk to an acceptable lower level (residual risk). This risk assessment was tabulated in a *Survey Risk Register* (refer Table 6.1, p. 71).

Key risk exposures identified	Inherent risk assessment: *Impact*	Inherent risk assessment: *Likelihood*	Inherent risk assessment: *OVERALL*	Risk mitigation strategies implemented	Residual risk assessment: *Impact*	Residual risk assessment: *Likelihood*	Residual risk assessment: *OVERALL*
1. Low participation rate	H	H	**H**	• Participation incentivised by providing respondents with a post-survey information systems audit benchmarking report at no cost; • Number of questions per survey kept to below 20; and • Contingency plan activated - survey dataset supplemented with data collected from real-world audits.	L	L	**L**
2. Response bias	H	H	**H**	• Response anomalies identified and queried with respondents.	L	M	**L**
3. Incorrect or missing responses;	H	M	**H**	• Independent review of questionnaire design and question validity by an expert with extensive experience in designing successful questionnaires;	L	M	**L**
4. Common method bias	H	M	**H**	• Independent review of questionnaire wording choices and sequencing by a number of experienced information systems auditors; and • Response anomalies identified and queried with respondents.	L	M	**L**
5. Random sampling error	H	M	**M**	• Survey invitations issued to the population of medium to large organisations of select industry categories deemed likely to have: ubiquitous information technology and an Internal Audit function.	L	L	**L**
6. Data-processing error	H	M	**M**	• Data-processing procedures include processing self-verification checks; and • Independent review of work performed.	L	L	**L**

Table 6.1, Survey Risk Register

Two mitigation strategies pertaining to Risk 1 in this register are discussed in the subsequent sub-sections.

6.2.1 Survey participation incentivised

To incentivise survey participation, targeted prospective survey participants were offered an *individualised audit benchmarking report* at no cost. Each individualised report benchmarked the particular participant against the survey population in respect of aspects around information systems audit resources and Information Technology Architecture intricacy and stability. These reports were prepared from survey data collected from this study and were provided to participants '*as is*', without warranty of any kind.

6.2.2 Low survey participation contingency

As a contingency in the event of low survey participation, the survey dataset would be supplemented with a case study dataset derived from real-world information systems audits undertaken by a second-tier accounting firm. This particular firm has permitted the use of client data on the understanding that client confidentiality would be maintained.

6.3 Sourcing listings of prospective survey participants

The process of sourcing listings of prospective survey participants entailed engaging in discussions with pertinent organisations, and exploring the viability of free and paid informational databases.

The outcome of each potential source is discussed in the following sub-sections.

6.3.1 Accounting firms in Australia

As part of their suite of business services, accounting firms conduct information systems audits in support of their financial statement audit engagements. These information systems audits are conducted on a needs basis, depending on the intricacy and pervasiveness of the client's relevant financial information systems as prescribed by the relevant auditing standards and by the particular accounting firm's audit methodology.

Separate discussions were initiated with two accounting firms, a Big 4 accounting firm and a second-tier accounting firm, to explore the possibility of entering into a research partnership arrangement. Overviews of these discussions are included below.

- *Big 4 accounting firm*

  From discussions with a Big 4 accounting firm it was understood that resources were not readily available within the firm to collate the specific information required. It was further understood that raw data pertaining to surveys run by the firm were collected on the basis that these would be kept confidential and as such would not be available to any external parties.

- *Second-tier accounting firm*

  From discussions with a second-tier accounting firm it was understood that around 30 information systems audit clients had ubiquitous information technology, and hence too few cases for statistically-reliable regression analysis. However, the firm agreed to avail working papers pertaining to these audits in the event of low survey participation (refer Sub-Section 6.2.2, p. 72).

6.3.2 Australian state government audit offices

Research opportunities were explored with the *Australasian Council of Auditor-Generals*. This Council represents member state and national *government audit offices* across Australia, Fiji, New Zealand, and Papua New Guinea; and its primary function is to facilitate information sharing between members. These audit offices are primarily responsible for conducting annual financial statement audits and performance audits of government organisations within their respective jurisdictions. In support of their financial statement audit engagements, audit offices conduct information systems audits for a significant portion of their respective clients, in-line with the Australian Auditing Standards and their respective audit methodologies.

In exploring the possibility of entering into research sharing agreements with interested Council members within Australia, it was understood that while some members expressed an interest, these members did not have available resources to collate the required data, and hence were unable to enter into an agreement.

6.3.3 International professional auditing bodies

The *Institute of Internal Auditors* and the *Information Systems Audit and Control Association* (both international professional auditing bodies) were approached. The Information Systems Audit and Controls Association was able to assist by publishing a page dedicated solely to this research project on its member's website. The project's web page invited suitable readers to participate in this research survey. As anticipated, this page did not yield any survey participants.

6.3.4 Social media

An article was published on *LinkedIn* that invited suitable readers to participate in this research survey. This article was shared on *Facebook* and *Twitter*. Unfortunately, this article did not yield any survey participants despite some community engagement.

6.3.5 Informational databases

From an evaluation of free and subscription informational databases, *Morningstar DatAnalysis* and the Australian government organisation listings were identified as suitable sources of prospective survey participants.

6.4 Survey management

The previous section described the process of sourcing lists of prospective survey participants. This section details the processes undertaken to select potential survey participants, and to develop survey questions.

6.4.1 Selecting prospective survey participants

Given the limited allocated research budget, it was determined that a maximum of 900 prospective survey participants could be approached. This sub-section outlines the processes undertaken to derive a list of 876 prospective survey participants from the selected informational databases (refer Sub-Section 6.3.5, above).

- *Corporations listed on the Australian Stock Exchange*

  A dataset comprising of 2,087 corporations listed on the Australian Stock Exchange was extracted from the Morningstar DatAnalysis. Given the budgetary constraints outlined above, this dataset was filtered to remove the following corporations:

  - Corporations identified as subsidiaries of parent corporations, due to the potential for duplication in respect of prospective survey participation

  - Corporations listed in the last three years, as these will be in various stages of information technology investment and maturity; and

  - Corporations unlikely to have ubiquitous information technology, such as corporations linked to commodity stock exchange indices (for example, the mining index), exchange-traded funds, investment funds or trusts, and real estate investment trusts.

- *Australian government organisations*

  Australian federal, state, and local government organisation lists were also filtered to remove organisation sub-entities due to the potential for duplication in respect of prospective survey participation.

6.4.2 Questionnaire design considerations

Two distinct survey questionnaire instruments were developed as follows:

- *Information systems audit questionnaire survey instrument*

  Intended to be completed by senior information systems audit personnel within participating organisations, this survey captured data pertaining to:

  - Hypothesis variables: mKNOW; REPORTED; and TASKCOMPLEX; and
  - Control variable: INDUSTRY.

- *Information technology environment questionnaire survey instrument*

  This survey was intended to be completed by key information technology personnel within the participating organisations. This instrument captured data pertaining to:

  - Hypothesis variables: ASSESSRISK; CHANGE; DEPEND; DIVERSE; and QUANTITY; and
  - Control variable: SIZE.

In designing these instruments, the following considerations and procedures were undertaken:

- *Inclusion of survey question explanatory notes*

  Survey questions were accompanied with brief explanatory notes that provided examples and clarification statements.

- *Inclusion of red herring and consistency check questions*

  A number of red herring and consistency check questions were included as part of the questionnaire survey.

- *Independent review*

  Survey design and question validity was independently and critically reviewed by an expert with extensive experience in developing successful self-administered questionnaire surveys.

- *Survey pilot*

  To address the risk of common method bias, the instruments were piloted by three experienced audit and risk managers to verify that survey questions were easily understood, readable, relevant, and logically sequenced.

6.4.3 Ethical considerations

Ethical considerations relevant to this study are discussed below.

- *Participant informed consent*

  Invitation letters included a comprehensive *Survey Participation Information* sheet that covered the details listed below. Interested parties were required to complete and sign an enclosed *Survey Participation Form*.

  - Participation benefits and risks
  - Extent of participation
  - Data privacy and confidentiality; and
  - Complaints handling procedures.

- *Data privacy*

  No personal data (as defined under the *Australian Privacy Principles*) or organisationally sensitive data was required for the purposes of this study. The survey data collected related to non-specific metrics pertaining to the participant's information systems audits and their information technology environment. The questionnaire surveys could not however be anonymous for the following two reasons:

- Respondent contact details were required for the purposes of forwarding the individualised audit benchmarking reports to the respective respondents (refer Sub-Section 6.2.1, p. 72); and

- Respondent's organisation name was required to merge the information systems audits survey data file with the information technology environment survey data file.

- *Research involving human participation*

  Given human participation in this study ethical approval was sought from the University's *Human Research Ethics Committee* to ensure adherence with the *Australian Code for the Responsible Conduct of Research*, the *National Statement on Ethical Conduct in Human Research*, and with the University's *Code of Conduct in Research Policy and Procedure*.

6.5 Survey outcome

This section covers the outcome of the questionnaire surveys, the research contingencies activated, and data integrity and response quality checks performed.

6.5.1 Response and completion rates

Both the information systems audit and information technology environment surveys were open for a period of nine months from the 2nd of February through to the 31st of October 2015. This unusually long period was to allow the social media article (refer p. 74) to gain good exposure across the selected social media channels.

From a total of 876 prospective survey participants, 32 organisations agreed to participate, of which 30 completed both survey instruments accordingly. The survey response and completion rates are discussed below.

- *Survey response rate*

  The achieved response rate of 3.42% is below the anticipated conservative response rate of around 7%, and well below the suggested response rates of around 10 to 25% generally exhibited by online surveys (Pedersen & Nielsen 2014; Sauermann & Roach 2013).

  This poor survey response performance is attributed primarily to 34 organisations who declined to participate due to internal resource constraints.

  Given the low response rate, the contingency plan was activated as outlined in Section 6.2 (p. 70). The activation of this plan is detailed later in Sub-Section 6.5.3.

- *Survey completion rate*

  A high survey completion rate of 93.75% was achieved. This is attributed primarily to the continual follow-up of survey participants.

6.5.2 Non-response bias

46.7% of respondents were found to belong to the government and education industry sector (refer Table 6.2, p. 80). However, whilst this would ordinarily raise non-response bias concerns, the dataset is yet to be supplemented with data collected from real-world audits (refer sub-section above). Section 7.2 (p. 83) provides an industry representation analysis over the combined survey and case study dataset.

6.5.3 Activation of contingency plan

Given the low survey response rate (refer p. 78), the contingency plan to supplement the survey dataset with case study data derived from real-world information systems audits was activated (refer Sub-Section 6.2.2, p. 72).

The supplementary dataset comprising 21 cases, was derived from audit and client source documents pertaining to information systems audits undertaken by a second-tier accounting firm over the period between 2012 and 2014. The researcher verified that no duplication existed between the survey and supplementary cases.

Industry	*Survey*	*Percentage*
Automotive	1	3.3%
Banking	1	3.3%
Consumer durables & apparel	-	0.0%
Diversified financials	1	3.3%
Financial services	-	0.0%
Food, beverage & tobacco	2	6.7%
Government, State / Federal	2	6.7%
Government, Local Council	7	23.3%
Industrial	-	0.0%
Materials	1	3.3%
Miscellaneous	-	0.0%
Pharmaceuticals & biotechnology	2	6.7%
Real estate	1	3.3%
Retail	2	6.7%
Software & services	1	3.3%
Technology hardware & equipment	1	3.3%
Telecommunications	1	3.3%
University	5	16.7%
Public utility	2	6.7%

Table 6.2, Survey non-response bias

The audit and client source documents included:

- Information systems audit budgeting records, and audit working papers and review notes

- Client provided network diagrams, organisational charts, data-flow diagrams between business-critical systems, application registers, disaster recovery plans, and populations of change requests and incidents in the preceding twelve months; and

- Management Letters issued and Management responses received.

Consistent with the questionnaire survey, these information systems audits (or *case studies*) represented a mixture of medium and large listed and privately held organisations in Australia where information technology is ubiquitous.

The researcher completed the same two survey questionnaires as completed by the survey participants, for each of the 21 case studies, the data for which was derived from the set of information systems audit and client documents for each case study. The researcher provided survey questionnaire responses objectively and responses are supported by the case study documentation reviewed.

6.5.4 Raw dataset integrity and response quality

To address the risk exposure to dataset integrity and quality issues, the following checks were undertaken:

- *Data integrity checks*

  These checks were performed on the survey dataset to detect and correct any data input, processing, or other errors, that may have been inadvertently generated by the respondents or the online survey system.

- *Response quality checks*

  These checks were performed to detect potential response inconsistencies or anomalies based on the researcher's industry experience (refer p. 4). Response inconsistencies were detected via an analysis of the red herring and consistency check questions included in the survey (refer Sub-Section 6.4.2, p. 76). Potential response inconsistencies and anomalies identified were queried with the respective respondents, often resulting in response corrections in the survey data file.

- *Survey commencement and completion date-time stamp logs analysis*

  This analysis was performed to identify any respondents who sped through the survey questions suggesting poor response quality; no survey ‘speeders’ were identified.

6.5.5 Research dataset

From the combined survey and case study datasets of 51 cases, a research dataset that included all the hypothesis and control variables was prepared in line with the variable measurement approaches detailed in Chapter 5 (p. 53).

CHAPTER 7 Descriptive Statistics

The previous chapter described the methodology approach adopted, and detailed the processes undertaken to collect the required datasets for the purposes of hypothesis testing. This chapter analyses the equality between survey and case study datasets, and examines the combined dataset in respect of industry representation and descriptive statistics.

7.1 Equality of dataset groups

As discussed in Sub-Section 6.5.3 (p. 79), a contingency plan was activated to supplement the survey dataset with case study data derived from real-world information systems audits. The survey and case study datasets comprise 30 and 21 cases, respectively. As expected, the standard deviations for case study cases were generally lower than those for survey cases (refer Appendix A, Exhibit A-4 and Exhibit A-5, pp. 108 and 109) as case study data is generally more accurate and not subject to recall bias (as is the case with survey data).

The variations in mean and median values between groups is attributed to size difference in information technology environments between the two samples. Specifically, survey cases have an average of 82 information technology personnel (iQITSTAFF) that manage an average of 3,953 end-user appliances (iQENDUSR), while case study cases have averages of 29 and 592 respectively.

7.2 Industry representation analysis

Effective detailed analysis for ‘industry representation’ bias in the combined dataset cannot be performed due to the limited number of cases (51). *However*, from a review of industry classifications (refer Appendix A, Exhibit A-1, p. 99), it was observed that 17% of cases pertain to the banking and financial services sectors. It is reasonable to expect that this group will have more intricate Information Technology Infrastructures relative to other sectors. Given the size of the dataset, the impact of this group on the regression results cannot be reliably determined.

7.3 Distribution outliers, modality, skewness and kurtosis

No modality issues were not detected; however, data outliers were identified across all distributions (refer Appendix A, Exhibit A-2, p. 100). Distributions were found to be highly positively skewed, with the skewness statistic ranging between 1.018 to 6.994 (refer Appendix A, Exhibit A-2 and Exhibit A-3, pp. 100 and 107, respectively). Variable DEPEND, and indicators iDBESPOK, iQBESPOK, and iQSERVER were found to be the most skewed. A mixture of negative and positive excess kurtosis was also found, with the kurtosis statistic ranging between -0.196 to 49.533. In terms of the extreme ends of the kurtosis spectrum, variable DEPEND and indicators iDBESPOK, iQBESPOK, iQENDUSR, iQNETDEV, and iQSERVER were found to be highly leptokurtic, while variables mKNOW and CHANGE, and indicator iDSERVER were found to be platykurtic.

Given the dataset issues described above, Partial Least Squares path modelling was used for hypothesis analysis as this is best suited for non-normal datasets. For the purposes of this analysis, SmartPLS (version 3) is used that requires the input of raw data (Garson 2016, p. 40) as datasets are automatically standardised with built-in algorithms.

CHAPTER 8 Results and Analysis

Chapter 6 described the research methodology and detailed the processes undertaken to collect the required datasets for hypothesis testing, while Chapter 7 provided descriptive statistics over the obtained datasets. This chapter outlines the regression procedures undertaken, and discusses and interprets the results from hypothesis regression testing. The results and analysis presented in this chapter are based on the combined survey and case study dataset which represents the full population of 51 cases.

8.1 Partial Least Squares path modelling

Given the presence of latent variables (refer Section 5.2, p. 55), the sample size (51 cases, refer Sub-Section 6.5.5, p. 82), and the non-normal data (refer Section 7.3, p. 84), Partial Least Squares path modelling is used for hypothesis regression analysis as this is best suited (Garson 2016, pp. 8 - 9; Hair Jr, Ringle & Sarstedt 2013; Marcoulides & Saunders 2006).

The following sub-sections provide an overview of Partial Least Squares algorithm and bootstrap settings, and model reliability and validity testing procedures undertaken. The reporting format in respect of these procedures is in line with generally accepted guidelines (Hair Jr, Ringle & Sarstedt 2013).

8.1.1 Partial Least Squares algorithm settings

SmartPLS (version 3.2.6) (Ringle, Wende & Becker 2015) was used for regression, bootstrapping, and reporting. The default algorithm and bootstrap settings were accepted and no weighting vector was used (refer Appendix A, Exhibit A-6, p. 110) (in SmartPLS, the *weighting vector* is a weighting per case to ensure the representatives of a sample with respect to the underlying population).

8.1.2 Path modelling procedures

The following procedures were performed:

- *Indicator loadings*

  In line with generally accepted guidelines (Hair Jr, Ringle & Sarstedt 2013), indicators with loadings below 0.40 were dropped, while those with loadings in the range of 0.40 to 0.70 were only dropped if *Composite Reliability* was improved. Indicators iDOPSYST, iDNETDEV, iDENDUSR, iDIDSYST, iQMODULE, iQSERVER, and iQNETDEV were dropped as a result of this process (refer Appendix A, Exhibit A-7, p. 111).

- *Multicollinearity*

  As anticipated (refer Sub-Section 5.8.2, p. 63) QUANTITY indicators iQBESPOK and iQOFFSHF had to be dropped as these presented significant multicollinearity issues with DIVERSITY indicators iDBESPOK and iDOFFSHF. In reviewing the descriptive statistics (refer Appendix A, Exhibit A-3, p. 107), it can be seen that these indicator pairs share the same data characteristics, and therefore represent the same Information Technology Infrastructure characteristics.

- *Discriminant validity*

  Discriminant validity ensures that a construct measure is empirically unique and as such requires that “a test not correlate too highly with measures from which it is supposed to differ” (Campbell 1960).

  Variable DEPEND presented a discriminant validity issue with variable DIVERSE. To eliminate this issue, DEPEND was moved under DIVERSE as indicator iDEPEND.

  Note: Hypothesis testing procedures in Section 8.2 were also performed with variable DEPEND dropped, with *negligible* impact on regression results.

8.1.3 Moderator mKNOW

The moderating effects of mKNOW in respect of hypotheses $H3_b$ and $H4_b$ could not be tested reliably due to the dataset size (51 cases, refer Sub-Section 6.5.5, p. 82). Specifically, if the full dataset were split into two or more sub-datasets to test the moderating effects of mKNOW, then each sub-dataset would comprise 25 or less cases (refer Figure 8.1 and Figure 8.2, below). Regression testing over such small datasets is not generally considered statistically reliable (Marcoulides & Saunders 2006).

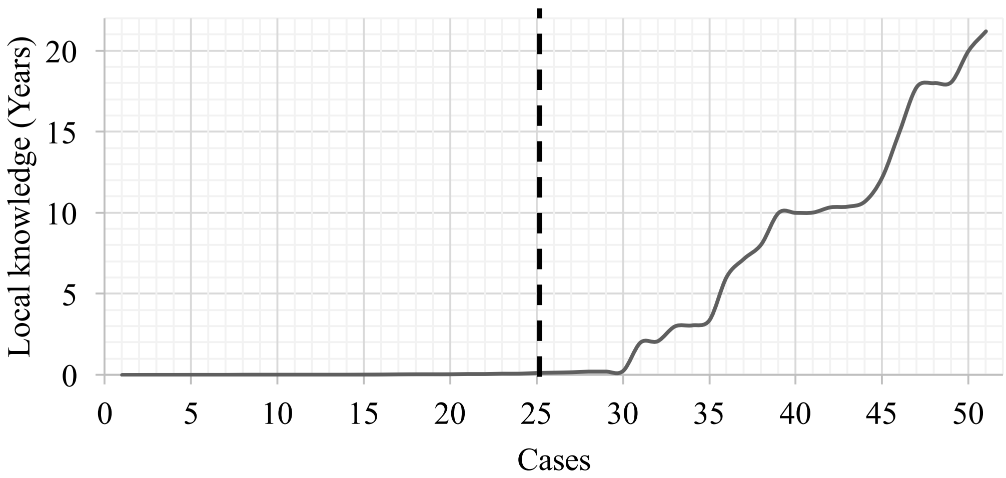


Figure 8.1, mKNOW variable – population split in to two

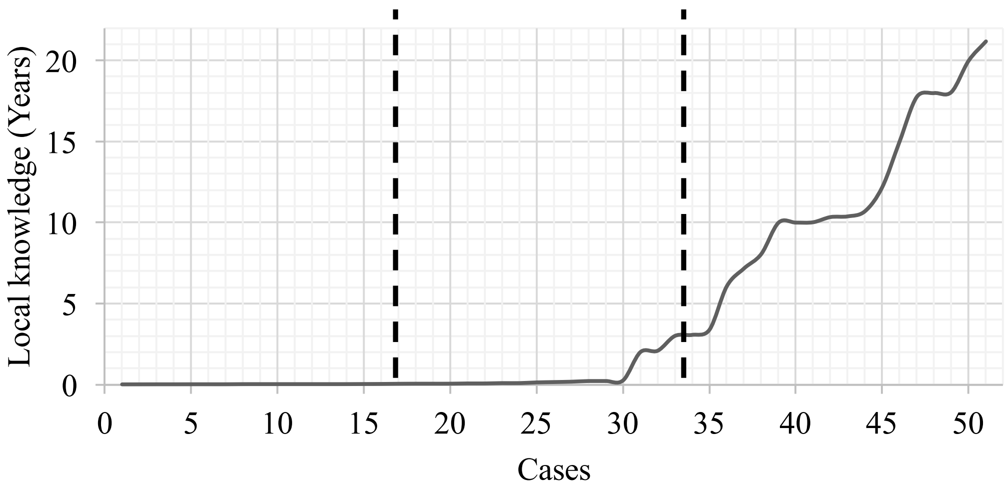


Figure 8.2, mKNOW variable – population split in to three

8.1.4 Model reliability and validity

To ensure reliability and validity of the Partial Least Squares model, the following tests were performed in line with generally accepted guidelines (Garson 2016, pp. 63 - 72; Hair Jr, Ringle & Sarstedt 2013). Specifically, the Partial Least Squares model satisfied the following tests:

- Average Variance Extracted values equal to, or greater than, 0.50 (refer to Appendix A, Exhibit A-7, p. 111)

- Cronbach's Alpha values equal to, or greater than, 0.70 (refer to Appendix A, Exhibit A-7, p. 111)

- Cross-loading values equal to, or lower than, 0.40 for indictors not meant to be measured (refer Appendix A, Exhibit A-8, p. 112)

- *Heterotrait-Monotrait Ratio* values equal to, or lower than, 0.90 (refer to Appendix A, Exhibit A-9, p. 113); and

- Internal *Variance Inflation Factor* values equal to, or lower than, 4.0 (refer to Appendix A, Exhibit A-10, p. 113).

8.2 Results and their interpretation

The results (summarised in Table 8.1, below) provided partial support for hypotheses H2 (refer Sub-Section 4.2.1, p. 45) and $H3_a$ (refer Sub-Section 4.3.1, p. 47). The results however did not support hypotheses H1 and $H4_a$ (refer Sections 4.1 and 4.4, pp. 41 and 49 respectively). These results are discussed in the following sub-sections, while the path diagram is included in Appendix B, Exhibit B-1, p. 115.

Dependent Variables (N=51)	*Independent variables*		
	ASSESSRISK	*REPORTED*	*TASKCOMPLEX*
ASSESSRISK		H4: 0.01 (0.95)	
CHANGE	H2: -0.09 (0.66)	H3: -0.12 (0.46)	H1: 0.12 (0.56)
DIVERSE	H2: **0.57 (0.01)**	H3: 0.01 (0.94)	H1: 0.31 (0.23)
QUANTITY	H2: 0.07 (0.66)	H3: **0.77 (0.00)**	H1: 0.30 (0.20)

Results shown: path coefficient β (p-value based on two-tailed test)

Table 8.1, Partial Least Squares results (total)

8.2.1 H2 (Risk of Material Systems Failure)

The results for H2 ($\beta = 0.57$, $p < 0.01$, $R^2 = 0.31$) suggest that the inter-dependencies and diversity (DIVERSE, includes iDEPEND) between information technology parts *alone* are moderately associated (+ve) with the extent of the assessment of the Risk of Material Systems Failure (ASSESSRISK):

$$ASSESSRISK_t : \int DEPEND_{t-1} \, ; DIVERSE_{t-1}$$

The absence of an association between CHANGE and ASSESSRISK could be attributed to information technology governance over the Change Management process (refer Section 5.4, p. 57). It is suggested that information technology governance processes tend to lower the Risk of Material Systems Failure.

As QUANTITY also represents the effects of size (through iQITSTAFF), the absence of an association between QUANTITY and ASSESSRISK could be attributed to a general failure to record incidents in respect of human error within information technology environments (refer Sub-Section 4.2.1, p. 45).

8.2.2 $H3_a$ (Reported findings)

In respect of $H3_a$ ($\beta = 0.77$, $p < 0.01$, $R^2 = 0.50$) the results suggest that the quantity of information technology parts (QUANTITY) *alone* is moderately associated (+ve) with the extent of information systems audit findings reported to Management (REPORTING):

$$REPORTED_t : \int QUANTITY_{t-1}$$

Given the absence of an association between DIVERSE and REPORTING, and given that QUANTITY also represents the effects of size, the association between QUANTITY and REPORTING suggests that generally a significant proportion of findings reported to Management relate to human process failures within the information technology environment.

In line with the explanation provided for H2 above, the absence of an association between CHANGE and REPORTING could also be attributed to generally robust governance over Change Management processes.

8.2.3 H1 (Information technology environment)

The absence of associations between the independent variables and TASKCOMPLEX was unexpected and is attributable to the use of audit labour hours to measure TASKCOMPLEX (refer Sub-Section 5.11, p. 62) for the following measurement limitations:

- Measurement is incomplete as the data pertaining to external auditors cannot be readily obtained; and
- Measurement is affected by the following factors:
  - Audit labour hour differences between audits conducted by internal auditors and consultants
  - Limited internal audit budgets, management push-back over planned audits, and the extent of involvement by the External Auditor, that will impact coverage over the internal information systems audit universe and restrict audit scope thereof; and
  - The extent to which internal audit programs are standardised.

8.2.4 $H4_a$ (Management of Systems Audit Risk)

The outcome for $H4_a$ is not surprising given the apparent conflict between the findings for H2 and $H3_a$ (former driven by the inter-dependencies and diversity between information technology parts, whereas the latter driven by the human element within information technology environments).

This result suggests that the extent of audit findings reported to Management are not correlated with the extent of the Risk of Material Systems Failure, which is attributable to:

- Possible information systems audit quality and audit coverage issues; and / or
- Management pressure to drop or water-down audit finding risk ratings.

8.2.5 Result differences between survey and case study datasets

Separate regression analysis was also performed over the survey and case study datasets (refer Appendix B, Exhibit B-2 and Exhibit B-3, p. 116). As expected, due to dataset size contributing to less than reliable statistical results, the results from each dataset were not significant, with one exception - the survey dataset provided support for $H3_a$ ($\beta = 0.72$, $p < 0.02$) in line with the main results in the combined dataset above.

CHAPTER 9 Conclusion

9.1 Overview

Leveraging Human Information Processing, Task Complexity, and Relational Complexity theoretical frameworks, the primary aim of this work was to determine empirically, in the context of information systems audit, if Task Complexity and Audit Risk are associated with Information Technology Architecture intricacy and stability. The central hypotheses are that Task Complexity and Audit Risk are each associated with Information Technology Architecture intricacy and stability.

Generally conducted in medium and large organisations where information technology is generally ubiquitous, information systems audits serve to determine the quality, reliability, security, continuity, effectiveness and efficiency of systems data input, processing, storage and output sub-systems (ISACA 2013; Rainer & Cagielski 2011; Ramamoorti & Weidenmier 2004).

Given the increasing pace of technological advancements, it is reasonable to suggest an inevitable renewed interest in Audit Task Complexity and Audit Risk research. There is no doubt that information technology has transformed how organisations conduct their activities (Han et al. 2016). The intricacy and continual change of leading information technology in a number of organisations today can present a challenge to even the most experienced information systems auditors. Whilst improving operational and internal control effectiveness and efficiency, technology progress tends to introduce new and unconventional organisational risk exposures, and thus creates new "challenges for auditors when auditing the effectiveness of internal controls" (Han et al. 2016). In this regard therefore, research around Audit Task Complexity and its relationship with human performance would be indispensable (Liu & Li 2012).

The body of Task Complexity research in auditing covers a paucity of eighteen studies (refer Table 2 1, p. 22), none of which examine Audit Task Complexity or Audit Risk in the context of Information Technology Architecture intricacy and stability. It is suggested that this literature limitation is due in part to the absence of an integrative Task Complexity framework (Bonner 1994). *However*, it would be reasonable to also suggest other contributing factors, such as the absence of archival data, and difficulties in obtaining auditor client data.

Departing from experimental methods generally adopted in relevant extant research, this study adopted survey-based and case study research methods to test the hypotheses with real-world data collected from medium to large Australian organisations. Senior information systems auditors and key information technology personnel pertaining to 30 participating organisations, each completed self-administered questionnaire survey instruments. The researcher completed the same survey questionnaire instruments for 21 additional case studies, the data for which was derived from information systems audit working papers obtained from a second-tier accounting firm.

9.2 Contribution to academic literature

This study tackles a novel research question using traditional survey methods and quantitative data analysis. Despite the limited results obtained, there is an opportunity to make the following contributions to academic literature:

- An adaption of the Audit Risk Model to overcome its shortcomings, resulting in the development of the Systems Audit Risk Model; and
- The results from the Partial Least Squares path modelling suggests that:
    - The inter-dependencies and diversity between information technology parts are positively associated with the extent of the assessment of the Risk of Material Systems Failure; and
    - The quantity of information technology parts is positively associated with the extent of information systems audit findings reported to Management.

9.3 Audit industry implications

In addition to addressing the identified knowledge gap, this research also contributes to the information systems audit profession's body of knowledge. This study provides practitioners with an understanding of the elements within Information Technology Architectures that are associated with Audit Task Complexity and Audit Risk. This knowledge will help practitioners further reduce Audit Risk by:

- Adjusting systems audit planning cycles accordingly
- Allocating auditors to engagements appropriately; and
- Developing better targeted systems audit programs.

From the interpretation of results (refer Section 8.2, p. 88), it may be beneficial for information systems audit practitioners to be aware that generally:

- Systems Audit Risk may not be effectively managed due to less than adequate auditor expertise, audit resource constraints, and or Management pressure to drop or water-down audit finding risk ratings

- The quantity of information technology parts drives the extent of information systems audit findings reported to Management

- The extent of inter-dependencies and diversity between information technology parts drives the extent of the Risk of Material Systems Failure

- A proportion of audit effort around Change Management processes may be better redirected to other information technology processes, such as Incident Management where the recording of information technology incidents attributable to human error may be significantly less than complete; and

- A significant proportion of information systems audit findings reported to Management focus on human process failures.

9.4 Research limitations

Data availability and reliability issues limited the accurate measurement of a number of variables; these issues are listed below:

- ASSESSRISK (refer Section 5.3, p. 55) is affected by the maturity of the internal control structure, the extent of preventative measures and continuous controls monitoring implemented, and the effectiveness of the internal audit function.
- CHANGE (refer Section 5.4, p. 57) is affected by the extent of the impact and risk exposure change requests may have on the information technology environment, and on the required levels of technical expertise and resources for these changes.
- mKNOW (refer Section 5.7, p. 61) and TASKCOMPLEX (refer Section 5.10, p. 65) are incomplete as the data pertaining to *external* auditors cannot be readily obtained.
- TASKCOMPLEX is also affected by audit labour hour differences between audits conducted by internal auditors and consultants, limited internal audit budgets, management push-back over planned audits, and the extent of audits conducted by the External Auditor, and the extent to which internal audit programs are standardised.
- REPORTED (refer Section 5.9, p. 64) is measured by the number of reported findings to Management which is affected by the consistency of risk ratings given to reported findings, the extent of finding-bundling in reported findings, and Management pressure over the extent of findings that get reported and over the risk ratings given to reported findings.

9.5 Further research opportunities

While stimulating further research in Audit Task Complexity and Audit Risk around information systems audit, this study can be further improved. For example, it is suggested that in-depth case studies can be undertaken with a view to improving the models and measurement of variables presented in this study.

Further, as articulated in Sub-Section 2.8.1 (p. 31), no extent research has been conducted to explore Task Complexity in auditing from an Audit and Risk Committee perspective. Answers to the following questions would invariably be of particular interest to Chief Audit Executives:

- Does an association exist between Audit and Risk Committee confidence and information systems audit Task Complexity?
- If such an association exists, how do the following factors impact this association:
    - Committee gender composition
    - Committee size composition; and
    - Timing of media reporting of security related issues.

APPENDIX A Descriptive Statistics

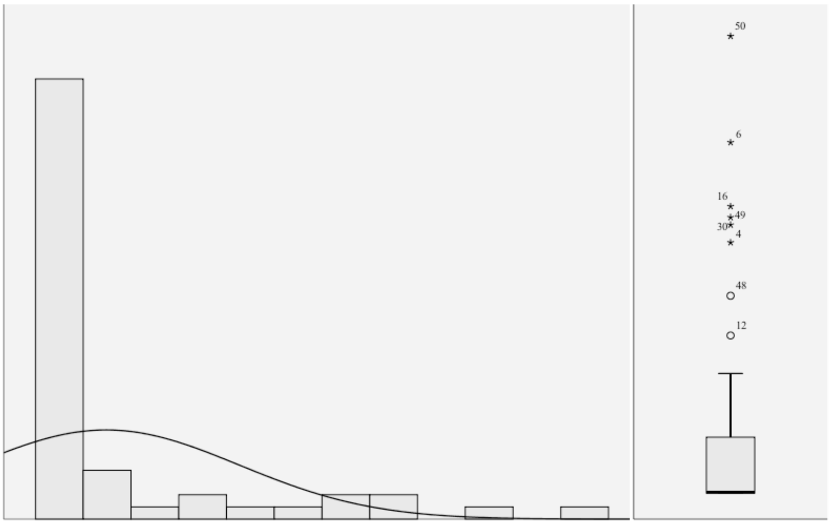
Exhibit A-1, Industry sector analysis

Industry sector	***Case studies***	***Survey***	***Total***	***Percentage***
Automotive	2	1	**3**	5.88%
Banking	1	1	**2**	3.92%
Consumer durables & apparel	1		**1**	1.96%
Diversified financials		1	**1**	1.96%
Financial services	7		**7**	13.73%
Food, beverage & tobacco		2	**2**	3.92%
Government, State / Federal		2	**2**	3.92%
Government, Local Council		7	**7**	13.73%
Industrial	1		**1**	1.96%
Materials		1	**1**	1.96%
Miscellaneous	1		**1**	1.96%
Pharmaceuticals & biotechnology		2	**2**	3.92%
Real estate		1	**1**	1.96%
Retail	4	2	**6**	11.76%
Software & services	1	1	**2**	3.92%
Technology hardware & equipment	1	1	**2**	3.92%
Telecommunications	1	1	**2**	3.92%
University	1	5	**6**	11.76%
Public utility		2	**2**	3.92%

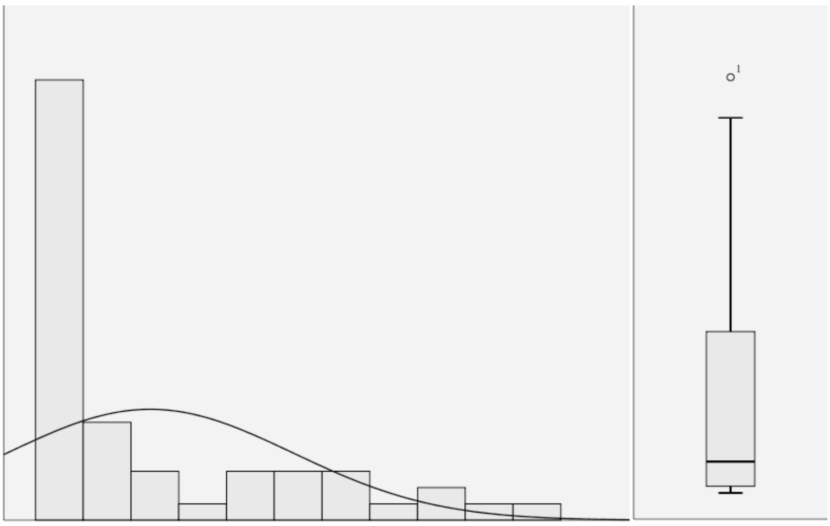
Exhibit A-2, Variable and indicator histograms and boxplots

ASSESSRISK

(Weighted)

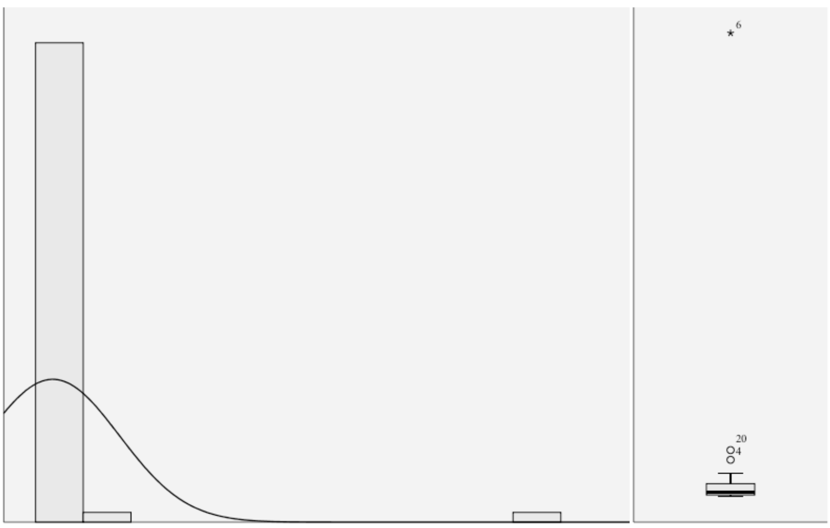


CHANGE



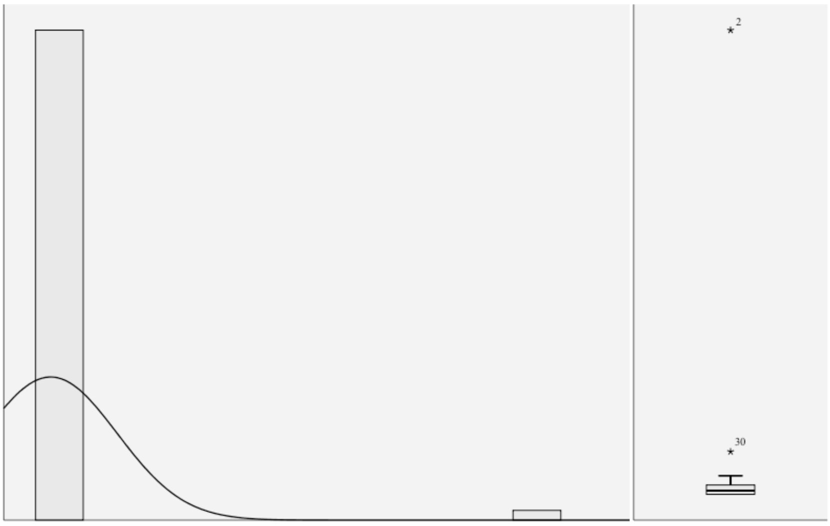
DEPEND

(inc. iDEPEND)

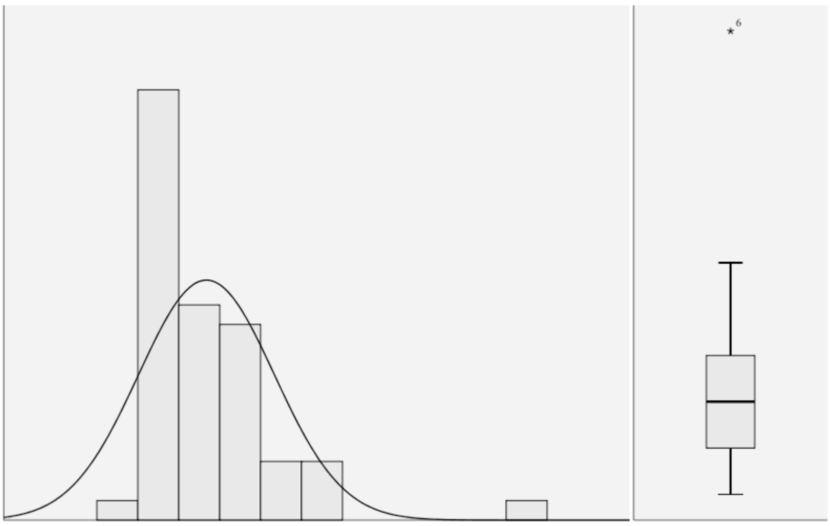


DIVERSE (latent variable indicators shown below)

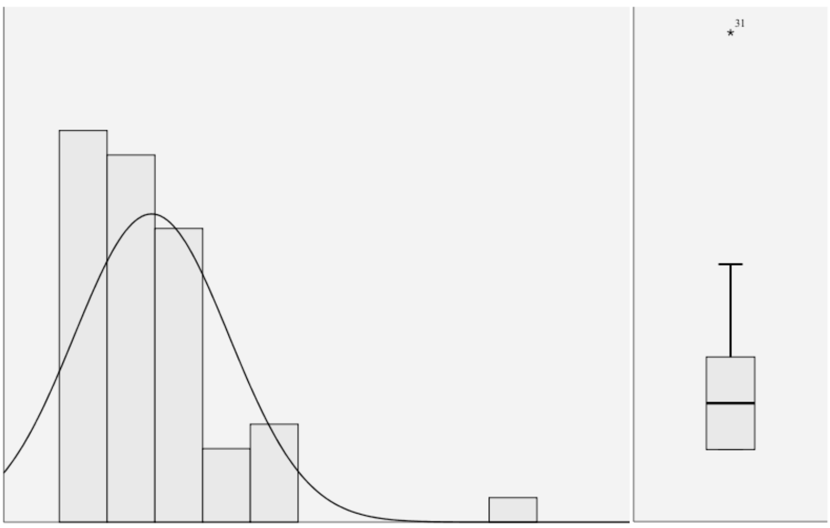
iDBESPOK



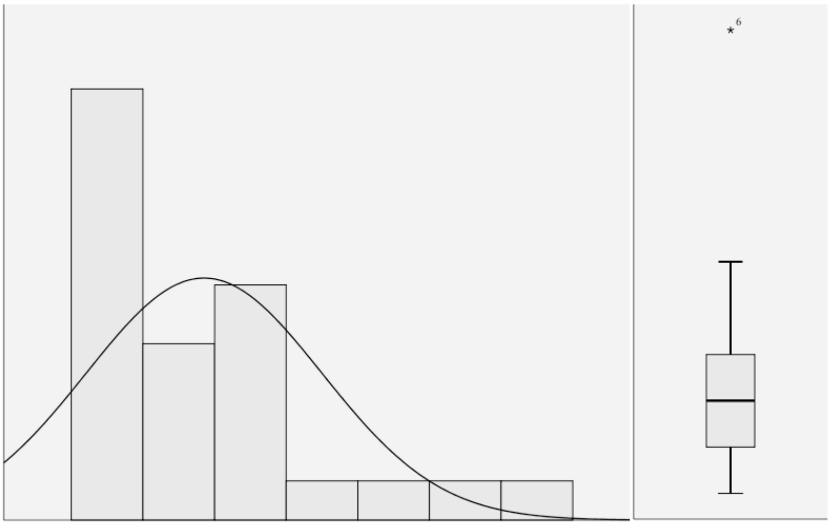
iDDBSYST



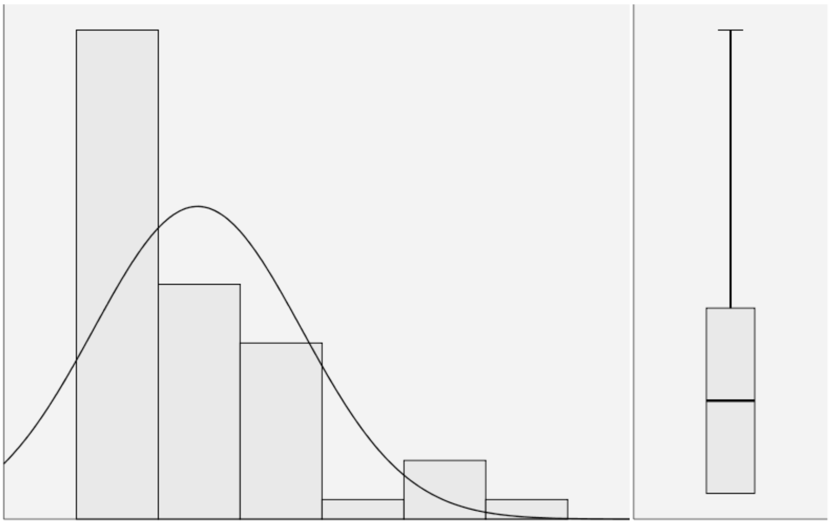
iDENDUSR



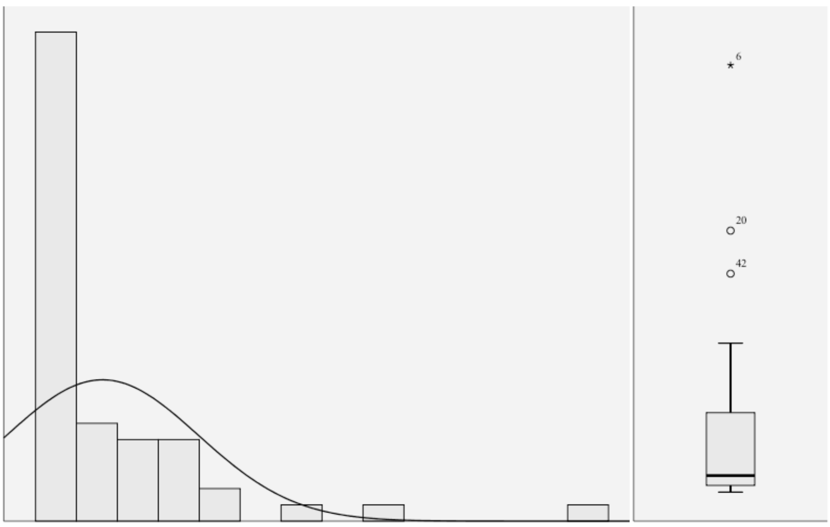
iDIDSYST



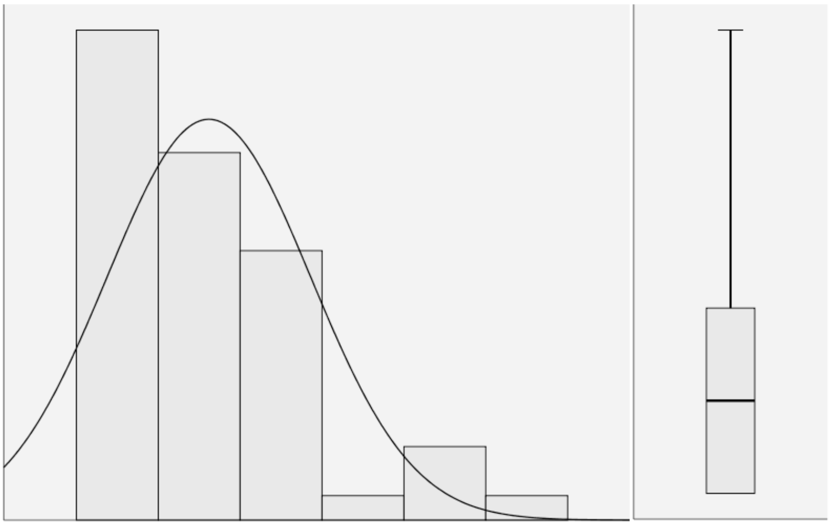
iDNETDEV



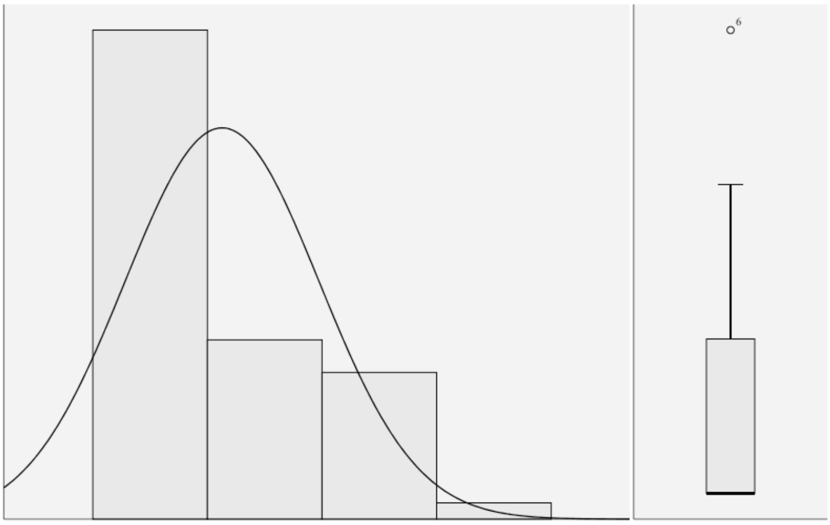
iDOFFSHF



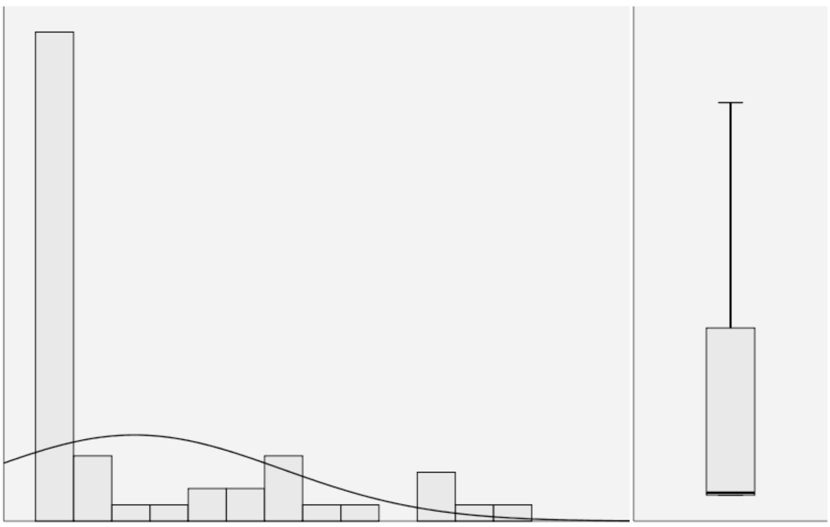
iDOPSYST



iDSERVER

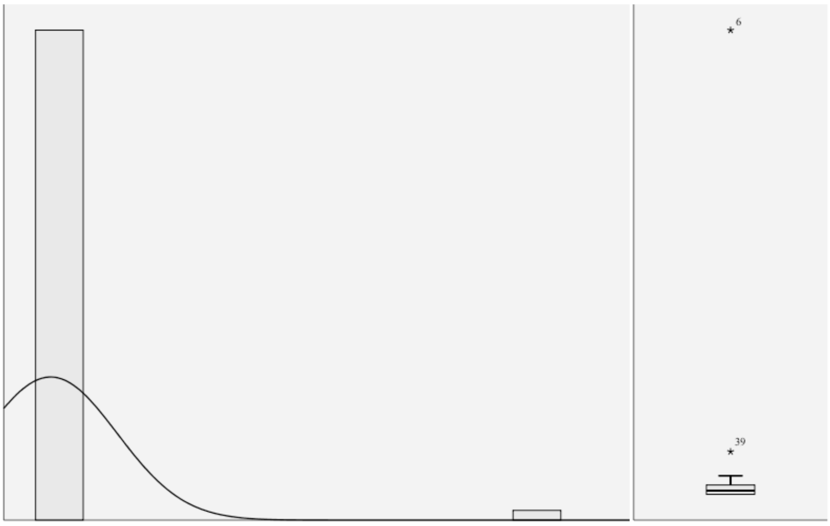


mKNOW

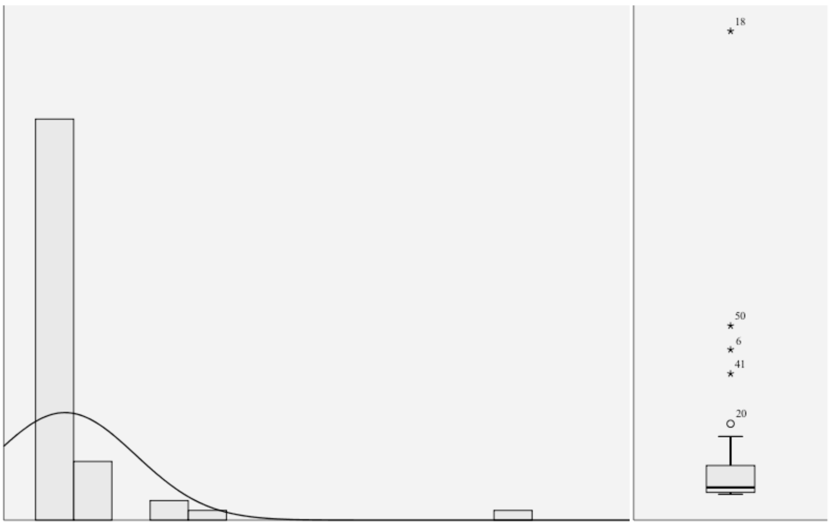


QUANTITY (latent variable indicators shown below)

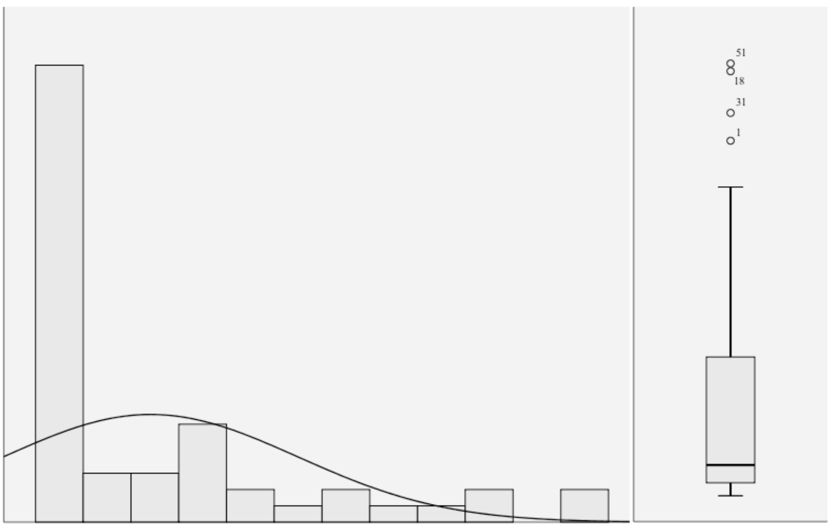
iQBESPOK



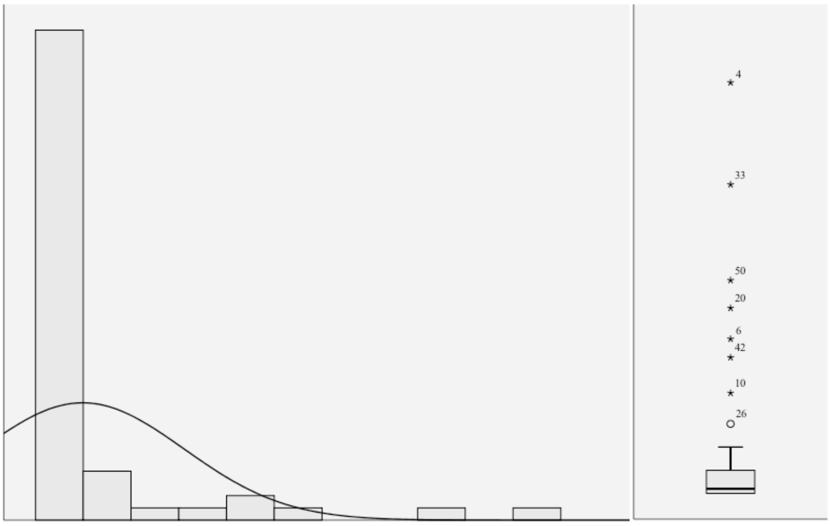
iQENDUSR



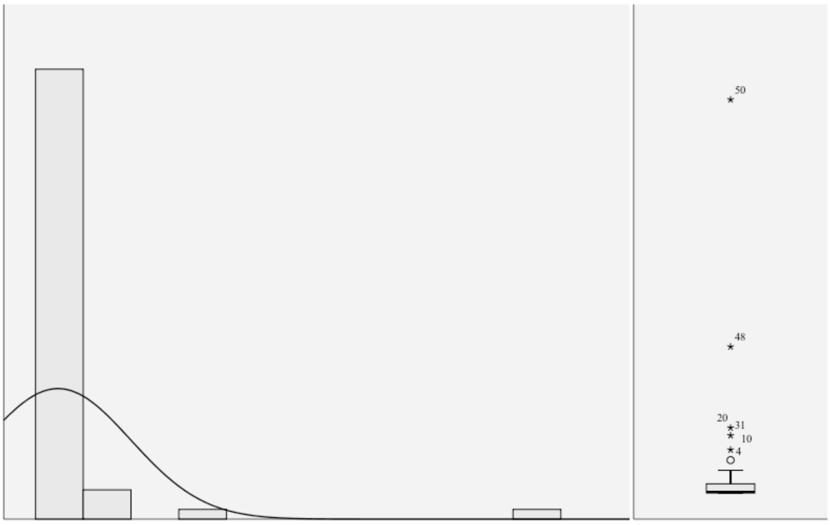
iQITSTAFF



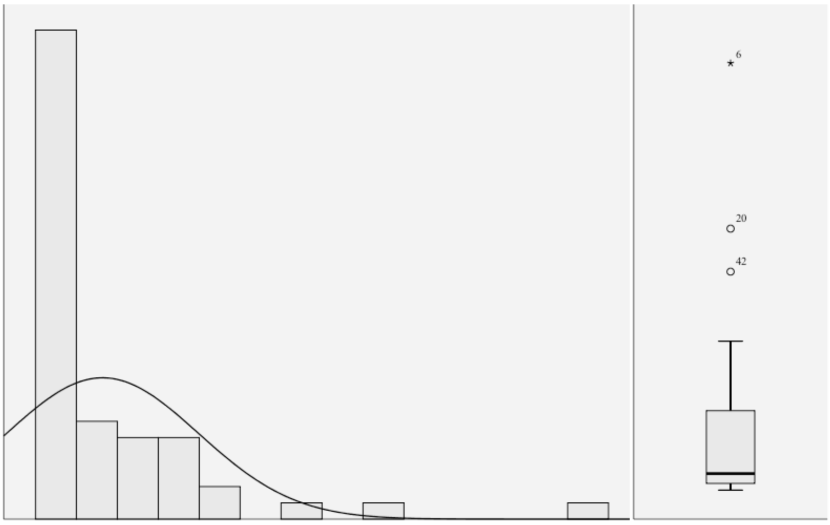
iQMODULE



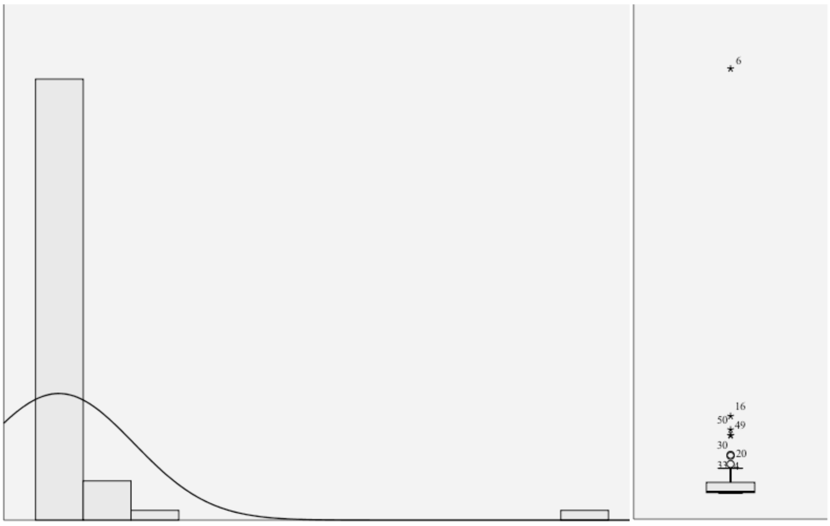
iQNETDEV



iQOFFSHF

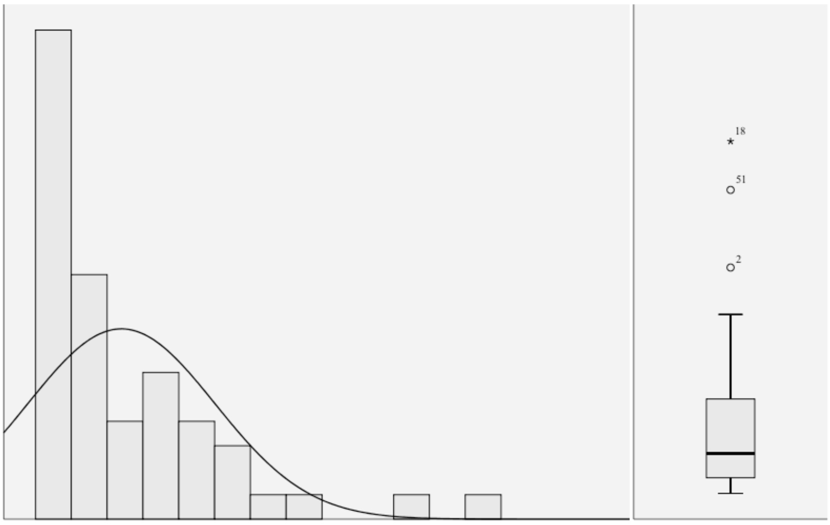


iQSERVER



REPORTED

(Weighted)



TASKCOMPLEX

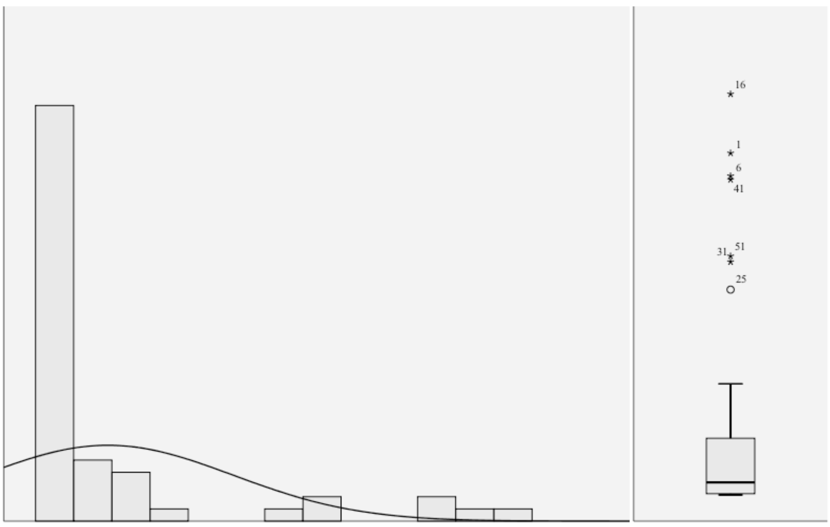


Exhibit A-3, Descriptive statistics (full population)

(W) *denotes weighted variable*

	No.	Missing	Mean	Median	Min	Max	Standard Deviation	Excess Kurtosis	Skewness
Case	1	0	26.000	26.000	1.000	51.000	14.720	-1.200	0.000
Source	2	0	1.412	1.000	1.000	2.000	0.492	-1.941	0.370
ASSESSRISK	3	0	13,639.020	250.000	3.000	105,312.000	26,088.605	3.515	2.102
ASSESSRISK(W)	4	0	14,784.980	300.000	4.000	118,435.000	27,613.404	3.939	2.122
CHANGE	5	0	1,600.353	552.000	10.000	7,200.000	1,974.955	0.622	1.313
DEPEND	6	0	36.196	9.000	0.000	1,000.000	137.906	48.527	6.892
iDOFFSHF	7	0	16.373	6.000	1.000	130.000	23.229	11.102	2.987
iDBESPOK	8	0	7.902	2.000	0.000	250.000	34.474	49.533	6.994
iDOPSYST	9	0	2.118	2.000	1.000	6.000	1.231	1.385	1.263
iDDBSYST	10	0	2.176	2.000	0.000	10.000	1.641	8.872	2.394
iDSERVER	11	0	1.627	1.000	1.000	4.000	0.839	-0.196	1.018
iDNETDEV	12	0	1.980	2.000	1.000	6.000	1.260	1.625	1.432
iDENDUSR	13	0	2.431	2.000	1.000	10.000	1.600	8.537	2.305
iDIDSYST	14	0	2.353	2.000	1.000	7.000	1.631	1.332	1.361
mKNOW	15	0	4.321	0.149	0.006	21.192	6.352	0.530	1.335
iQITSTAFF	16	0	60.255	20.000	0.000	280.000	76.340	1.609	1.578
iQOFFSHF	17	0	16.373	6.000	1.000	130.000	23.229	11.102	2.987
iQBESPOK	18	0	7.902	2.000	0.000	250.000	34.474	49.533	6.994
iQMODULE	19	0	24.686	3.000	0.000	266.000	52.572	9.988	3.073
iQSERVER	20	0	48.608	4.000	1.000	1,100.000	155.896	41.693	6.221
iQNETDEV	21	0	235.510	20.000	1.000	5,100.000	754.506	34.797	5.633
iQENDUSR	22	0	2,568.843	600.000	12.000	40,000.000	6,106.108	27.971	4.908
REPORTED	23	0	42.980	26.000	0.000	301.000	51.160	11.724	2.921
REPORTED(W)	24	0	59.941	34.500	0.000	304.000	64.705	4.101	1.904
TASKCOMPLEX	25	0	1,261.654	280.000	10.500	8,662.500	2,164.227	3.693	2.162

Exhibit A-4, Descriptive statistics (survey population)

***(W)** denotes weighted variable*

	No.	Missing	Mean	Median	Min	Max	Standard Deviation	Excess Kurtosis	Skewness
Case	1	0	25.600	30.000	2.000	51.000	15.662	-1.420	0.001
Source	2	0	1.000	1.000	1.000	1.000	0.000	�	�
ASSESSRISK	3	0	20,778.767	6,661.000	15.000	105,312.000	29,777.840	1.334	1.533
ASSESSRISK(W)	4	0	22,652.267	9,340.000	18.000	118,435.000	31,516.008	1.740	1.559
CHANGE	5	0	2,015.000	1,296.000	30.000	6,500.000	1,950.088	-0.350	0.951
DEPEND	6	0	57.867	19.000	0.000	1,000.000	176.508	28.842	5.327
iDOFFSHF	7	0	25.267	20.000	2.000	130.000	26.845	6.931	2.364
iDBESPOK	8	0	12.400	4.000	0.000	250.000	44.369	29.264	5.382
iDOPSYST	9	0	2.567	3.000	1.000	6.000	1.309	0.550	0.881
iDDBSYST	10	0	2.667	2.000	1.000	10.000	1.795	8.208	2.354
iDSERVER	11	0	1.833	2.000	1.000	4.000	0.860	-0.474	0.676
iDNETDEV	12	0	2.467	2.000	1.000	6.000	1.408	0.014	0.827
iDENDUSR	13	0	3.000	3.000	1.000	10.000	1.732	7.788	2.311
iDIDSYST	14	0	2.300	2.000	1.000	7.000	1.735	0.935	1.364
mKNOW	15	0	6.258	3.064	0.021	21.192	7.038	-0.651	0.871
iQITSTAFF	16	0	81.800	55.000	4.000	280.000	80.898	0.643	1.247
iQOFFSHF	17	0	25.267	20.000	2.000	130.000	26.845	6.931	2.364
iQBESPOK	18	0	12.400	4.000	0.000	250.000	44.369	29.264	5.382
iQMODULE	19	0	40.033	14.000	0.000	266.000	64.163	4.723	2.199
iQSERVER	20	0	75.800	20.000	2.000	1,100.000	197.051	25.611	4.919
iQNETDEV	21	0	382.467	65.000	1.000	5,100.000	955.269	20.509	4.342
iQENDUSR	22	0	3,952.933	1,500.000	90.000	40,000.000	7,603.404	16.948	3.857
REPORTED	23	0	54.533	39.000	0.000	301.000	59.185	9.055	2.606
REPORTED(W)	24	0	79.500	60.000	0.000	304.000	72.679	2.437	1.525
TASKCOMPLEX	25	0	1,721.988	798.000	35.000	8,662.500	2,285.613	2.527	1.875

Exhibit A-5, Descriptive statistics (case study population)

***(W)** denotes weighted variable*

	No.	Missing	Mean	Median	Min	Max	Standard Deviation	Excess Kurtosis	Skewness
Case	1	0	26.571	25.000	1.000	49.000	13.236	-0.762	0.054
Source	2	0	2.000	2.000	2.000	2.000	0.000	�	�
ASSESSRISK	3	0	3,439.381	45.000	3.000	68,124.000	14,468.066	20.972	4.578
ASSESSRISK(W)	4	0	3,546.000	60.000	4.000	69,570.000	14,768.542	20.966	4.577
CHANGE	5	0	1,008.000	150.000	10.000	7,200.000	1,855.636	5.080	2.320
DEPEND	6	0	5.238	3.000	0.000	25.000	7.077	2.395	1.820
iDOFFSHF	7	0	3.667	2.000	1.000	12.000	2.551	4.253	1.926
iDBESPOK	8	0	1.476	1.000	0.000	8.000	1.942	5.161	2.120
iDOPSYST	9	0	1.476	1.000	1.000	4.000	0.732	5.426	2.057
iDDBSYST	10	0	1.476	1.000	0.000	5.000	1.052	5.030	2.053
iDSERVER	11	0	1.333	1.000	1.000	3.000	0.713	2.085	1.923
iDNETDEV	12	0	1.286	1.000	1.000	2.000	0.452	-1.064	1.023
iDENDUSR	13	0	1.619	1.000	1.000	4.000	0.898	0.726	1.313
iDIDSYST	14	0	2.429	2.000	1.000	7.000	1.466	3.260	1.521
mKNOW	15	0	1.555	0.021	0.006	12.191	3.769	3.512	2.253
iQITSTAFF	16	0	29.476	9.000	0.000	230.000	56.510	7.565	2.776
iQOFFSHF	17	0	3.667	2.000	1.000	12.000	2.551	4.253	1.926
iQBESPOK	18	0	1.476	1.000	0.000	8.000	1.942	5.161	2.120
iQMODULE	19	0	2.762	2.000	0.000	15.000	3.728	4.490	2.034
iQSERVER	20	0	9.762	2.000	1.000	150.000	31.419	20.813	4.554
iQNETDEV	21	0	25.571	6.000	1.000	300.000	63.102	18.427	4.207
iQENDUSR	22	0	591.571	135.000	12.000	3,800.000	1,146.157	4.075	2.320
REPORTED	23	0	26.476	16.000	4.000	132.000	29.818	6.980	2.523
REPORTED(W)	24	0	32.000	17.000	3.000	154.500	35.983	5.632	2.284
TASKCOMPLEX	25	0	604.033	35.000	10.500	7,388.500	1,782.429	10.678	3.315

Exhibit A-6, Partial Least Squares algorithm settings

Algorithm settings for SmartPLS version 3.2.6.

Data file Settings	
Data file	Combined dataset (file 71.01.030) [51 records]
Missing value marker	none
Data Setup Settings	
Algorithm to handle missing data	None
Weighting Vector	-
PLS Algorithm Settings	
Data metric	Mean 0, Var 1
Initial Weights	1.0
Max. number of iterations	300
Stop criterion	7
Use Lohmoeller settings?	No
Weighting scheme	Path
Bootstrapping Settings	
Complexity	Complete Bootstrapping
Confidence interval method	Bias-Corrected and Accelerated (BCa) Bootstrap
Parallel processing	Yes
Samples	500
Sign changes	No Sign Changes
Significance level	0.05
Test type	Two Tailed
Construct Outer Weighting Mode Settings	
ASSESSRISK	Automatic
CHANGE	Automatic
DIVERSE	Automatic
QUANTITY	Automatic
REPORTED	Automatic
TASKCOMPLEX	Automatic

Exhibit A-7, Indicator and construct reliability, and construct validity

***Note**: Where variables are their own indicators (such as ASSESSRISK), indicators are prefixed with the letter 'i' (for example, iASSESSRISK).*

Variables and indicators	***Indicator Loadings[a]***	***Cronbach's Alpha***	***Composite Reliability***	***Average Variance Extracted***
ASSESSRISK		1.00	1.00	1.00
iASSESSRISK	1.00			
CHANGE		0.00	0.00	0.00
iCHANGE	1.00			
DIVERSE		0.90	0.93	0.71
iDEPEND	0.91			
iDBESPOK	0.90			
iDDBSYST	0.88			
iDOFFSHF	0.85			
iDSERVER	0.66			
QUANTITY		0.76	0.89	0.81
iQENDUSR	0.87			
iQITSTAFF	0.92			
REPORTED		1.00	1.00	1.00
iREPORTED	1.00			
TASKCOMPLEX		1.00	1.00	1.00
iTASKCOMPLEX	1.00			

[a] *All loadings are significant at $p < 0.001$ level, based on two-tailed test*

Exhibit A-8, Partial Least Squares cross-loadings

***Note**: Where variables are their own indicators (such as ASSESSRISK), indicators are prefixed with the letter 'i' (for example, iASSESSRISK).*

Variables and indicators	***ASSESSRISK***	***CHANGE***	***DIVERSE***	***QUANTITY***	***REPORTED***	***TASKCOMPLEX***
ASSESSRISK						
iASSESSRISK	**1.00**	0.25	0.55	0.27	0.19	0.22
CHANGE						
iCHANGE	0.25	**1.00**	0.52	0.65	0.39	0.48
DIVERSE						
iDEPEND	0.46	0.37	**0.92**	0.29	0.15	0.37
iDBESPOK	0.41	0.36	**0.90**	0.27	0.15	0.39
iDDBSYST	0.49	0.56	**0.88**	0.39	0.23	0.49
iDOFFSHF	0.63	0.45	**0.85**	0.40	0.20	0.31
iDSERVER	0.30	0.42	**0.66**	0.50	0.48	0.54
QUANTITY						
iQENDUSR	0.27	0.52	0.39	**0.87**	0.62	0.29
iQITSTAFF	0.21	0.63	0.42	**0.92**	0.64	0.61
REPORTED						
iREPORTED	0.19	0.39	0.30	0.70	**1.00**	0.41
TASKCOMPLEX						
iTASKCOMPLEX	0.22	0.48	0.51	0.52	0.41	**1.00**

Exhibit A-9, Heterotrait-Monotrait Ratio

Variables	***ASSESSRISK.***	***CHANGE***	***DIVERSE***	***QUANTITY***	***REPORTED***	***TASKCOMPLEX***
ASSESSRISK						
CHANGE	0.25					
DIVERSE	0.58	0.54				
QUANTITY	0.31	0.74	0.53			
REPORTED	0.19	0.39	0.31	0.80		
TASKCOMPLEX	0.22	0.48	0.53	0.58	0.41	

Exhibit A-10, Internal Variance Inflation Factors

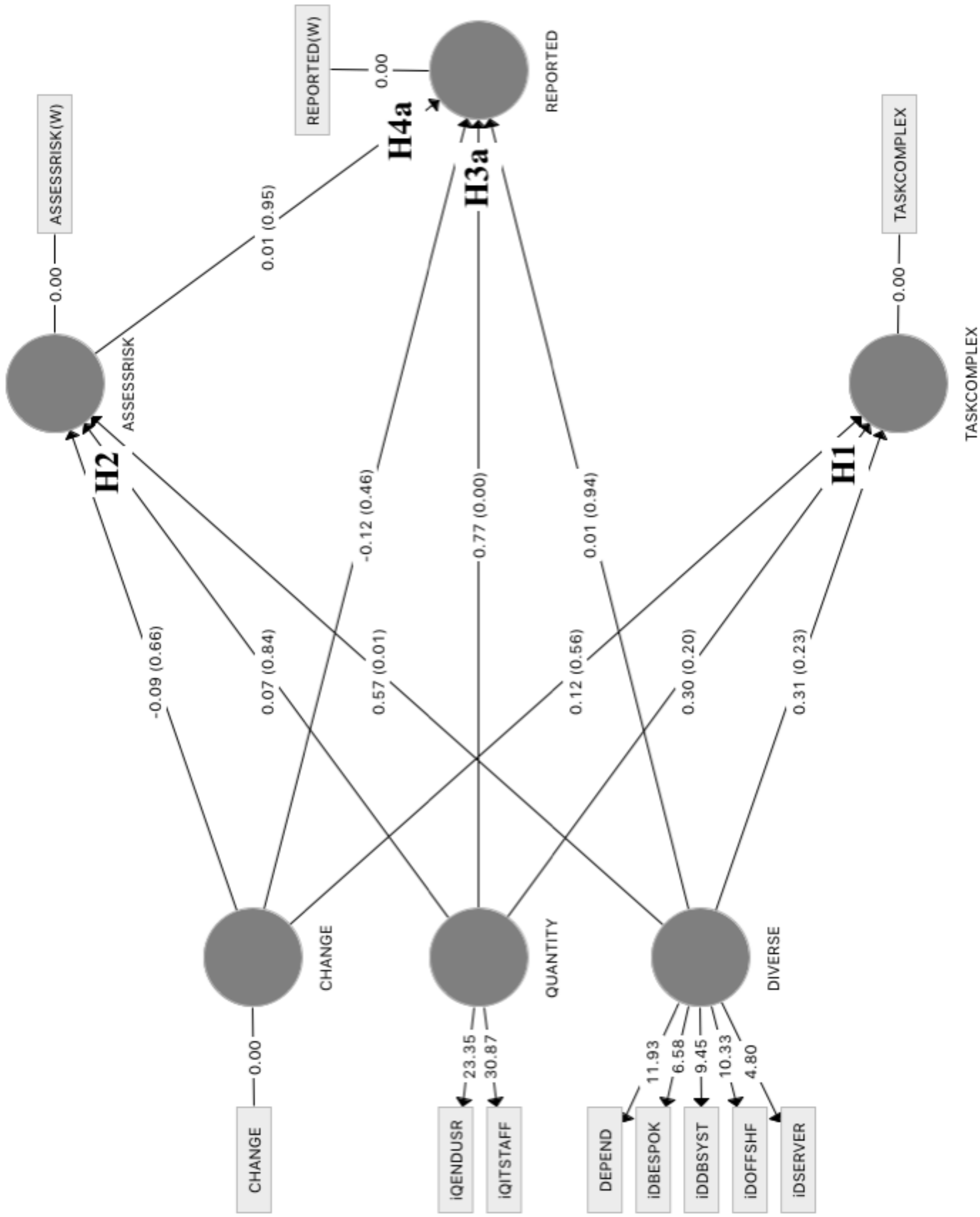
Variables	***ASSESSRISK.***	***CHANGE***	***DIVERSE***	***QUANTITY***	***REPORTED***	***TASKCOMPLEX***
ASSESSRISK					1.44	
CHANGE	1.96				1.97	1.96
DIVERSE	1.42				1.88	1.42
QUANTITY	1.78				1.79	1.78
REPORTED						
TASKCOMPLEX						

Exhibit A-11, Average Variance Extracted

Variables	*AVE*
ASSESSRISK	1.00
CHANGE	
DIVERSE	0.71
QUANTITY	0.81
REPORTED	1.00
TASKCOMPLEX	1.00

APPENDIX B Regression Results

Exhibit B-1, Partial Least Squares path diagram



Path coefficients and p-values based on two-tailed tests (in brackets) shown between variables, while t-values shown against indicators

Exhibit B-2, Partial Least Squares results (survey dataset only)

Variables (N=30)	***ASSESSRISK***	***REPORTED***	***TASKCOMPLEX***
ASSESSRISK →		-0.02 (0.92)	
CHANGE →	-0.20 (0.28)	-0.16 (0.46)	-0.14 (0.46)
DIVERSE →	0.58 (0.09)	0.05 (0.89)	0.49 (0.19)
QUANTITY →	0.05 (0.88)	**0.72 (0.02)**	0.28 (0.27)

Results shown: path coefficient β (p-value)

Exhibit B-3, Partial Least Squares results (case study dataset only)

Variables (N=21)	***ASSESSRISK***	***REPORTED***	***TASKCOMPLEX***
ASSESSRISK →		-0.14 (0.89)	
CHANGE →	-0.27 (0.84)	-0.22 (0.87)	0.13 (0.87)
DIVERSE →	0.74 (0.17)	-0.54 (0.27)	-0.38 (0.30)
QUANTITY →	0.13 (0.92)	1.37 (0.31)	1.04 (0.19)

Results shown: path coefficient β (p-value)

APPENDIX C Miscellaneous

Exhibit C-1, Information systems audit survey instrument

UNIVERSITY OF SOUTHERN QUEENSLAND

Systems Complexity & Audit Risk

Research Project - Internal Audit survey

Welcome

Thank you for your time; depending on your organisation, this survey could take as little as 10 minutes to complete.

Information about this benchmarking project is available from the survey participant information page. Clicking on the '*Submit*' button at the conclusion of this survey is accepted as an indication of your consent to participate in this project.

Once this survey is closed, participant responses will be analysed and a benchmark report will be forwarded to your Internal Audit department.

Kindly note: An alert will appear if Javascript or cookies are not enabled on your browser. If your browser settings cannot be altered, or if alternate personal computers are unavailable, please print this survey in *landscape* then mail the completed survey to: << address not shown >>.

Please contact Steve Filletti via email (u1045467@umail.usq.edu.au) with any queries you may have.

Thank you.

---

1. *I am ready to start the survey now*

☐ Yes

---

2. **Please select up to 3 industry classifications that best describe your organisation's business operations:**

☐ Automobiles & Components	☐ Banks	☐ Capit
☐ Commercial & Professional Services	☐ Consumer Durables & Apparel	☐ Diver
☐ Energy	☐ Food & Staples Retailing	☐ Food,
☐ Government, Federal organisation	☐ Government, Local Council	☐ Gover
☐ Health Care Equipment & Services	☐ Hotels Restaurants & Leisure	☐ House
☐ Insurance	☐ Materials	☐ Media
☐ Pharmaceuticals & Biotechnology	☐ Real Estate	☐ Retail
☐ Semiconductors & Semiconductor Equipment	☐ Software & Services	☐ Techn
☐ Telecommunication Services	☐ Transportation	☐ Utiliti

3. **Please provide the total number of employees within your organisation at this time:**

- Include full-time, part-time, and contract employees BUT please do not include staff pertaining to outsourced service providers.

4. **Please provide the number of full-time in-house internal IT auditors between 01.01.2012 and 31.12.2014:**

- Include contracting full-time internal IT auditors engaged during those years.

2012 ______
2013 ______
2014 ______

5. **Please provide the number of part-time in-house internal IT auditors between 01.01.2012 and 31.12.2014:**

- Include contracting part-time internal IT auditors engaged during those years.

2012 ______
2013 ______
2014 ______

6. **From the previous question, please provide the average days per week, part-time in-house internal IT auditor(s) were engaged between 01.01.2012 and 31.12.2014:**

- For example, if John and Peter work 3 days and 2 days per week respectively, then the response would be 2.5.

2012 ______
2013 ______
2014 ______

7. **Please provide the number of weeks IT audit external consultants were engaged between 01.01.2012 and 31.12.2014:**

- Please do not include IT audit activities performed by your external auditor.

2012 ______
2013 ______
2014 ______

8. **Please provide the percentage of time your in-house Internal IT auditor(s) devoted to NON - IT audit related activities between 01.01.2012 and 31.12.2014:**

	Nil	10%	20%	30%	40%	50%	60%	70%	Not applicable
2012	○	○	○	○	○	○	○	○	○
2013	○	○	○	○	○	○	○	○	○
2014	○	○	○	○	○	○	○	○	○

9. **Please provide the combined IT audit experience (in years) of your in-house internal IT auditor(s) at this time:**

- For example, John worked at company A for 3 years then 4 years at your organisation, therefore the combined IT audit experience would be 7.

Combined IT audit experience, in years ______

10. **Please provide the combined years of IT audit service your in-house internal IT auditor(s) provided to your organisation at this time:**

- For example, John and Mary have been with your organisation for 3 and 5 years respectively (as IT auditors), therefore the combined years of service would be 8.

Combined years of IT audit service [ ]

11. **If you have cyclical risk-based annual IT audit plans, please indicate your planning cycle:**

○ 2-year planning cycle
○ 3-year planning cycle
○ 4-year planning cycle
○ 5-year + planning cycle
○ Not applicable

12. **Please provide the percentage of time your in-house Internal IT auditor(s) devoted to data analytics between 01.01.2012 and 31.12.2014:**

	Nil	10%	20%	30%	40%	50%	60%	70%	Not applicable
2012	○	○	○	○	○	○	○	○	○
2013	○	○	○	○	○	○	○	○	○
2014	○	○	○	○	○	○	○	○	○

13. **Please provide the number of IT audits completed by your in-house internal IT auditor(s) between 01.01.2012 and 31.12.2014:**

2012 [ ]
2013 [ ]
2014 [ ]

14. **Please provide the number of IT audit findings your in-house internal IT auditor(s) reported in the 3 years between 01.01.2012 and 31.12.2014:**

- Break-down findings by high, moderate and low risk exposures, and opportunities for improvement.

High risk [ ]
Moderate risk [ ]
Low risk [ ]
Improvements [ ]

15. **Please indicate if your External Auditor completed IT audits between 01.01.2012 and 31.12.2014:**

	Yes	No
2012	○	○
2013	○	○
2014	○	○

16. **Please provide the number of IT audit findings your External Auditor reported for the 3 years between 01.01.2012 and 31.12.2014:**

- Break-down findings by high, moderate and low risk exposures, and opportunities for improvement.

High risk	
Medium risk	
Low risk	
Improvements	

17. **Please provide the number of IT audits completed by your IT audit external consultant(s) between 01.01.2012 and 31.12.2014:**

2012	
2013	
2014	

18. **Please provide the number of IT audit findings your IT audit external consultant(s) reported for the 3 years between 01.01.2012 and 31.12.2014:**

- Break-down findings by high, moderate and low risk exposures, and opportunities for improvement.

High risk	
Medium risk	
Low risk	
Improvements	

Kindly ensure that all questions are completed and responses provided are accurate before submitting your survey.

Thank you for your time in completing this survey.

Exhibit C-2, Information technology environment survey instrument

UNIVERSITY OF SOUTHERN QUEENSLAND

Systems Complexity & Audit Risk

Research Project - IT Survey

Welcome

Thank you for your time; depending on your organisation, this survey could take as little as 10 minutes to complete.

Information about this benchmarking project is available from the survey participant information page. Clicking on the '*Submit*' button at the conclusion of this survey is accepted as an indication of your consent to participate in this project.

Once this survey is closed, participant responses will be analysed and a benchmark report will be forwarded to your Internal Audit department.

Kindly note: An alert will appear if Javascript or cookies are not enabled on your browser. If your browser settings cannot be altered, or if alternate personal computers are unavailable, please print this survey in landscape then mail the completed survey to: << address not shown >>.

Please contact Steve Filletti via email (u1045467@umail.usq.edu.au) with any queries you may have.

Thank you.

---

1. *I am ready to start the survey now*

☐ Yes

---

2. **Please provide the total number of IT employees supporting your organisation at this time:**

- Include full-time, part-time, and contract employees BUT do not include staff pertaining to outsourced IT service providers.

[ ]

3. **Please provide the number of IT Service Requests <u>completed</u> for the 3 years between 01.01.2012 and 31.12.2014:**

[ ]

4. **Please provide the number of IT Change Requests <u>completed</u> for the 3 years between 01.01.2012 and 31.12.2014:**

[ ]

5. **Please provide the number of IT incidents recorded for the 3 years between 01.01.2012 and 31.12.2014:**

Total number of IT incidents

Number of Severity 1 and 2 IT incidents

6. **Please provide the number of different business-critical applications supporting operations across your organisation at this time:**

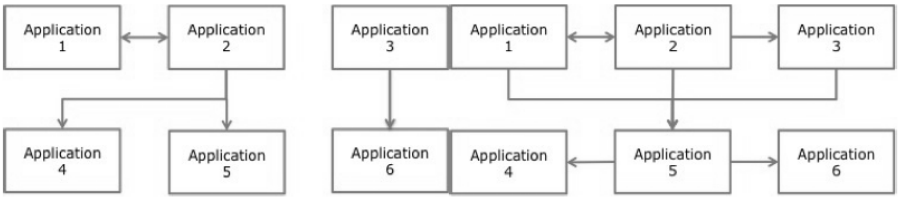
- Include in-house custom-built applications **and** off-the-shelf applications
- Off-the-shelf applications includes customised and cloud-type off-the-shelf applications
- **Do not count** application modules separately here, for example SAP installed with CO and HR modules would count as 1 application
- **Do not include** office productivity tools such as Microsoft Acess, Excel, and Word.

Off-the-shelf applications

In-house custom-built applications

7. **From the previous question, please provide the number of data interfaces between your business-critical applications:**

- The example on the left (below) comprises 4 data interfaces, while the example of the right comprises 7 data interfaces.



Example A: 4 data interfaces

Example B: 7 data interfaces

Data interfaces

8. **From the number of off-the-shelf applications above, please provide the total number of application modules installed / utilised:**

- For example, SAP utilising FI, CO and HR modules = 3 modules.

Modules

9. **Please provide the number of different operating systems currently supporting your business-critical applications:**

- Examples of operating system publishers include Linux, MS Windows, Red Hat, IBM, and Unix
- **Only count** different publishers, for example MS Windows XP, MS Windows 8, MS Windows Server would count as the same publisher.

Operating system publishers

10. **Please provide the number of <u>different</u> database systems currently supporting your business-critical applications:**

- Do not count database versions as different database systems; please only count different database publishers, examples include DB2, MS SQL, MySQL, ORACLE, postgreSQL, and SYBASE
- For example MS SQL supporting 2 applications and Oracle supporting 1 application = 2 brands

Database publishers [ ]

11. **Please provide the number of physical server devices currently hosting your business-critical applications:**

Server devices [ ]

12. **From the previous question, please provide the number of <u>different brands</u> of physical server devices:**

- For example, if you have a mixture of HP, DELL, and IBM server devices then you would have a total of 3 brands
- Do not count server models as separate brands, for example an IBM x3100 and an IBM x3800 are the same brand and therefore count as 1 brand.

Server brands [ ]

13. **Please provide the number of IT network devices currently supporting your organisation:**

- Include router, firewall, wireless access, and intrusion detection and prevention devices.

Network devices [ ]

14. **From the previous question, please provide the number of <u>different brands</u> of IT network devices:**

- **Do not count** brand product lines as different brands, e.g. a CISCO ASA 5505 and a CISCO 892 count as 1 brand.

Network brands [ ]

15. **Please provide the total number of desktops, laptops, and tablets currently in commission within your organisation:**

Desktops, laptops, and tablets [ ]

16. **From the previous question, please provide the number of <u>different brands</u> of desktops, laptops, and tablets:**

- **Do not count** brand product lines and versions as different brands, e.g. iPads and Macbooks are Apple products and therefore count as 1 brand.

Desktops, laptops, and tablets brands [ ]

17. **Please provide the number of different anti-virus AND network identity management systems across your organisation:**

- Examples of Network Identity Management Systems include LDAP, Microsoft Active Directory, and Novell eDirectory
- Some organisations install different anti-virus systems across their network - for example AVG for end-user devices and NORTON for servers, therefore this would count as 2 systems.

Anti-virus systems	
Network identity management systems	

Kindly ensure that all questions are completed and responses provided are accurate before submitting your survey.

Thank you for your time in completing this survey.

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